RUSSIAN RIVER BIOLOGICAL ASSESSMENT

INTERIM REPORT 3: FLOW-RELATED HABITAT

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
San Francisco District
San Francisco, California

and

SONOMA COUNTY WATER AGENCY
Santa Rosa, California

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Walnut Creek, California

April 5, 2002

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BACKGROUND

The Sonoma County Water Agency (SCWA), the U.S. Army Corps of Engineers (USACE) and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) are undertaking a Section 7 Consultation under the Federal Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) to evaluate effects of their operations and maintenance activities on listed species and their critical habitat. The Russian River watershed is designated as critical habitat for threatened stocks of coho salmon, steelhead, and chinook salmon. SCWA, USACE and MCRRFCD operate and maintain facilities and conduct activities related to flood control, channel maintenance, water diversion and storage, hydroelectric power generation, and fish production and passage.

Federal agencies such as USACE are required under the ESA to consult with the Secretary of Commerce to insure that their actions are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat. As part of the Section 7 Consultation, USACE and SCWA will submit to NMFS a biological assessment (BA) that will provide the basis for NMFS to prepare a biological opinion (BO) that will evaluate project operations (USACE, *et al*. 2000). The BA will integrate a number of interim reports on various project operations.

Lake Sonoma (on Dry Creek) and Lake Mendocino (on the East Fork of the Russian River) are operated for flood control, water supply and hydroelectric generation. They are operated in accordance with criteria established by the State Water Resources Control Board (SWRCB) Decision 1610 (D1610)(SWRCB 1986), which established minimum instream flow requirements for Dry Creek and the Russian River under normal, dry, and critical water supply conditions. Water supply condition is based on the cumulative inflow to Lake Pillsbury. The water supply condition is determined on the first of each month from January through June with the June water supply condition continuing through December. Within the evaluation period used in this document (1929 to 1995), the percentage of months a given water supply condition was in effect was normal 70 to 90 percent, dry 9 to 13 percent and critical 1.5 to 6 percent.

Water imported from the Eel River via the Potter Valley Project (PVP) and flow from the East Fork Russian River upstream of Lake Mendocino are stored in Lake Mendocino and released from Coyote Valley Dam. Lake Sonoma stores water from the upper portion of Dry Creek during the wet season (November through April) and releases this water during the dry season (June through October). The timing and magnitude of flow releases from these dams are determined by the USACE when the dams are being operated principally for flood control and by SCWA when the dams are being operated principally for water supply. A more complete description of project facilities and operations is provided in Section 1.5.

PURPOSE OF THIS REPORT

This interim report addresses the suitability of flow-related habitat for protected coho salmon, steelhead, and chinook salmon, and their designated critical habitat in the Russian River and Dry

Creek under current project operations at Coyote Valley Dam and Warm Springs Dam. This report provides an assessment of the suitability of habitat under current operations for these species based on existing flow regimes and associated water temperatures and dissolved oxygen (DO) concentrations.

The potential effects evaluated include:

- The timing and magnitude of existing flows and their effects on habitat quantity and quality,
- Temperature and DO concentrations resulting from these flows, and
- Physical and biological processes within the estuary.

This report evaluates current operations based on meeting the flow requirements of D1610 for both current (Year 2000) and anticipated future (Year 2020) water demand levels. In the rest of this report, these demand scenarios are abbreviated D1610/2000 and D1610/2020, respectively.

EVALUATION TECHNIQUES

REACHES EVALUATED

In this evaluation, the Russian River has been divided into three reaches based on those established by Winzler and Kelly (1978). The upper Russian River extends from Coyote Valley Dam downstream to the Sonoma-Mendocino County line, just upstream of Cloverdale. The middle Russian River extends from the county line to the confluence of Dry Creek. The lower Russian River extends from the confluence of Dry Creek to the upstream end of the estuary. The upper reach is used for all lifestages of steelhead and chinook salmon, and as a migration corridor by coho salmon. Both coho and steelhead rely primarily on tributary habitat for spawning and rearing, however. The middle reach serves primarily as a migration corridor, but the area upstream of Asti may be used for spawning and rearing by steelhead and chinook salmon. The lower Russian River is thought to be a migration corridor for all three species and generally is not used for other life history stages. Dry Creek is treated as a single reach in this evaluation and is used by all three species for all life history stages.

In addition to these riverine reaches, habitat conditions in the estuary are evaluated, which extends from near the confluence of Austin Creek to the Russian River's mouth at the Pacific Ocean, near Jenner. The estuary may be used by salmonids for passage and rearing, but not for spawning.

EVALUATION TOOLS

Flow Evaluation

In this report, a summary of existing flow conditions in the Russian River and Dry Creek is provided based on the Russian River System Model (RRSM). The RRSM was developed and is maintained by SCWA (Flugum 1996, R. Beach and C. Murray pers. comm. 2001). This model integrates the factors influencing streamflows in the Russian River and Dry Creek whether or not they are related to project operations. Thus, loss of flow due to transpiration, loss to groundwater, other diverters, *etc*., are all included in the flow estimates provided. This allows the formulation of an overall picture of flow-related habitat conditions for the three protected salmonid species. Where flow levels appear to result in impaired conditions for salmonids, the level to which the project contributes to this impairment has been evaluated. A qualitative description of the potential effects of these flows on the salmonid species and lifestages is provided based on personal observations and discussions with biologists from NMFS, California Department of Fish and Game (CDFG), and SCWA who are knowledgeable about the system.

USACE and SCWA elected to undertake additional data collection cooperatively with CDFG and NMFS for analysis of flow-related effects on habitat, based on empirical evidence and professional judgement (USACE letter to NMFS, May 15, 2001). This study, the *Russian River Flow-Assessment Study*, was conducted during the late summer/fall of 2001, and the results will be used to develop scoring criteria that will enable a more quantitative evaluation of current conditions and alternatives (as yet to be identified) in the Draft BA. Until this data analysis is complete and project operations have been evaluated based upon the results of that study, USACE and SCWA consider the findings of the flow evaluation preliminary.

Temperature and Dissolved Oxygen Evaluation

The temperature and DO concentrations associated with current operations under D1610 were evaluated using the Russian River Water Quality Model (RRWQM)(RMA 2001). This model estimates water temperature and DO levels at specific locations along the Russian River and Dry Creek based on a variety of factors including the quantity and temperature of water released from the dams. A complete description of the RRWQM is provided in *HEC-5Q Simulation of Water Quality in the Russian River Basin - Final Report* (RMA 2001). The temperature and DO values output by this model were used in conjunction with the temperature and DO scoring criteria outlined in Section 2.2.2.2 to evaluate the suitability of current water quality for important life history stages of the protected species.

SUMMARY OF RESULTS

To minimize redundancy in this Executive Summary, the following summary of results describes the conditions that occur during different life history events for the three species. The habitat requirements of the three species during a particular life history stage are often similar, as are the times of year when these events occur, although some differences in timing are notable. The summary begins with a brief description of flow, temperature, and DO concentrations. The suitability of these conditions is then discussed sequentially for the upstream passage, spawning and incubation, rearing, and emigration. These sections are followed by a summary of habitat conditions in the estuary, which is subject to different processes than the river. The Executive Summary concludes with a Statement of Effects for the three species.

FLOW, TEMPERATURE AND DISSOLVED OXYGEN CONDITIONS

Project operations generally store water in the winter and augment flows in the summer. In most years, these operations generally result in only small changes during the wet winter period when many important life history activities occur, such as upstream passage, spawning incubation/ emergence, and downstream passage of salmonids. Flows during the summer period are augmented by water supply deliveries. Under the D1610/2020 scenario, Coyote Valley Dam flow releases remain similar to those of the D1610/2000 scenario under normal and dry water supply conditions, but are substantially reduced from May through August in critical water supply conditions. Under the D1610/2020 scenario, flows in Dry Creek are increased from June through October under normal and dry water supply conditions and from June through September under critical water supply conditions. In critical water supply conditions, flows in October and November can reach extremely low levels.

In general, water temperature is usually good to excellent for salmonids from November through April. Summer and fall have high water temperatures that may provide sub-optimal and occasionally potentially lethal conditions in the middle and lower Russian River. The upper Russian River has conditions that are stressful for salmonids, but rearing may occur. During the summer months, water temperatures in Dry Creek are markedly better than those in the Russian River and are generally at optimal or slightly cooler than optimal levels near Warm Springs Dam. Summer water temperatures in the lower portion of Dry Creek may be warm enough to stress rearing salmonids, in spite of the cold water releases from Lake Sonoma.

Modeled DO levels were generally rated good to excellent in all reaches of the Russian River and Dry Creek for coho salmon and steelhead. They were generally rated good in all reaches for chinook salmon. Occasionally, stressful DO values may occur for chinook egg incubation in the upper portion of Dry Creek.

RIVERINE HABITAT

Upstream Passage

D1610/2000 scenario flows are generally suitable for upstream passage throughout the Russian River and Dry Creek under normal water supply conditions, which occur 70 to 90 percent of the time. Under dry water supply conditions, which occur 9 to 13 percent of the time, upstream passage may be somewhat impaired in the middle and upper reaches for all species. The model results showed the impairment extending through most of the migration season for coho and chinook salmon, but impairment limited to the upper river in January for steelhead. Under critical water supply conditions, which occur 1.5 to 6 percent of the time, passage may be blocked from August through December, which would affect adult chinook and coho salmon. During periods of impeded passage, upstream migration may be possible during and following storm events. Passage was likely unimpeded for steelhead, which migrate from January to March when flows are higher. Migration up Dry Creek appears to be unimpeded in all water supply conditions.

Under the D1610/2020 scenario, flows would be more restrictive for chinook than under the D1610/2000 scenario in the early part of their migration season in dry and critical water supply conditions. These lower flows may further reduce the opportunity of chinook salmon to successfully migrate upstream during these dry and critical water supply conditions. These lower flows may extend into the early part of the coho migration season, and therefore may affect their migration opportunities as well. Flows are generally higher by December, so coho salmon would have migration opportunities in December and January, and steelhead upstream migration would be largely unaffected relative to the D1610/2000 scenario.

Warm water temperatures may be present during the early portion of the upstream migration season for chinook and coho salmon. Water temperatures appear to be stressful for adult chinook salmon during August through October. Later, between December through February, water temperatures are near optimal levels. Coho salmon have a peak migration period during the time when water temperatures are more acceptable. Steelhead migrate upstream later in the season and therefore experience cooler water temperatures, which are near optimal for this lifestage. DO concentrations are nearly optimal for the upstream migration of all species. The flow regimes that would occur under the D1610/2020 scenario had similar temperature and DO scores for this lifestage of coho salmon, steelhead and chinook salmon.

Spawning and Incubation

Spawning and egg incubation generally occur from November through May; the exact timing depends on the species. The peak of coho and chinook salmon spawning occurs in November and December, while the peak of steelhead spawning occurs in February or March. Steelhead and chinook spawn in the mainstem above Asti (although steelhead use primarily tributaries for spawning and rearing), and all three species spawn in Dry Creek. Flows under both normal and dry water supply conditions appear to provide suitable habitat for spawning and incubation of steelhead and chinook salmon in the middle and upper reaches of the mainstem. With the lower flows that exist during critical water supply conditions, the amount of available spawning area may be substantially lower than normal or dry water supply conditions, especially for chinook. During critical water supply conditions, inflows to the project reservoirs only exceeded outflows in about 20 percent of days. Thus, the project may result in reduced spawning habitat for these species about 0.3 to 1.2 percent (1.5 percent of years times 20 percent of days) of the entire evaluation period.

Flow conditions in Dry Creek for spawning and incubation are very stable regardless of the water supply condition. These life history activities do well under stable flow conditions. Dry Creek provides suitable spawning and incubation habitat for all three species under the D1610/2000 scenario.

Under the D1610/2020 scenario, flows in Dry Creek are higher than under the D1610/2000 scenario during normal and dry water supply conditions, and during August and September in critical water supply conditions. Critical water supply condition flows in October and November are very low, but return to more typical levels from December through March. The low November flows could adversely affect coho and chinook salmon spawning and incubation habitat by decreasing the amount of area available and the suitability of velocities over appropriate spawning locations.

Water temperatures in the mainstem are generally good for chinook salmon spawning and incubation. Temperatures are also generally good for spawning and incubation for all three species on Dry Creek. Water temperature model results indicate that temperatures in the mainstem may be stressful for steelhead during the latter part of their incubation season (April and May), with temperatures reaching potentially lethal levels in May. Temperatures in April and May in the lower end of Dry Creek may also become stressful for steelhead incubation. DO concentrations were good to excellent for spawning and incubation of coho and steelhead in Dry Creek and for spawning and incubation of steelhead and chinook on the Russian River. Occasionally, lower DO scores occurred for chinook egg incubation in the upper reach of Dry Creek. These low DO scores occurred primarily in November, and were generally rated as stressful. The cause of the low DO scores for chinook incubation in November below Lake

Sonoma is likely a joint function of algal die-off in Lake Sonoma and the high DO requirements for chinook salmon incubation.

Under the D1610/2020 scenario, scores for temperature and DO remained largely unchanged from those under the D1610/2000 scenario.

Rearing

Flows under the D1610/2000 scenario provide rearing habitat for steelhead and chinook salmon in the upper and middle reaches of the Russian River under both normal and dry water supply conditions. Water velocities in some areas may be higher than optimal for rearing salmonids, but substantial areas are available where velocities are acceptable. The lower mainstem is not thought to provide substantial rearing habitat during the summer months for these species due to poor habitat conditions and very high water temperatures. In critical water supply conditions, low flows during the late summer and fall reduce the amount of habitat for steelhead in both the middle and upper reaches. The reduced habitat may concentrate juvenile steelhead into pools and increase their exposure to predators that have also taken refuge there.

Under the D1610/2020 scenario, flows would be very similar to those occurring under the D1610/2000 scenario during normal and dry water supply conditions. Under the D1610/2020 scenario in critical water supply conditions, flow would be nearly eliminated during the summer and fall months, which would substantially compress rearing habitat for steelhead into pools as resulted from the D1610/2000 scenario under critical water supply conditions. Very low flows during May and June adversely affect habitat during the latter part of the chinook rearing season.

The current flow regime in Dry Creek under the D1610/2000 scenario provides rearing habitat for all three protected salmonid species under normal, dry, and critically dry conditions. Flow in Dry Creek is relatively stable regardless of water supply condition. The flows greater than 90 cfs present in Dry Creek may result in velocities that are higher than optimal for rearing salmonids, however. Under the D1610/2020 scenario, flows in Dry Creek would be increased over what is present under the D1610/2000 scenario throughout the summer months under all water supply conditions. This would increase velocities to more unsuitable levels during much of the summer. In October and November under critical water supply conditions, flows would be reduced to almost zero, which would concentrate rearing fish into pools, decreasing the habitat area available to them, reducing the available food supply, increasing competition and potentially increasing their exposure to predators.

Water temperatures in the upper portion of Dry Creek under D1610/2000 are consistently good or optimal throughout the summer for the juvenile coho salmon and steelhead rearing there (juvenile chinook salmon have emigrated by this time). Water temperatures in the middle and lower reaches of the Russian River are sufficiently high to reduce the potential for steelhead rearing through the summer and early fall. In the upper reach of the Russian River and the lower portion of Dry Creek, temperatures are stressful through the summer months, but remain within a range that may allow steelhead rearing. Temperatures in the lower portion of Dry Creek are likely too high to support coho salmon rearing. DO concentration are good to excellent for rearing of all species in Dry Creek and the Russian River. Under the D1610/2020 scenario, temperature, and DO conditions are similar to those of the D1610/2000 scenario.

Emigration

Emigration for all three species occurs from February to mid-May and extends through June for steelhead and chinook salmon. The duration of the emigration for an individual smolt is important, particularly late in the season. The longer a smolt is in the river on its way to the ocean, the longer that individual is exposed to stressful water temperatures and to predators. Flows are generally highest during the early portion of the migration period and decline toward the end of the period. Higher flows are generally better for emigrating salmonids because they can take advantage of the current to help carry them downstream. However, smolts actively migrate and swim downstream in the absence of high flows. Normal water supply conditions under the D1610/2000 scenario provide adequate flows for emigration. Under dry water supply conditions, flows are substantially lower, and therefore emigration would be slower. There would still be substantial velocity to assist smolts in their emigration, although flows decline in April and May, which would reduce the speed of emigration in those months. In critical water supply conditions, flows drop even further to the point where velocities may be quite slow. Under these conditions, emigration may be even further prolonged.

Under D1610/2020 scenario, flow levels are not substantially different from the D1610/2000 scenario in normal and dry water supply conditions. During critical water supply conditions, flow levels in the upper and middle Russian River are generally similar or slightly higher than the D1610/2000 scenario from February through April, but substantially lower in May and June. This would reduce the suitability of conditions for the emigration of smolts late in the emigration season. In the lower Russian River above the Wohler inflatable dam, flows under D1610/2020 scenario in June are slightly higher than flows under D1610/2000 scenario. The reverse is true in May below Wohler inflatable dam. Thus, emigration conditions under the D1610/2020 scenario would improve in June, but would be worse in May when compared to the D1610/2000 scenario. Flows in Dry Creek would be very similar or slightly increased under both scenarios from February through April, and would be substantially increased in May and June. This would improve the suitability of conditions for emigrating coho, steelhead, and chinook.

Water temperatures for emigrating salmonids are good from February through April, but may become stressful during May and very stressful in June. Most coho salmon, steelhead, and chinook salmon migrate downstream before very stressful temperatures occur. Late migrants, particularly steelhead and chinook salmon, would encounter these stressful temperatures. DO concentrations are good to excellent for all species during the emigration season. The D1610/2020 scenario resulted in temperature and DO scores similar to those occurring under the D1610/2000 scenario.

ESTUARY HABITAT

The augmented flow in the Russian River estuary under the D1610/2000 scenario has several beneficial effects: it may maintain or improve water temperatures and DO levels; it helps dilute and flush nutrients and potentially toxic chemicals; and it may increase the amount of shallow water habitat available for salmonids and their food. The need to repeatedly breach the sandbar at the mouth of the estuary in the late summer and fall to prevent local flooding may reduce the value of the estuary for rearing. This frequent breaching causes continually changing habitat conditions (depth, salinity, temperature, and DO) in portions of the estuary. However, because the sandbar is open most of the summer, and because it does not generally remain closed for more than three to ten days at a time in the fall, the estuary tends to be open more than closed. The short duration of sandbar closures may limit the development of the poor water quality conditions that can be observed during the transition phase that occurs after the sandbar closes. The food organisms inhabiting the estuary can tolerate a wide range of salinity, temperature and DO concentrations and can likely tolerate the conditions following sandbar closure for a few days, although some stress would be expected. Nonetheless, the cyclic closure of the sandbar may reduce the suitability of the estuary for some food organisms and thus may also reduce its suitability for juvenile salmonids. However, salmonids are highly mobile and can move away from areas of poor water quality. They also may be able to shift to other food resources to offset this lost production. The extent to which they may successfully do this has not been documented.

The D1610/2020 scenario would reduce flows to the estuary by 20 to 30 percent from May through November. This would likely increase the period of closure of the sandbar. This may decrease the need to breach the sandbar as frequently; however, artificial breaching would still likely be necessary. The reduced flows under the D1610/2020 scenario will reduce the benefits associated with improved water temperature and DO levels, and dilution of nutrients as the estuary would not be flushed of these pollutants as frequently. This would tend to make water quality less suitable for salmonids and other estuarine organisms. The flow is unlikely to be reduced enough to allow a freshwater regime to become established in the estuary, however. Additionally, the increased duration of time that the sandbar-open photic zone community is at depths greater than light can penetrate the water column may reduce the productivity of this shallow water habitat. There would be insufficient time for areas at higher elevations to successfully establish themselves, and therefore there would likely be no additional shallow water communities in this area. The D1610/2020 scenario would therefore decrease the suitability of the estuary for salmonids relative to the D1610/2000 scenario.

STATEMENT OF EFFECTS

The analyses presented in this report show that the flow levels resulting from the operation of Coyote Valley Dam and Warm Springs Dam for flood control, water supply, and D1610 minimum flow releases provide a substantial amount of suitable habitat for all lifestages of protected salmonids. Many miles of habitat exist below each of these facilities where flow-related habitat, including spatial habitat, temperature and DO meet the needs for the completion of upstream passage, spawning and incubation, rearing, and emigration during normal water supply conditions, which exist 70 to 90 percent of the time, depending on month. In some areas of Dry Creek and the Russian River, summer flows under normal water supply conditions may exceed the preferred velocities for rearing coho and steelhead.

Under dry water supply conditions, which occur 9 to 13 percent of the time, habitat continues to support the spawning and incubation, rearing, and emigration lifestages. The upstream passage of all species remains good through the lower reach of the Russian River and Dry Creek. The upstream passage of adult coho and chinook salmon through the middle and upper reaches of the Russian River may be somewhat impaired. Steelhead also may experience some impairment in the upper reach. Adult salmonids may need to wait for pulses of flow associated with storm events to move upstream during some portions of the upstream migration period.

Under critical water supply conditions, which occur 1.5 to 6 percent of the time, habitat suitability for all lifestages of all species is reduced from those during dry and normal water supply conditions. Upstream passage is substantially impaired for all three species in all of the mainstem reaches, although passage up Dry Creek would remain available. The impairment in upstream passage in the mainstem, however, is not principally due to project operations. In critical water supply conditions during the migration season, Coyote Valley Dam releases more water than it receives from upstream sources except in 20 percent of the days. Therefore, only a small portion of the impaired passage condition can be attributed to the project. The lower flows in critical water supply conditions may also result in reduced area available for spawning and rearing, and may prolong emigration substantially.

Under the D1610/2020 scenario, conditions in normal and dry water supply conditions would be similar to those under the D1610/2000 scenario. Under future demands, habitat conditions during dry water supply conditions would be less favorable for salmonids than they are currently. Upstream passage would become further impaired, including passage on Dry Creek. Additionally, rearing habitat in May and June would become limited to isolated pools, and summer flows and water velocities on Dry Creek would increase substantially relative to the current demand during critical water supply condition.

Temperatures are generally suitable for all salmonid lifestages between November and April, but may begin to warm to stressful levels in May and very stressful levels in June. These very stressful temperatures persist in the mainstem, and stressful temperatures persist in lower Dry Creek, through the summer. These warm summer water temperatures are caused by the warm air temperatures of the interior valley and lack of riparian shading. Releases from both dams are made from their cool hypolimnetic water, the coolest water available for release. Thus, the warm water temperatures are not a project effect. These cool areas provide substantial amounts of suitable habitat for salmonids and are considered a beneficial effect of the project.

DO concentrations are suitable for all lifestages in all reaches. The only exception to this would be upper Dry Creek, where DO levels are sometimes stressful for chinook egg incubation during November. Temperature and DO conditions are similar to those that currently exist under the D1610/2020 scenario.

There are numerous factors that contribute to poor habitat conditions in the Russian River basin including high summer water temperatures, lack of channel structure and habitat complexity, agricultural and urban encroachment on the flood plains and riparian corridors, and the introduction of non-native species. These factors are not directly related to project operations. The following effects are directly related to flows from project operations, and are summarized in Table ES-1.

The habitat conditions that result from the flow releases from Coyote Valley and Warm Springs dams were evaluated. These evaluations found some impairment of upstream migration for all three species in the middle and upper Russian River during dry and critical water supply conditions under both demand scenarios. Under the D1610/2020 scenario critical water supply condition, the passage impairment becomes more severe and extends into the lower portion of Dry Creek, where it would affect chinook and coho salmon.

Table ES-1 Summary of Findings

Flows

Normal Water Supply Conditions

- Appears to be suitable for all species and lifestages in both Dry Creek and the upper and middle Russian River.
- Suitability of rearing habitat may be impaired by velocities that are higher than optimal in some areas.

Dry Water Supply Conditions

- Upstream passage is somewhat impaired for all species in the middle and upper Russian River.
- Habitat appears suitable for all other lifestages.
- Rearing habitat may be improved over normal water supply conditions by reduced velocities at these lower flows.

Critical Water Supply Conditions

- Habitat suitability is decreased for most species and lifestages.
- Passage is substantially impaired.
- Spawning and rearing is reduced in quantity and quality.
- Steelhead rearing habitat is reduced.
- Suitability of emigration flows is reduced.
- 2020 demand further reduces rearing habitat suitability for steelhead and coho.

Temperature

- Temperatures are generally suitable for salmonids from October through April.
- Temperatures become stressful in May in all reaches except upper Dry Creek.
- Temperatures during the summer months are at levels considered extremely stressful for steelhead.

Dissolved Oxygen

- Generally very good for all species and lifestages in all areas.
- May be stressful for chinook spawning and incubation in Upper Dry Creek mainly in November.

Estuary

2000 Demand

- Augmented flow may decrease nutrient loading to the estuary.
- Augmented flow creates the need to artificially breach the sandbar, which may reduce habitat value.

2020 Demand

- During critical water supply conditions, reduced habitat may occur from increased flow in some months and reduced flow in others.
- During critical and dry water supply conditions, passage is reduced in the early chinook migration period.

Synthesis - Existing conditions provide a substantial amount of habitat in the upper portion of Dry Creek and the upper Russian River.

Coho

- High water velocities may decrease habitat suitability for fry and juveniles in some areas.
- Upstream passage may be impaired a very small proportion of the time in critical and dry water supply conditions.

Steelhead

- High water velocities may decrease the suitability of rearing habitat in Dry Creek and upper Russian River.
- Very low flows may decrease steelhead and chinook rearing under critical water supply conditions and impair upstream migration.
- High summer water temperatures limit rearing in the mainstem; 2020 Demand will not reduce temperature.

Chinook

- High water velocities may decrease habitat suitability for fry and juveniles, but early emigration reduces the effect.
- Upstream passage may be impaired in a small proportion of the time in critical water supply conditions.

A second area of effect was the reduction of suitable spawning and incubation habitat under critical water supply conditions for both demand scenarios. This reduction was found in the upper and middle Russian River for chinook salmon and steelhead. Under the D1610/2020 scenario, spawning and incubation habitat for coho and chinook salmon in Dry Creek would also be reduced under critical water supply conditions.

Summer flow levels for both demand scenarios result in velocities that are higher than optimal for juvenile salmonids. High velocities may affect steelhead in some portions of both Dry Creek and the Russian River and coho salmon in some portions of Dry Creek.

CONCLUSION

The results of this analysis are considered preliminary until the results of the flow-habitat relationship study can be incorporated. The results of the water temperature and DO analysis are complete, but need to be integrated with the final flow effects before a final statement of project effects can be made. The conclusions resulting from these analyses will be included in the Draft BA.

The flows resulting from the operation of Coyote Valley and Warm Springs dams are likely to adversely affect coho salmon, steelhead and chinook salmon. Although the operations of the project under the current demand scenario have may have adverse effects on critical habitat, these changes in habitat seem unlikely to diminish the capability of the habitat to the extent that they fail to satisfy the essential requirements of the three species. Thus, it is concluded that current project operations do not adversely modify the critical habitat of coho salmon, steelhead, or chinook salmon. Under the D1610/2020 scenario, the increased flows in Dry Creek in dry and critical water supply conditions would result in conditions that would likely substantially decrease summer habitat for steelhead and coho. This may make the good habitat that currently exists in Dry Creek unusable. The loss of this important rearing habitat would likely have a pronounced effect on the population levels of all three species within the basin. Therefore, it is concluded that the D1610/2020 scenario would adversely modify the critical habitat of all three species.

1.1 SECTION 7 CONSULTATION

The Sonoma County Water Agency (SCWA), the U.S. Army Corps of Engineers (USACE), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) are undertaking a Section 7 Consultation under the Federal Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) to evaluate affects of operations and maintenance activities on listed species and their critical habitats. The activities of the USACE, SCWA, and MCRRFCD span the Russian River watershed from Coyote Valley Dam and Warm Springs Dam to the estuary, as well as some tributaries. The Russian River watershed is designated as critical habitat for threatened stocks of coho salmon, steelhead, and chinook salmon. SCWA, USACE, and MCRRFCD operate and maintain facilities and conduct activities related to flood control, channel maintenance, water diversion and storage, hydroelectric power generation, and fish production and passage. SCWA, USACE, and MCRRFCD are also participants in a number of institutional agreements related to the fulfillment of their respective responsibilities.

Federal agencies such as the USACE are required under the ESA to consult with the Secretary of Commerce to insure that their actions are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat. The USACE, SCWA, and NMFS have entered into a Memorandum of Understanding (MOU) that establishes a framework for the consultation and conference required by the ESA with respect to the activities of the USACE, SCWA and MCRRFCD that may directly or indirectly affect coho salmon, steelhead and chinook salmon in the Russian River. The MOU acknowledges the involvement of other agencies including the California Department of Fish and Game (CDFG), the U.S. Fish and Wildlife Service (USFWS), the State Water Resources Control Board (SWRCB), the North Coast Regional Water Quality Control Board (RWQCB), the State Coastal Conservancy, and the Mendocino County Inland Water and Power Commission (MCIWPC).

1.2 SCOPE OF THE BIOLOGICAL ASSESSMENT

As part of the Section 7 Consultation, the USACE and SCWA will submit to NMFS a biological assessment (BA) that provides a description of the actions subject to consultation, including the facilities, operations, maintenance and existing conservation actions. The BA will describe existing conditions, including information on hydrology, water quality, habitat conditions, and fish populations. The BA will provide the basis for NMFS to prepare a biological opinion (BO) that will evaluate the project, including conservation actions.

This document presents an analysis of the potential for adverse affects to the Russian River populations of coho salmon, steelhead, and chinook salmon as a result of certain activities. Because the ESA prohibits take of any individuals, the document will come to a conclusion of "likely to adversely affect" if any individual fish could be harmed by the proposed action, even if the overall risk of an adverse effect to the overall population is low. Such a conclusion will mean that one or more listed fish might be harmed by the proposed action. Once a BA containing this determination is submitted to NMFS, formal consultation under the ESA will be initiated. During the formal consultation process, NMFS will make an assessment of whether the proposed action is likely to jeopardize the continued existence of the species, and make a determination if critical habitat is adversely modified or destroyed. NMFS will present this conclusion in the form of a BO.

The BA will integrate a number of Interim Reports:

Report 1	Flood Control Operations
Report 2	Fish Facility Operations
Report 3	Flow-Related Habitat
Report 4	Water Supply and Diversion Facilities
Report 5	Channel Maintenance
Report 6	Restoration and Conservation Actions
Report 7	Hydroelectric Projects Operations
Report 8	Estuary Management Plan

This report, *Interim Report 3: Flow-Related Habitat* evaluates the effects of flow releases on listed fish species and their designated critical habitat in the Russian River. These releases include minimum instream flow requirements under Decision 1610 (D1610), water supply operations, flood control operations, and hydroelectric operations. The activities evaluated include:

- Releases from Warm Springs Dam
- Releases from Coyote Valley Dam

USACE and SCWA collected further information to quantify the effect of flow-related activities on coho salmon, steelhead, and chinook salmon during 2001 (USACE letter to NMFS, May 15, 2001). The additional information was collected in a cooperative effort with NMFS and CDFG. The results of this study, *The Russian River Flow-Assessment Study*, will be incorporated in the analysis of flow-related effects and presented in the Draft BA.

1.3 STATUS OF COHO SALMON, STEELHEAD, AND CHINOOK SALMON IN THE RUSSIAN RIVER

Biological resources of primary concern within the project area are coho salmon, steelhead and chinook salmon. These species are each listed as threatened under the ESA. The pertinent Federal Register notices for these species are provided in Table 1-1. Coho salmon and steelhead are native Russian River species, although there have been many plantings from other river systems (CDFG 1991). It is uncertain whether chinook salmon is a native species of the Russian River (NMFS 1999). They have been stocked in the past, but were not stocked since 1998, and continue to reproduce in the watershed. The Central California Coast Coho Salmon Evolutionarily Significant Unit (ESU), which contains the Russian River, extends from Punta Gorda in Northern California south to and including the San Lorenzo River in Central California, and includes tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River system. The Russian River is the largest drainage in the Central California Coast Steelhead ESU, which extends from the Russian River down the coast to Soquel Creek near Santa Cruz, California. The chinook salmon listing defined the population unit that contains the Russian River as the California Coastal ESU. This ESU encompasses the region from Redwood Creek in Humboldt County to the Russian River (Sonoma County).

Critical habitat for each of these species within the Russian River is designated as the current estuarine and freshwater range of the species including "all waterways, substrate, and adjacent riparian zones…". For each species, NMFS has specifically excluded areas above Warm Springs and Coyote Valley dams and within tribal lands.

Table 1-1 Federal Register Notices for the Salmonids of the Russian River

Species	Listing	Take Prohibitions	Critical Habitat
Coho Salmon	Vol. 61, No. 212, pp. 56138-56147 Oct. 31, 1996	Vol. 67, No. 6, Pgs. 1116-1133 January 9, 2002	Vol. 64, No. 86, pp. 24049-24062 May 5, 1999
Steelhead	Vol. 62, No. 159, pp. 43937-43954 Aug. 18, 1997	Vol. 65, No. 132, pp. 42422-42481 July 10, 2000	Vol. 65, No. 32, pp. 7764-7787 February 16, 2000
Chinook Salmon	Vol. 64, No. 179, pp. 50394-50415 Sept. 16, 1999	Vol. 67, No. 6, Pgs. 1116-1133 January 9, 2002	Vol. 65, No. 32, pp. 7764-7787 February 16, 2000

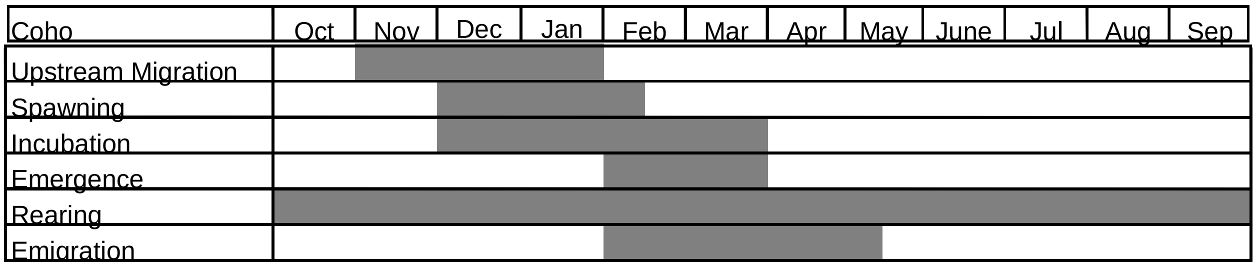
Life history descriptions for these species are provided in Section 1.3.1 through 1.3.3 so that effects from project operations can be evaluated. All three species are anadromous, but steelhead can also exhibit a life history type that spends its entire life cycle in freshwater. These species migrate upstream from the ocean as adults and spawn in gravel substrate. Their eggs incubate for a short period, depending on water temperature, and generally hatch in the winter and spring. Juveniles spend varying amounts of time rearing in the streams and then migrate out to the ocean, completing the cycle. Details on life history, timing, and habitat requirements are provided for each species.

1.3.1 Coho Salmon

Coho salmon are much less abundant than steelhead in the Russian River basin. Spawning occurs in approximately 20 tributaries of the lower Russian River, including Dry Creek. In wet years, coho salmon have been seen as far upstream as Ukiah. The Don Clausen Fish Hatchery (DCFH) on Dry Creek produced and released an average of about 70,000 age 1+ coho salmon each year (1980 to 1998). However, no coho have been produced in the last two years.

1.3.1.1 Life History

The coho salmon life history is quite rigid, with a relatively fixed three-year life cycle. The best available information suggests that life history stages occur during times outlined in Figure 1-1 (EIP Assoc. 1993, SCWA 1996, SWRCB 1997, RMI [Resource Management International, Inc.] 1997, pers. comm. S. White 1999). Most coho enter the Russian River in November and December and spawn in December and January. Spawning and rearing occur in tributaries to the lower Russian River. The most upstream tributaries with coho salmon populations include



(EIP Assoc. 1993, SCWA 1996a, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999-2001).

Figure 1-1 Phenology of Coho Salmon

Forsythe, Mariposa, Rocky, Fisher, and Corral creeks. The mainstem below Cloverdale serves primarily as a passage corridor between the ocean and the tributary habitat.

After hatching, young coho spend about one year in freshwater before they become smolts and migrate to the ocean. Freshwater habitat requirements for coho rearing include adequate cover, food supply, and water temperatures. Primary habitat for coho includes pools with extensive cover. Outmigration takes place in late winter and spring. Coho salmon live in the ocean for about a year and a half, return as three-year-olds to spawn, and then die. The factors most limiting to juvenile coho production may include high summer water temperatures, poor summer and winter habitat quality, and predation (SCWA 2000).

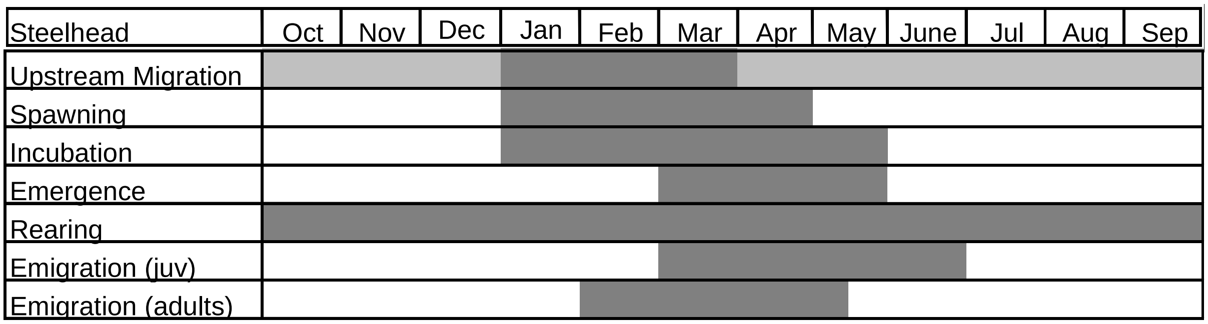
1.3.2 Steelhead

There have been no recent efforts to quantify steelhead populations in the Russian River, but there is general agreement that the population has declined in the last 30 years (CDFG 1984, 1991a). SCWA, CDFG and NMFS are currently developing programs to monitor trends in salmonid populations within the designated critical habitat boundaries for the basin. There has been substantial planting of hatchery reared steelhead within the basin, which may have affected the genetic constitution of the remaining natural population. Almost all steelhead planted prior to 1980 were from out-of-basin stocks (Steiner 1996). Since 1982, stocking of hatchery reared steelhead has been limited to progeny of fish returning to the DCFH and the Coyote Valley Fish Facility.

Steelhead occupy all of the major tributaries and most of the smaller ones in the Russian River watershed. Many of the minor tributaries may provide spawning or rearing habitat under specific hydrologic conditions. Steelhead use the lower and middle mainstem Russian River primarily for migration to and from spawning and nursery areas in the tributaries and the mainstem above Cloverdale. The majority of spawning and rearing habitat for steelhead occurs in the tributaries. Some juvenile rearing may occur in the mainstem before smolt outmigration.

1.3.2.1 Life History

Adult steelhead generally begin returning to the Russian River in November or December, with the first heavy rains of the season, and continue to migrate upstream into March or April. Adults



Note: Peak upstream migration occurs January through March, but adults have been observed in all months. (EIP Assoc. 1993, SCWA 1996a, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999-2001).

Figure 1-2 Phenology of Steelhead in the Russian River Basin

have been observed in the Russian River during all months (pers. comm. S. White SCWA 1999). However, the peak migration period tends to be January through March (Figure 1-2).

Flow conditions are suitable for upstream migration in most of the Russian River and larger tributaries during the majority of the spawning period in most years. Sandbars blocking the river mouth in some years may delay entry into the river. However, when the sand barrier is closed, the flow is probably too low and water temperature is too high to provide suitable conditions for migrating adults farther up the river (CDFG 1991a).

Most spawning takes place from January through April, depending on the time of freshwater entry (Figure 1-2). Steelhead spawn and rear in tributaries from Jenner Creek near the mouth, to upper basin streams including Forsythe, Mariposa, Rocky, Fisher and Corral creeks. Steelhead usually spawn in the tributaries, where fish ascend as high as flows allow (USACE 1982). Gravel and streamflow conditions suitable for spawning are prevalent in the Russian River mainstem and tributaries (Winzler and Kelly Consulting Engineers [Winzler and Kelly] 1978), although gravel mining and sedimentation have diminished gravel quality and quantity in many areas of the mainstem. In some years, in the lower and middle mainstem (below Cloverdale) and the lower reaches of tributaries, water temperatures exceed 55°F by April (Winzler and Kelly 1978), which may limit the survival of eggs and fry in these areas.

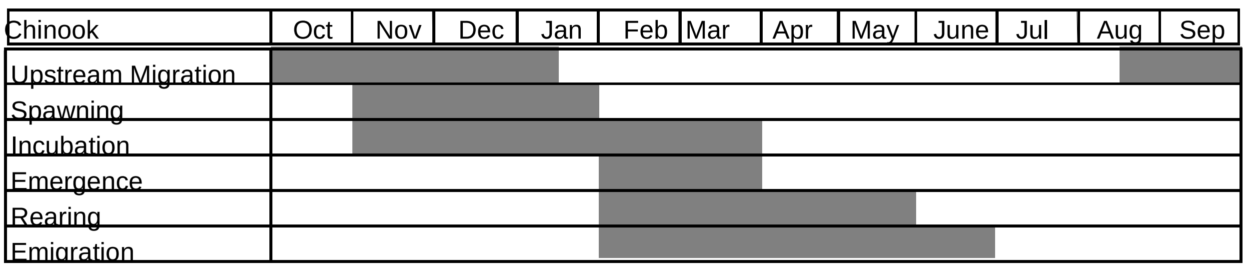
After hatching, steelhead spend one to four years in freshwater. Fry and juvenile steelhead are extremely adaptable in their habitat selection. Requirements for steelhead rearing include adequate cover, food supply, and water temperatures. The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable habitat; generally these areas have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing. The lower sections of the tributaries provide less cover; the streams are often wide and shallow and have little riparian vegetation, and water temperatures are often too warm to support steelhead. In the summer, these areas can completely dry up. Available cover has been reduced in much of the mainstem and in many tributaries due to loss of riparian vegetation and changes in stream morphology.

Emigration usually occurs between February and June, depending on flow and water temperatures (Figure 1-2). Sufficient flow is required to cue smolts downstream migration. Excessively high water temperatures in late spring may inhibit smoltification in late migrants.

1.3.3 Chinook Salmon

The historic extent of naturally occurring chinook salmon in the Russian River is debated (NMFS 1999). Whether or not chinook were present historically, the total run of chinook salmon today, hatchery and natural combined, is small. Historic spawning distribution is unknown, but suitable habitat formerly existed in the upper mainstem and in low gradient tributaries. Chinook currently spawn in the mainstem and larger tributaries, including Dry Creek. Chinook tissue samples were collected in 2000 by SCWA, CDFG, and NMFS from the mainstem, Forsythe, Feliz and Dry creeks, and there were anecdotal reports of chinook in the Big Sulphur system.

1.3.3.1 Life History



(EIP Assoc. 1993, SCWA 1996a, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999-2001).

Figure 1-3 Phenology of Chinook Salmon in the Russian River Basin

Adult chinook salmon begin returning to the Russian River as early as August, but the bulk of upstream migration occurs from late October through mid-December (White 2000, White 2001). Most spawning occurs after Thanksgiving. Chinook may continue to enter the river and spawn into the month of January (Figure 1-3) (pers. comm. S. White SCWA 1999).

Unlike steelhead and coho, the young chinook begin their outmigration soon after emerging from the gravel. Freshwater residence, including outmigration, usually ranges from two to four months, but occasionally chinook juveniles will spend one year in fresh water. From February through June, chinook move downstream (Figure 1-3). Ocean residence can be from one to seven years, but most chinook return to the Russian River as two to four-year-old adults. Like coho salmon, chinook die soon after spawning.

1.4 Existing Environment

The Russian River watershed drains approximately 1,485 square miles of northwestern California, including much of Sonoma and Mendocino Counties (SCWA 1999a) (Figure 1-4) lying between the coastal mountain range on the west and the Mayacmas Mountains on the east.

Approximately 85 percent of the basin is hilly or mountainous terrain, with the remaining 15 percent composed of alluvial valleys. The Russian River flows southward from its headwaters

FIGURE 1-4
MAP OF THE RUSSIAN RIVER WATERSHED AND LOCATION OF REACH BOUNDARIES

about 16 miles north of Ukiah through the Redwood, Ukiah, Hopland, Alexander, and Healdsburg Valleys, and across the northwestern part of the Santa Rosa Plain, a distance of 90 miles. At Mirabel Park, the river turns west and flows through a narrow canyon in the coastal range for about 22 miles before entering the Pacific Ocean at Jenner. The mainstem Russian River is formed at the junction of the mainstem of the Russian River (also known as the West Fork) and East Fork Russian River, at an area commonly known as the Forks, about two miles north of the city of Ukiah. The mainstem of the Russian River is uncontrolled and drains an area of 100 square miles to the north and northwest of the Forks. The East Fork Russian River drains an area of 105 square miles to the northeast of the Forks, but is controlled by Coyote Valley Dam and Lake Mendocino less than one mile above the Forks. The East Fork Russian River also receives substantial inflow from an inter-basin transfer of water from the Eel River through the Potter Valley Project (PVP). Major tributaries of the Russian River downstream of the Forks include Big Sulphur Creek, Maacama Creek, Dry Creek, and Mark West Creek.

In the Ukiah Valley, the Russian River flows in a relatively straight channel lined with dense riparian vegetation. A combination of factors, including instream gravel mining, channel straightening, flood control activities and releases from Lake Mendocino on the East Fork, have caused up to 16 feet of channel bed degradation from the mid-1960s to the mid-1980s at the City of Ukiah (EIP 1993).

Downstream of the Ukiah Valley, the Russian River flows through entrenched reaches between Hopland and Cloverdale. The river then enters the 20-mile long alluvial Alexander Valley. Here the river flows through a wide, shallow, sinuously braided channel that migrates laterally, causing banks to erode (EIP 1993). Gravel extraction occurs in the channel and vineyard development has been taking place on the floodplain. Both degradation and aggradation have been measured at river cross-sections in the valley during the past two decades (EIP 1993).

The river exits the Alexander Valley through the steeper Digger Bend section, where the river makes an abrupt turn to the west and then resumes its southerly course at Healdsburg. About one mile south of Healdsburg, Dry Creek flows into the Russian River.

Dry Creek is one of the major tributaries to the Russian River. Warm Springs Dam and Lake Sonoma are located approximately 14 miles upstream of the mouth. About 130 square miles of watershed lie above these facilities, which block the upstream migration of anadromous species to historic spawning and rearing areas above the dam. The DCFH was constructed in 1980 at the base of Warm Springs Dam to mitigate for the lost salmon and steelhead production. It was also intended to enhance the production of coho salmon and Chinook salmon, as well as to mitigate for the loss of steelhead spawning and rearing habitat upstream of Coyote Valley Dam. The potential effects of DCFH on native stocks of anadromous salmonids is discussed in *Interim Report 2: Fish Facility Operations*. Flows in Dry Creek are substantially altered by the operation of the dam.

Coho, steelhead and chinook all utilize the Dry Creek watershed. Steelhead and chinook use the mainstem of Dry Creek, and steelhead use many of its tributaries as well. Coho salmon also presumably use the mainstem of Dry Creek and some of its tributaries, however CDFG surveys during the last two spawning seasons found no adult coho carcasses in Dry Creek (B. Coey April 2001). Survey efforts in 1993 revealed the presence of coho salmon in Mill and Felta creeks, which are tributaries of Dry Creek.

CDFG habitat surveys in the tributaries of Mill, Felta, Palmer, and Angel creeks indicate that the Dry Creek system is moderately to highly incised, depending on the distance from the Russian River. This incision is thought to be the result of mining-induced incision of the Russian River channel, as well as mining in Dry Creek itself. These historic gravel-mining operations have resulted in severe erosion, degradation, and channel widening on Dry Creek, which along with the construction and operation of Warm Springs Dam have required various channel improvements. Effects of SCWA channel maintenance activities in Dry Creek and the Russian River related to obligations to the USACE, are evaluated in *Interim Report 5: Channel Maintenance*.

From Dry Creek, the Russian River, which contains a substantial flow contribution from Dry Creek, continues its southerly course for approximately 8 to 10 miles to Mirabel Park. This reach is incised and straightened as the result of historic gravel mining operations. SCWA operates diversion and infiltration facilities near Wohler Bridge. These facilities divert an amount approximately equivalent to the flow releases from the Dry Creek system during the summer months.

Below Mirabel Park, the Russian River flows westerly through a narrow valley bounded by mountains. The channel is straight and deep, with a low floodplain in the town of Guerneville on the north side of the river. On average, Guerneville is subject to flooding once every five years (EIP 1993). Gravel and sandbars are common along the channel. Below Guerneville, the Russian River flows into its estuary near the confluence with Big Austin and Willow creeks.

The estuary extends approximately six to seven miles to the river's mouth near Jenner. Tidal influence may be observed as far as ten miles upstream to Monte Rio (Russian River Estuary Interagency Task Force [RREITF] 1994). Willow Creek Marsh occasionally receives saltwater intrusions and is considered a vital part of the estuarine system. Under the current hydrologic regime, the Russian River estuary appears to have stable channel morphology (RREITF 1994).

1.4.1 HYDROLOGY

The Russian River watershed is divided into a fog-influenced coastal region and an interior region with hot, dry summers typical of a Mediterranean climate. The basin-wide mean annual precipitation is 41 inches, with a range of 22 to 80 inches (USACE 1982). The greatest precipitation occurs at high elevations near Mount St. Helena and in coastal mountains near Cazadero, while the lowest precipitation occurs in the southern Santa Rosa Plain (USACE 1982). Approximately 93 percent of the annual runoff occurs from November to April (USACE 1986) as a result of Pacific frontal storms. Runoff during the months of June to October is negligible.

The pre-development (*i.e.*, pre-1908) runoff regime had episodic flows; high winter flows reflected the intensity and duration of storms, and low summer flows ranging between 0 and 20 cubic feet per second (cfs) were sustained by groundwater (Steiner Environmental Consulting [Steiner] 1996). Water development in the Russian River basin modified the natural hydrologic regime, decreasing the magnitude and prolonging the duration of winter storm events and substantially increasing flows during the summer months.

The Russian River continues to have highly variable flows. Under current conditions, flows during the winter are typically much higher than the summer flows. About 80 percent of the annual discharge occurs during winter (Jones & Stokes Associates [Jones & Stokes] 1972), and the basin has been subjected to many damaging floods. The Russian River watershed responds rapidly to variations in rainfall that often result in flash floods. On February 17, 1986, peak flows were 32,900 cfs at Hopland, 71,100 cfs at Healdsburg, and 102,000 cfs at Guerneville. Peak flood flow on Dry Creek prior to regulation by Warm Springs Dam was 32,400 cfs on January 31, 1963, and after regulation, the peak flow was 7,600 cfs on January 8, 1995 (U.S. Geological Survey [USGS] gage data).

Streamflow in the East Fork Russian River and the mainstem located downstream of the Forks during the summer months is substantially augmented by water imported from the Eel River by the PVP (Steiner 1996) and from Lake Mendocino. Flows in Dry Creek and in the Russian River between Dry Creek and Mirabel Park are augmented in the summer and decreased in the winter by the operation of Lake Sonoma.

Streamflow and stage data are currently monitored by the USGS at 17 gages along the Russian River and various tributaries; stage data are collected at 5 additional gages. Historically, the USGS collected streamflow data at an additional 16 gages. USGS also has collected sediment data at 8 sites and water quality data at 5 sites. Table 1-2 shows the average annual discharge at selected locations. Flow increases substantially with distance downstream. Streamflow on the East Fork Russian River near Ukiah represents approximately 50 percent of the average annual flow expected at Hopland, 25 percent of the average annual flow seen at Healdsburg, and 15 percent of the average annual flow seen at Guerneville.

Table 1-2 Average Annual Discharge

Site	Drainage Area (mi^2)	Period of Record	Avg. Ann. Discharge (cfs)
East Fork RR near Ukiah	105	1952-1999	336
RR near Hopland	362	1940-1999	715
RR near Healdsburg	793	1940-1999	1,444
RR near Guerneville	1,338	1940-1999	2,320
Dry Creek near Geyserville	162	1960-1983	354
Dry Creek near Geyserville	162	1983-1999	299 [a]

Source: USGS gage data (as of 10-2001)
(a) 1983-1990 is the period with operation of Warm Springs Dam on Dry Creek

Three major reservoirs provide water supply storage for the Russian River watershed: Lake Pillsbury on the Eel River, Lake Mendocino, and Lake Sonoma. Scott Dam impounds Eel River water and forms Lake Pillsbury. Coyote Valley Dam impounds Lake Mendocino, and is located on the East Fork Russian River about 0.8 miles upstream of its confluence with the Russian River. Warm Springs Dam impounds Lake Sonoma, and is located at the confluence of Warm

Springs Creek and Dry Creek, approximately 14 miles northwest of Healdsburg in Sonoma County. Each reservoir and its effect on flows are described in the following subsections.

1.4.1.1 Potter Valley Project

The PVP is comprised of Scott Dam and Lake Pillsbury, Cape Horn Dam, a diversion tunnel from the Eel River to the Russian River, and the Potter Valley Hydroelectric Project. Constructed in 1908, PVP diversions from the Eel River have been used to generate power, irrigate agricultural land in Potter Valley, and augment summer flows in the Russian River. Pacific Gas & Electric (PG&E) purchased the PVP in September of 1929. The quantity of water that can be diverted to PG&E's Potter Valley Power Plant is affected by the releases required to maintain the fishery in the Eel River and an agreement with the U.S. Forest Service to maintain high reservoir levels in Lake Pillsbury until Labor Day of each year for recreational use. The PVP has a maximum capacity of 350 cfs. From 1922 to 1992, diversions from Lake Pillsbury to the East Fork Russian River watershed have averaged 159,000 AF/year.

Lake Pillsbury and the PVP are being addressed in a separate Section 7 Consultation between NMFS and the Federal Energy Regulatory Commission (FERC) (NMFS 2000). Changes to the release criteria and minimum flow provisions in the 1983 FERC permit for the PVP have been proposed and are the subject of an Environmental Impact Statement (EIS) issued in May 2000 by FERC. If implemented, the proposed action would reduce the quantity of water diverted to the Russian River basin via the PVP.

The PVP diversion significantly altered the natural streamflow in the Russian River (SCWA 1999a). Releases from Coyote Valley Dam maintain flow in the East Fork Russian River during the summer months when the river would otherwise be dry, or nearly dry. Between construction of Scott Dam in 1922 and construction of Coyote Valley Dam in 1959, Eel River water stored in Lake Pillsbury and diverted to the East Fork Russian River helped provide significant base flows throughout the year. Presently, operation of the PVP is not coordinated with the operation of Coyote Valley Dam and is not subject to SCWA or USACE control.

1.4.1.2 Lake Mendocino

Lake Mendocino is a multipurpose reservoir that provides flood protection to areas below Coyote Valley Dam and supplies water for domestic, industrial and agricultural uses. Coyote Valley Dam began storing water in 1959. Lake Mendocino has a 122,400 acre-foot capacity, and regulates flood runoff from a 105 square mile basin.

Winter operations primarily include water storage until the dedicated flood storage space is reached and releases are made for flood control. The flood control pool is large enough to store all of the runoff of the East Fork Russian River during the 50-year flood at Guerneville (USACE 1986). The greatest monthly reductions in lake level occur during late spring and early summer. When the water level rises above the top of the water supply pool and into the flood control pool, USACE determines releases. When possible, releases from Coyote Valley Dam are controlled so that flow at Hopland, about 14 miles downstream, does not exceed the 8,000 cfs channel capacity (this is sometimes not possible when inflow to the lake is very high). USACE also determines releases during inspections and for maintenance and repair of the project.

The water release schedule of Coyote Valley Dam is designed to supply an adequate flow of water to the Russian River during the dry summer months to satisfy instream flow requirements, meet water user needs, and produce power. Releases from the Coyote Valley Dam water supply pool are determined by SCWA.

A hydroelectric power generation facility owned by the City of Ukiah is located at the dam. However, this facility does not control any water releases. The hydroelectric facility is not currently operated due to minor damage to a diverter wall that controls flows to power plant turbines. The City of Ukiah is in the process of scheduling the needed repairs.

The operation of Coyote Valley Dam has altered year-round mainstem flow patterns. Dam operations lessened discharge peaks, prolonged winter high flows, and increased summer flows above Healdsburg up to 200 cfs. The new flow regime changed channel morphology basin-wide (Steiner 1996). During the rainy season (November through May), natural streamflow (rather than reservoir releases) accounts for most of the flow of the Russian River. Coyote Valley Dam has only a slight effect on winter flood flows at Healdsburg because it controls only approximately 13 percent of the watershed (EIP 1993). A study by the USACE in 1986 evaluated the effect of Coyote Valley Dam on the flood of 1964. The results indicated that operation of the dam reduced the flood peak by 29 percent at Hopland, 14 miles downstream; 21 percent at Cloverdale, 30 miles downstream; 11 percent at Healdsburg, 58 miles downstream; and 7 percent at Guerneville, 74 miles downstream.

From June through September, the natural flow in the Russian River downstream of Coyote Valley Dam and above Dry Creek is augmented by water that is imported from the Eel River via the PVP and stored in Lake Mendocino. Releases from Lake Mendocino are made from a port located at the bottom of the reservoir, 128 feet below the dam spillway crest.

1.4.1.3 Lake Sonoma

Lake Sonoma is a multipurpose reservoir operated for flood control, water conservation, and recreation. Warm Springs Dam was constructed by the USACE in 1983 and became operational in 1984. Lake Sonoma has a 130,000 AF flood control storage capacity, which is sufficient to capture runoff from the 100-year, 6-day flood event. During the winter months, Warm Springs Dam operates to maximize reductions in peak flood discharges on Dry Creek and the Russian River below Healdsburg. Flood control releases from Warm Springs Dam are controlled, when possible, so that flow at Guerneville, about 25 miles downstream, does not exceed the channel capacity of 35,000 cfs. Excess storm runoff is captured in the conservation pool during the rainy season, which normally begins in November and lasts through April.

The conservation (water supply) pool, which has a 245,000 AF capacity, begins to rise fairly rapidly after the winter rains begin, and normally reaches the full pool stage between January and March, until about May, when outflow begins to exceed inflow. From July through September there is little to no inflow, and the reservoir normally reaches its lowest level in November. Average annual discharge on Dry Creek since construction of Warm Springs Dam (period 1983 to 1999) is about 80 percent of the unregulated (period 1939 to 1983) average annual flow condition (Table 1-2).

During the summer months, water released from Lake Sonoma is used to meet municipal and incidental agricultural water supply demands in the lower Russian River area, as well as in southern Sonoma and northern Marin counties (USACE 1998). These releases must also meet minimum instream flow requirements. To meet these needs, water released from Lake Sonoma commingles with releases from Coyote Valley Dam at the mouth of Dry Creek.

As is typical in Northern California reservoirs, water stored in Lake Sonoma becomes isothermal (thermally unstratified) in the winter months and strongly stratified in the low inflow summer months. Multiple-level outlets in Warm Springs Dam are used to control the water temperature and turbidity of downstream releases. The selection of water intake levels from Warm Springs Dam is determined by USACE in coordination with CDFG to meet the water quality needs of the DCFH located at the base of the dam. This controls the water quality of releases to Dry Creek as well. USACE data for outlet temperatures for Warm Springs Dam from January through November of 1999 demonstrate that the ability to draw cooler water from deeper, cooler depths of Lake Sonoma can keep the release water temperatures cooler during summer months, improving conditions for coldwater species.

As with Lake Mendocino, SCWA determines the rate of water release from the water supply pool in Lake Sonoma, and USACE determines releases from the flood control pool. USACE, in consultation with SCWA, SWRCB, NMFS and other regulatory agencies, determines releases during inspections, maintenance, and repairs for the project.

1.4.1.4 Wohler and Mirabel Diversion Facilities

SCWA's diversion facilities along the Russian River are located in the Wohler and Mirabel areas, on SCWA property. Water from Lake Sonoma storage is released into Dry Creek for re-diversion by the SCWA water supply system. Generally, this occurs when flows are normally low and water demand is high (summer). SCWA is currently authorized to divert and re-divert a total of 92 million gallons per day (mgd) and 75,000 acre-feet per year (AFY) from the Russian River, at a maximum rate of 180 cfs. Peak demand on the water transmission system usually occurs in July, and reached a maximum average monthly demand of approximately 81 mgd in July 1999.

Water is impounded behind the 11-foot tall Mirabel inflatable dam from late spring through the onset of winter rains, to divert water to SCWA's water supply facilities and increase aquifer infiltration rates. SCWA operates five Ranney collector wells and six infiltration ponds. SCWA diverts water directly from the Russian River above the Mirabel Dam to fill the infiltration ponds. Water is extracted by the Ranney collectors from the aquifer beneath the streambed. During a portion of the year (generally during the low-flow season), surface water is diverted into infiltration ponds at Mirabel and Wohler to increase water production. Diversion rates to the infiltration ponds are based on demands on SCWA's water supply and transmission system and on the ability to operate the inflatable dam.

Expansion of the existing water transmission system was approved by SCWA's Board of Directors in December 1998, with the Water Supply and Transmission System Project (WSTSP). The WSTSP's objective is to provide a safe, economical, and reliable water supply to meet future needs in the SCWA service area. There are several purposes of the proposed WSTSP.

These are: 1) to implement water conservation measures that would result in the savings of approximately 6,600 AFY, and expand the water education program, 2) to increase the amount of water diverted from the Russian River (a combination of re-diversion of stored water and direct diversion of winter flow) by 26,000 AFY, thereby increasing the total amount of diversion from 75,000 AFY to approximately 101,000 AFY, and 3) to increase the transmission system capacity by 57 mgd, thereby increasing the total capacity of the transmission system from 92 mgd to 149 mgd. Water supply operations would still maintain compliance with minimum instream flows specified in SWRCB D1610.

The effects from operation of these diversion facilities not associated with flow levels are assessed in *Interim Report 4: Water Supply and Diversion Facilities.* The flow-related effects of these operations are incorporated into this document.

1.4.2 Russian River Estuary

The operation of the project affects the estuary primarily in the summer months when it augments the flow into the estuary. The Russian River estuary may provide valuable rearing habitat for juvenile salmonids. Estuaries have been found to be important salmonid habitat in other coastal systems in California and elsewhere (Smith 1990). In the Russian River this may be especially true because the coastal fog belt moderates high water temperatures in the summer. Preliminary data from the Mirabel sampling program indicate that naturally spawned juvenile chinook salmon migrate down the Russian River in the spring (SCWA 2000). These fish may rear for a time in some part of the estuary. The tributaries in the lower Russian River contain high quality steelhead spawning and rearing habitat. Steelhead rear in freshwater throughout the year and may make use of suitable portions of the estuary. However, the larger size and morphology of the Russian River indicate it may function somewhat differently from the smaller estuaries studied elsewhere.

California estuaries can function in either a sandbar-open or a sandbar-closed configuration. When estuaries are open, good water quality is maintained by tidal mixing or high river flows. When estuaries are closed, good water quality develops when the system is converted to freshwater, and saline water is forced out of the system. The intermediate state, just after thesandbaropens or is closed, provides a situation of rapid transition, when habitat and water quality changes dramatically. This transition period creates tremendous environmental challenges for organisms within at least some portions of the estuary. After these transition periods, the flora and fauna of the estuary undergo dramatic changes in response to the changed environment.

Project operations affect the estuary primarily in the summer months when flows are augmented. Augmented summer flows have the potential to affect several components of salmonid rearing habitat in the estuary. These include water quality (including temperature, DO and salinity), primary productivity and the availability of aquatic invertebrates, availability of shallow water habitat, and the concentration of nutrients and toxic runoff. An effect associated with augmented flows is the need to artificially breach the sandbar periodically to prevent flooding of local properties. The potential effects of this breaching on habitat were discussed in *Report 8: Estuary Management Plan*.

1.5 PROJECT DESCRIPTION

1.5.1 REGULATION OF FLOWS IN RUSSIAN RIVER AND DRY CREEK UNDER SWRCB D1610 – LOW-FLOW CONDITIONS

Lake Sonoma and Lake Mendocino operate in accordance with criteria established in 1986 by the SWRCB D1610 (SWRCB 1986). D1610 adopted, with one minor change, the criteria included in an agreement between CDFG and SCWA that established flow requirements for Dry Creek and the Russian River (SCWA and CDFG 1985).

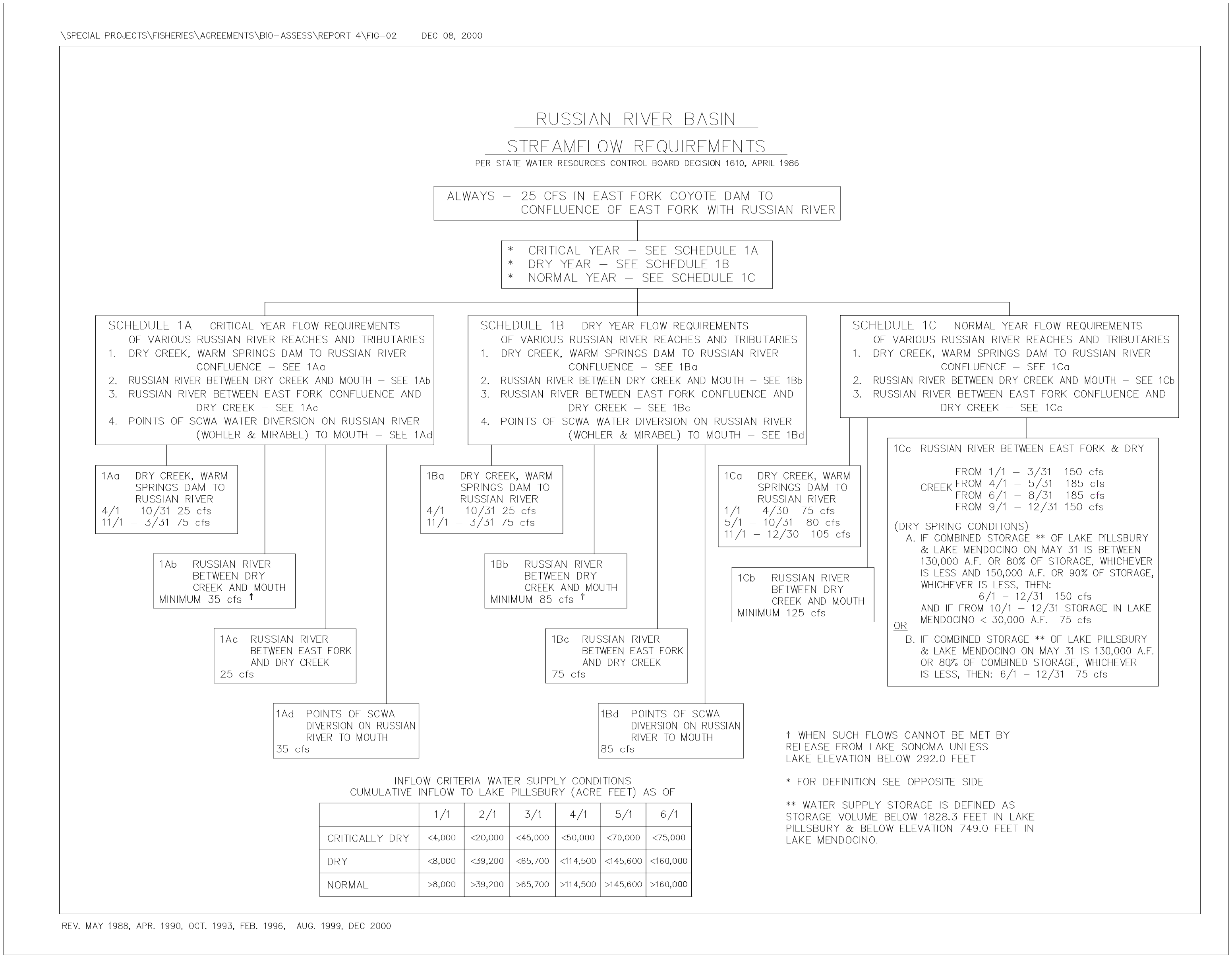
For the purpose of managing water supply releases from Lake Mendocino and Lake Sonoma, the river can be divided into two sections that operate independently of each other. These are (1) the Russian River between Lake Mendocino and Healdsburg; and (2) the Russian River from Healdsburg to Jenner, including Dry Creek.

The flow requirements for the Russian River from Lake Mendocino to Healdsburg were primarily based upon maintaining the highest sustainable flows possible to support recreation and the salmonid fishery below Coyote Valley Dam. These flow requirements were also based in part on an evaluation of fish habitat and barriers to fish migration performed by Winzler and Kelly under a contract with the USACE (USACE 1978) (Figure 1-5). The flow requirements were set with the assumption that the water supply available from Lake Mendocino would be available to satisfy flow needs between Lake Mendocino and Dry Creek, and expected diversions along this reach of the Russian River. The summer flows for this reach were limited only by the mutual desire of SCWA and CDFG to avoid dewatering Lake Mendocino.

The flow requirements for the Russian River downstream from its confluence with Dry Creek during normal water supply conditions were primarily based on a desire to maintain flows upon which the substantial recreational canoeing industry on the Russian River had developed. The reduced flow requirements for dry and critical water supply conditions were based on consideration of warm water fish and wildlife needs, since the lower portion of the Russian River is too warm to provide extensive rearing habitat for steelhead and salmon (SWRCB 1986).

The flow requirements for Dry Creek were based upon an instream flow assessment performed by CDFG in 1975 and 1976 (CDFG 1977). These requirements meet the fish spawning, passage and rearing needs determined by CDFG. These flows are designed to sustain the native fish populations below Warm Springs Dam, and to provide enhanced steelhead and salmon spawning and nursery habitat in Dry Creek. They also consider the DCFH operations at Warm Springs Dam.

As the local sponsor for the two federal water supply/flood control projects in the Russian River watershed, SCWA, under operational agreements with the USACE, manages the water supply storage space in both Coyote Valley and Warm Springs reservoirs. SCWA's goal when



	1/1	2/1	3/1	4/1	5/1	6/1
CRITICALLY DRY	<4,000	<20,000	<45,000	<50,000	<70,000	<75,000
DRY	<8,000	<39,200	<65,700	<114,500	<145,600	<160,000
NORMAL	>8,000	>39,200	>65,700	>114,500	>145,600	>160,000

Figure 1-5 Russian River Basin Streamflow Requirements

determining releases from the water supply pool in these reservoirs is to optimize the water supply yield of the system and maintain flows in the Russian River and Dry Creek. SCWA holds water rights to divert and re-divert water stored and released from these water supply reservoirs. SCWA delivers wholesale water to its customers[1] through its water transmission system under an existing water supply agreement. These facilities and their operation are described in *Interim Report 4: Water Supply and Diversion Facilities*. In addition, SCWA has agreements with the City of Healdsburg, the Town of Windsor, the Russian River County Water District, and Camp Meeker Recreation and Park District to supply water from the Russian River under SCWA's water rights. This analysis addresses the effects of releases and rediversion of water under SCWA's existing water rights.

1.5.1.1 Russian River between Lake Mendocino and Healdsburg

As described above, Lake Mendocino has distinct pools for water supply and flood control, determined by the elevation of the water surface. The elevation of the top of the water supply pool in Lake Mendocino changes in the fall and spring months. Approximately 20,000 acre feet of additional water can be stored for water supply in the flood control pool toward the end of the rainy season (March to April) as the need for flood control storage decreases. The USACE decides whether this additional water storage becomes available in March or April. In practice, the USACE has allowed the reservoir to fill early under dry conditions, beginning as early as February. In October, when the need for flood control storage increases again, the reservoir level must be reduced to its winter level (737.5 to 748 feet above mean sea level [MSL]).

During water supply operations, water is released from Lake Mendocino to meet water supply demands between Lake Mendocino and Healdsburg, and the required minimum flow at Healdsburg. No additional water is released from Lake Mendocino for diversions by SCWA or any other diverters below Dry Creek.

Figure 1-5 summarizes the minimum flow requirements contained in SWRCB D1610. In the Russian River system, minimum flow rates are required to be maintained throughout entire reaches of the river, rather than at specified points. In the Russian River between Lake Mendocino and Healdsburg, separate minimum flow requirements prevail in the short reach between Lake Mendocino and the Forks and between the Forks and Dry Creek. The point on the river with the lowest flow, referred to as the controlling point, determines the magnitude of the reservoir release. The location of the controlling point changes during the year. In the winter, when flows are increasing downstream, the controlling point is just below Coyote Valley Dam. In the summer, when tributary inflows have receded and flows are being reduced by water supply demands, the controlling point is at the Healdsburg gage. The transition from upstream to downstream control usually occurs during a period of one to three weeks in May or June, depending on the amount of spring rainfall. D1610 sets separate minimum instream flow releases for the lower Russian River below Healdsburg and for Dry Creek.

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[1] Primary customers consist of the cities of Cotati, Petaluma, Rohnert Park, Santa Rosa and Sonoma; and the Forestville, North Marin and Valley of the Moon Water Districts. SCWA also has an agreement with Marin Municipal Water District.

Under D1610, minimum flows in both the upper and lower Russian River vary depending upon water supply condition. Water supply condition is determined based on the cumulative inflow to Lake Pillsbury on the first of each month between January and June and is represented as critically dry, dry, or normal (Figure 1-5). The water supply condition can vary from month to month until June 1 when it becomes stable until the following January. Within the normal year minimum flow criteria, there is a separate schedule referred to as the "dry spring" criteria that is dependent upon the total combined storage in Lake Mendocino and Lake Pillsbury on May 31 of each year. These criteria allow successive reductions in minimum flows for the mainstem Russian River when the combined storage falls below 90 percent and 80 percent of the capacities of Lake Pillsbury and Lake Mendocino, respectively. This provision reflects the importance of the storage space in Lake Pillsbury and the storage space within the flood pool of Lake Mendocino in sustaining the flows in the Russian River system, and the fact that this storage space cannot be fully utilized in dry spring conditions. In about 11 percent of years, "dry spring" water supply conditions prevail from June through December. Dry spring conditions do not apply to the January through May period.

1.5.1.2 Russian River below Healdsburg and Dry Creek

The Russian River from Healdsburg to its mouth at Jenner operates in much the same manner as the Russian River above Healdsburg. Lake Sonoma, like Lake Mendocino, has separate water supply and flood control pools. However, no encroachment is permitted into the flood pool of Lake Sonoma for water supply purposes.

The general operating rule for Lake Sonoma water supply releases is to discharge water needed to satisfy demands (mostly SCWA's) between Dry Creek and the Hacienda gage, and meet the minimum flow at Hacienda. Under current demands, during normal summer conditions, water supply releases from Lake Sonoma are typically controlled by the required minimum flows in Dry Creek.

1.5.1.3 Operational Considerations in Flow Regulation

Because of the way minimum flow requirements are applied in the mainstem Russian River, SCWA must release enough water from Lake Mendocino and Lake Sonoma to meet all downstream water supply diversions, while also ensuring that releases are adequate to meet minimum flows. In theory, only enough water would be released from each reservoir to exactly meet water supply demands and minimum streamflow requirements. In practice, there are several factors that increase the amount of water that must be released during water supply operations. These factors include the length of time it takes water to travel from the reservoirs to downstream monitoring points, changes in weather, variability in water demand and diversion, and SCWA does not control most of the downstream water diversions.

Under current demands, during a normal summer SCWA must release over 300 cfs from Lake Mendocino to satisfy all water supply demands and meet the 185 cfs minimum at Healdsburg. During the summer months, flow targets need to be at least 10 to 20 cfs above the minimum flows at Healdsburg to ensure that instream flow requirements are met in spite of fluctuating demands. Because a change in release at Lake Mendocino may take three days to appear at Healdsburg, changes in demand must be anticipated several days in advance. The same applies to release changes from Lake Sonoma, the effect of which takes several days to reach the Hacienda Bridge. To distinguish the effects of release changes, SCWA must allow downstream flows to stabilize before making additional release modifications.

1.5.2 Flood Control Operations

1.5.2.1 Flood Control Operations of Coyote Valley Dam

USACE's primary objective for flood control releases from Lake Mendocino is to prevent flood flows on the East Fork Russian River from contributing to overbank flood stages on the Russian River below Coyote Valley Dam. The specific criteria for flood control operation are described in the Water Control Manual for Coyote Valley Dam (CVD Water Control Manual) (USACE, Exhibit A 1998). The general criteria for releases from the flood control pool, which includes all reservoir storage above the top of the water conservation pool, calls for successively increasing releases in three stages as reservoir levels rise toward the emergency spillway. The Hopland streamflow gage, 14 miles downstream of Coyote Valley Dam, is the most downstream monitoring point for decisions affecting flood control releases from Lake Mendocino.

USACE limits releases from Lake Mendocino to prevent local flooding at Hopland, which generally occurs when flows exceed 8,000 cfs. Because bank sloughing is likely to occur when flows decrease too rapidly, USACE limits changes in releases from Lake Mendocino to 1,000 cfs per hour.

More specific directions are included in Exhibit A to the CVD water control manual, titled "Standing Instructions to Damtenders" (CVD standing instructions). Operation for flood control is according to the Flood Control Diagram summarized by Exhibit A of the CVD Standing Instructions:

> *Schedules 1, 2 and 3 are used to empty the flood control space following a storm. Under these schedules, releases will be limited to: (1) the discharge that does not cause the flow at Russian River near Hopland to exceed 8,000 cfs and (2) the discharge that results in flow at Hopland being less than that reached during the previous storm. In addition, releases will be limited to (1) between 2,000 and 4,000 cfs if the reservoir pool did not reach elevation 746 feet MSL, (2) 4,000 cfs if the highest reservoir pool level reached was between elevation 746 and 755 feet MSL, and (3) 6,400 cfs if the pool level exceeded elevation 755 feet MSL. Schedules 1, 2 and 3 are used only if no significant rainfall is predicted.*
>
> *If significant rainfall is forecasted (1 inch in 24 hours or 0.5 inch in any six-hour period) maximum releases are limited to 2,000 cfs so that the reservoir releases can be reduced to 25 cfs within 1½ hours if necessary. Also, when flow in the West Fork of the Russian River at Ukiah exceeds 2,500 cfs and is rising, releases from the reservoir will be reduced to 25 cfs.*
>
> *Outlet works gates may be used when the pool level is above the spillway crest (elevation 764.8 MSL) for Flood Control Schedule 3 releases, however the sum of the spill and the releases must not exceed 6,400 cfs.*

> *The Emergency Release Schedule is used between elevation 764.7 and 773 feet MSL, at which stage the flood control gates are fully open. The flood control gates remain fully open until the reservoir pool has receded to elevation 773 feet MSL, at which time the Emergency Release Schedule is implemented. When the reservoir pool has receded to elevation 764.7 feet MSL, Release Schedule 3 is maintained.*

Inflows to Lake Mendocino were historically measured directly at the USGS gauging station on the East Fork Russian River, just upstream of Lake Mendocino. This station (USGS Station No. 11461500) captures approximately 92 of the 105 square miles of drainage area contributing runoff to Lake Mendocino. Flow records for the station are no longer maintained by the USGS. However, stage records are being maintained by the USGS. Inflow to Lake Mendocino is computed from change in storage and releases.

Figure 1-6 shows plots of reservoir inflow, storage, and releases from Lake Mendocino during the 1996 to 1997 flood control season.

Discharge capacity from the reservoir, with all gates open, is 6,500 cfs at the bottom of the flood control pool (*i.e.*, when the water surface elevation reaches the stage when the reservoir is converted from water supply operation to flood control operation), and 7,300 cfs at full pool. Releases above this level would require use of the spillway. The discharge capacity of the spillway is 35,800 cfs.

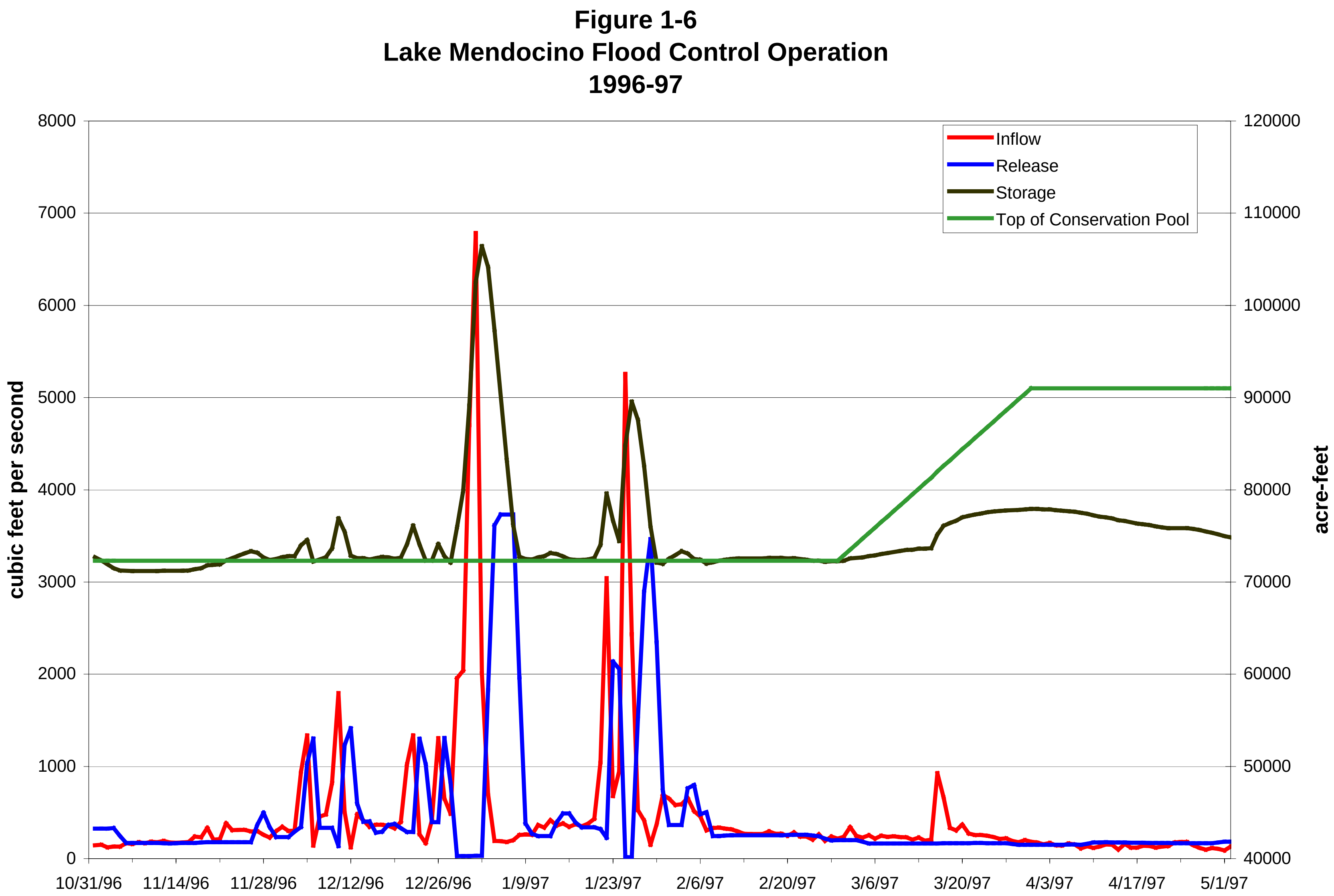


Figure 1-6 Reservoir Inflow, Storage and Releases from Lake Mendocino, 1996 to 1997

1.5.2.2 Flood Control Operations of Warm Springs Dam

USACE's primary objective for flood control operation at Warm Springs Dam is to maximize the reduction in peak flood discharges on Dry Creek and the Russian River below Healdsburg. Because of the long travel time for water flow between Coyote Valley Dam and the Russian River/Dry Creek confluence, the operation of Warm Springs Dam for flood control purposes is independent of the Coyote Valley Dam operation.

The criteria for flood control operation of Lake Sonoma are similar to those for Lake Mendocino and are described in the Warm Springs Dam Water Control Manual (WSD Water Control Manual) (USACE, Exhibit A, 1998). Releases from the flood control pool includes all reservoir storage over elevation 451.1 feet MSL. As with Lake Mendocino, flood control includes three successive flood control pools, or schedules. For Lake Sonoma, the Hacienda Bridge gage, located approximately 16 miles downstream of Warm Springs Dam, is the most downstream monitoring point for decisions affecting flood control releases from Lake Sonoma.

USACE limits releases from Lake Sonoma to restrict flows on the Russian River at Guerneville to 35,000 cfs, which is the approximate channel capacity in Guerneville. USACE also limits releases to prevent flooding downstream along Dry Creek, which generally occurs when flows just below the dam exceed 6,000 cfs. As with releases from Lake Mendocino, USACE limits changes in releases to 1,000 cfs per hour to prevent downstream bank sloughing.

More specific directions are included in Exhibit A to the WSD Water Control Manual, titled "Standing Instructions to Damtenders" (WSD standing instructions). Operation for flood control is in accordance to the Flood Control Diagram summarized by Section 9b of the WSD Standing Instructions:

> *Schedules 1 and 2 are used to empty the flood control space following a storm. Under these schedules releases will be limited to: (1) the discharge that does not cause the flow at Russian River near Guerneville to exceed 35,000 cfs and (2) the discharge that results in flow at Guerneville being less than that reached during the previous storm. In addition, releases will be limited to: (1) 2,000 cfs if the reservoir pool did not reach elevation 455 feet MSL, (2) 4,000 cfs if the highest reservoir pool level reached was between elevation 455 and 468 MSL, and (3) 6,000 cfs if the pool level exceeded elevation 468 MSL. Schedules 1, 2 and 3 are used only if no significant rainfall is predicted. If significant rainfall is forecasted (1 inch in 24 hours or 0.5 inch in any six-hour period) maximum releases are limited to 2,000 cfs so that the reservoir releases can be reduced to 25 cfs minimum within 1½ hours if necessary.*
>
> *Release schedule 3 will be maintained until elevation 502 MSL is reached by regulation of the outlet so that the combined flow from spills (pool above elevation 495 MSL) and releases through the outlet works will not exceed 6,000 cfs.*
>
> *The Emergency Release Schedule is used between elevation 502 MSL and elevation 505 MSL at which stage the flood control gates are fully open. The*

flood control gates remain fully open until the reservoir pool has receded to elevation 505 MSL, at which time the Emergency Release Schedule is implemented. When the reservoir pool has receded to elevation 502 MSL release schedule 3 is maintained.

The allowable water conservation storage in Lake Sonoma remains constant throughout the year. Because of the configuration of the watershed above Lake Sonoma, direct measurement of reservoir inflow by stream gauging is impractical. Consequently, inflow is calculated as the algebraic sum of releases, changes in storage, and the estimated evaporation.

Figure 1-7 shows reservoir inflow, storage, and releases from Lake Sonoma during the 1996 to 1997 flood control season.

Water is released from Warm Springs Dam for flood control purposes through the use of outlet works in the left abutment of the dam, or through the use of the spillway, located in a natural saddle shape on the left abutment of the dam. The control structure accommodates multiple intakes designed for municipal and industrial uses, as well as for meeting water quality requirements. Maximum discharge capacity of the outlet works is 8,100 cfs when the reservoir pool is at 513.1 feet MSL. The spillway was designed for a discharge of 29,600 cfs with the maximum reservoir pool elevation level 18 feet above the spillway crest.

1.5.3 Hydroelectric Facility Operations

1.5.3.1 Lake Mendocino Hydroelectric Power Plant

The Lake Mendocino Hydroelectric Power Plant (LMHPP) was completed in May of 1986 at a total cost of approximately $22 million. The power plant was added as an external facility to the downstream base of Coyote Valley Dam, which was not originally designed to supply a hydroelectric plant (City of Ukiah 1981) and has a total generation capacity of 3.5 megawatts (MW) through two generators rated at 1 and 2.5 MW. The LMHPP is owned and operated by the City of Ukiah. The City of Ukiah operates the project under a 50-year license issued April 1, 1982, by FERC (Project No. 2481-001). The City of Ukiah is a member of the Northern California Power Authority (NCPA). NCPA owns and operates various power generation plants throughout California and provides power to their members. The City of Ukiah uses the LMHPP to supplement other power sources within the city's system and has no contractual minimum power output requirements to maintain. Therefore, it has no right to control water releases. Power output is determined by the amount of water released from the dam for water supply, minimum instream flow requirements, and flood control, rather than power generation needs.

Water flows are directed through the LMHPP from an outlet pipe from the dam. The 959-foot long, 12.5-foot diameter concrete pipe extends beneath the dam between its upstream and downstream sides. Flows exiting the facility run through a rip rapped channel that merges with the East Fork Russian River that is approximately 700 feet downstream from the LMHPP.

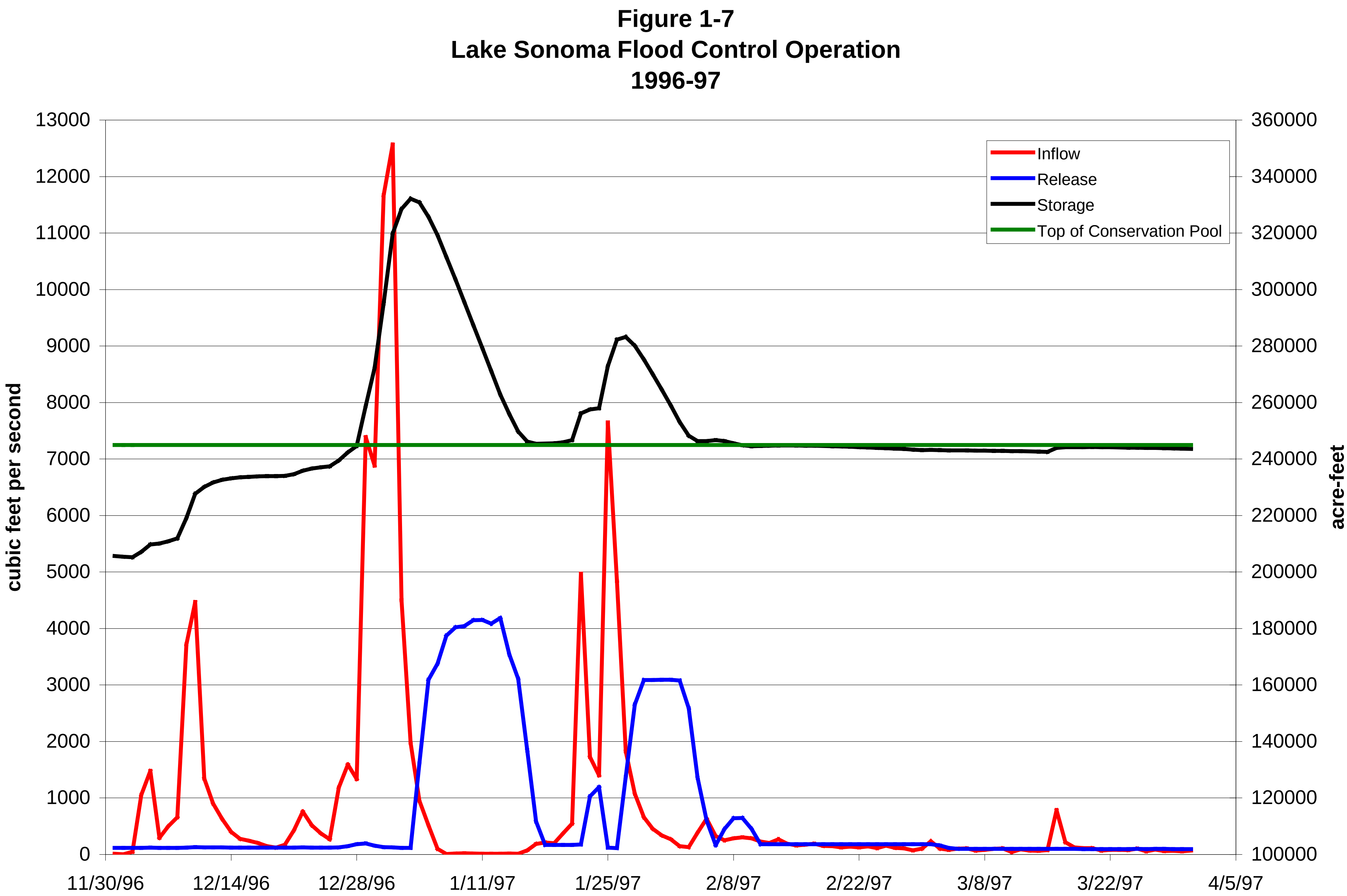


Figure 1-7 Reservoir Inflow, Storage and Releases from Lake Sonoma, 1996 to 1997

The hydraulic turbines require flows between 175 and 400 cfs to operate and produce electrical power. Flows below 175 cfs are not sufficient to produce power. Dam flows, which pass through the facility, are maintained at a minimum of 25 cfs. All flow changes are controlled by the USACE as requested by SCWA during the water supply season, and determined and controlled by the USACE during the flood season.

The City of Ukiah has an agreement with FERC that is endorsed by CDFG and USFWS to provide between 7 cfs and 15 cfs of water to operate the fish facility at Coyote Valley Dam (FERC 1983). Minimum flow rates were specified for the hatchery facility in accordance with D1610. FERC permit guidelines require the City of Ukiah to maintain DO levels downstream of the LMHPP at 7.5 milligrams per liter (mg/l) at least 90 percent of the time, with a minimum requirement of 7 mg/l, and a monthly median value of 10 mg/l for the year (FERC 1982). When the turbines are in operation and the DO level approaches 7 mg/l, the turbines are shutdown and the flow is diverted to the bypass valves. The City of Ukiah continuously monitors the DO level on a computer system.

The City of Ukiah has no control over the level of releases from the dam, and is not currently operating the LMHPP due to minor damage to a diverter wall that controls flows to power plant turbines. The City of Ukiah is in the process of scheduling the needed repairs. When in operation, the LMHPP produces an average of eight to nine million kilowatt-hours of power annually.

1.5.3.2 Warm Springs Dam Hydroelectric Facility

The Warm Springs Dam (WSD) Hydroelectric Facility is owned and operated by SCWA. The hydroelectric facility was completed in December 1988 at a total cost of approximately $5 million. SCWA operates the facility under a 50-year license issued by the FERC on December 18, 1984 (Project No. 3351-002). The WSD Hydroelectric Facility’s generator has a power rating of 2.6 MW. The facility is located within the control structure of the outlet works for the Warm Springs Dam.

Water from Lake Sonoma flows to the hydraulic turbines via a vertical wet-well located in the control structure that draws water from two horizontal low-flow tunnels positioned at two different elevations. One of the low-flow tunnels is currently not operational. Water from the tunnels drops between 132 and 221 feet to the turbines. Water passing through the turbines flows through a 2,047-foot long outlet pipe to a stilling basin located at the base of the dam. From the stilling basin, water either flows through a channelized portion of Dry Creek, or is diverted for use in the DCFH at Warm Springs Dam. The stilling basin is a concrete lined basin at the mouth of the outlet pipe. A two-step weir, approximately 18-feet high, is used to reduce the water velocity from the outlet pipe and to keep fish that are downstream of the dam from entering the outlet pipe.

During normal releases of storage water through the low-flow tunnels and the wet well, the WSD Hydroelectric Facility is in operation. A minimum flow of 100 cfs is needed to operate the turbines. The maximum flow capacity for the Warm Springs facility’s turbine is 175 cfs.

Each year between 11 and 15 million kilowatt-hours of power are produced and sold to PG&E. In addition, SCWA also receives a "capacity payment" for the value of the power generation made available during the peak power demand season. To fill its obligations under its contract with PG&E, SCWA must generate a constant minimum of 1.246 MW during June, July, and August, which are the peak demand months for power consumption (PG&E 1984). This contract expires in December 2008. Some short-term exceptions to this power requirement are allowed for circumstances beyond SCWA's control. A 20-inch bypass line was installed inside the conduit to provide water to the hatchery in the event of a gate failure. This bypass line can divert water through the hatchery and to Dry Creek at a maximum flow capacity of about 40 cfs.

Flows through the WSD Hydroelectric Facility are determined by water supply needs and minimum instream flow requirements. The water supply needs and minimum instream flow requirements set by the SWRCB D1610 (SWRCB 1986) are greater than the flows needed to meet the minimum power generation requirements and so generation needs currently do not control release rates. In the future, as the water supply demands of SCWA and other water users downstream of Warm Springs Dam increase, (particularly during June, July, and August), it is anticipated that minimum power generation requirements will have no influence on streamflows.

1.5.4 ESTUARY MANAGEMENT

The Russian River Estuary Management Plan was developed using the Preferred Alternative presented in the Russian River Estuary Study (RREITF 1994), and recommendations from a monitoring program, to evaluate the effects of breaching the estuary during the period from 1996 to 2000 (Merritt Smith Consulting [MSC] 1997, 1998, 2000). Under the plan, the sandbar is breached when water levels in the estuary reach between 4.5 and 7 feet in elevation at the Jenner gage. Water levels are determined from the automated tide recorder located at the Jenner Visitor's Center. The maximum water elevation was selected to minimize the discharge of anoxic water from Willow Creek Marsh into the Estuary and to avoid high flushing velocities caused by high water elevations in the estuary prior to breaching, and to prevent the flooding of property. The number of breaching events varies from year to year depending on the amount of inflow and beach and ocean conditions that determine the frequency of closure of the Russian River sandbar. For most of the years that were studied, sandbar closures and breachings were generally concentrated in the fall.

The objective of this report is to describe the existing flow regime within the Russian River and Dry Creek, and to evaluate how the activities in the watershed by USACE and SCWA may affect flow-related habitat for coho salmon, steelhead, and chinook salmon. This report evaluates the flow that would be expected to occur under the requirements of D1610 based on two levels of demand: (1) current demand (Year 2000) and (2) the anticipated future demand (Year 2020); including the future demands identified in the WSTSP Environmental Impact Report (SCWA 1996). These operating scenarios are referred to as the D1610/2000 and the D1610/2020 scenarios, respectively, in the remainder of this document. In river systems, the timing and quantity of flow can affect the availability and quality of habitat for organisms that reside within the stream. Flow also affects the water quality of a river or streams, specifically the temperatures and DO concentrations. These potential effects, and the methods and criteria that were used to evaluate them, are discussed in this section.

2.1 FLOW

2.1.1 ISSUES OF CONCERN

The operation of Coyote Valley and Warm Springs dams changes the quantity and timing of flow in the mainstem Russian River and Dry Creek. As described in Section 1.4.1.1, the PVP diverts water into the Russian River basin, and releases from Coyote Valley Dam augment flows in the upper and middle reaches during the summer months. Summer flow in the lower reach is augmented by releases from both Coyote Valley and Warm Springs dams. Dry Creek's flows are augmented in the summer months by releases from Warm Springs Dam. Releases from both dams are made to satisfy the minimum instream flows required by D1610, as well as to provide water supply for agricultural, municipal, and industrial uses. During the winter months, both dams operate to reduce the flood risk downstream of these facilities. These operations reduce the magnitude of flows during storm events and extend the duration of elevated flow levels following storms. This occurs because the dams store some of the water from storm events and release this water at reduced flow levels after the peak has passed. During most of the winter months, the operation of the dams affects flow levels most during flood control operations, but normal releases are generally a small proportion of the total flow in the mainstem Russian River.

Flow regulation may have direct and indirect affects on protected fish species and their habitat. Changes in flow regime affect the amount of wetted area and, thus, the area available to fish, as well as the depths and velocities in those areas. These changes affect the physical area available for different life history activities, such as spawning and rearing. They may also affect the suitability of conditions for particular life history events. For example, a reduction in flow level will cause a reduction of depth in riffle areas, which may affect an adult's ability to migrate upstream to spawning areas.

Upstream passage is essential for anadromous salmonids to complete their life cycle. Most of the suitable spawning and rearing areas for all three species are located either in the upper portions of the mainstem (chinook salmon and some steelhead), on Dry Creek (all three species), or on other tributaries to the mainstem located throughout the watershed (mainly coho and steelhead). Adult salmonids must be able to enter the river and migrate upstream to these areas. Flow levels can directly affect their ability to complete this migration by altering the depths and velocities at potential barriers to migration, such as shallow riffles. Upstream migration for coho salmon and steelhead occurs during the winter months when base flows are high in the system, regardless of project operations (although during the beginning of coho migration in November, water supply and minimum flow releases may still be controlling operations, see below).

During their migration period, the dams are operated in flood control mode, which skims the peaks off runoff during storms, and releases this runoff at a more moderate rate over a period of several days following the storm. The upstream migration of adult salmonids is often cued in part by storm flow peaks (Bjronn and Reiser 1991). However, the majority of storm runoff in the Russian River comes from the outflow of unregulated tributaries. Coyote Valley Dam controls only 13 percent and Warm Springs Dam controls only 9 percent of the Russian River watershed. Thus, during a storm, the dams have the capacity to contain only 21 percent of the total runoff. During these times, the dams would likely be releasing as much water as possible, unless predicted flows were very high, and the reduction in flow caused by the dam is probably substantially less than 30 percent. There would still be a substantial storm peak to cue migration, and the reduced magnitude and increased duration of flows would likely benefit salmonids by somewhat diminishing the peak velocities, providing a longer migration window. Therefore, project affects on migration occurring during flood control operations are likely to be beneficial and if any adverse affects occur, they are likely to be minimal.

Chinook migration may begin as early as August and continue into January, although the peak of chinook migration occurs in October and November. During the first two to three months of this timeframe, river flows are governed by D1610 and water supply releases. This operation mode can continue into November depending on when fall rains commence. These operations increase dry season flow, which improves conditions for the upstream migration of chinook salmon. Thus, project affects on chinook migration are likely to be minimal.

Salmonids place their eggs in pool tailouts (the shallow, downstream end of a pool where velocity begins to accelerate), and in riffles in areas where hydraulic conditions and channel geometry result in high intragravel flow rates. Flow levels can affect the amount of suitable area available for spawning. Once eggs are laid, they must remain undisturbed until they hatch (the incubation period), and the alevins (larval salmonids) emerge from the gravels. During this time, it is important that the nests (redds) are not scoured from the gravels, and the redds are not dewatered and desiccated. The effects of project operations on redd scour are discussed in *Interim Report 1: Flood Control Operations*.

Coho salmon and steelhead juveniles rear in freshwater for at least a full year before they emigrate to the ocean. Chinook salmon juveniles reside in freshwater for only a few weeks to a few months prior to emigrating. Thus, coho and steelhead fry and juveniles are exposed to the full range of project operations during their freshwater rearing phase. Chinook salmon juveniles generally emigrate from February into June, and thus are not present during the entire summer. During the summer, the releases are made from the reservoirs to meet minimum flow requirements and water supply needs. These operations may positively or negatively affect the habitat used by these species during their freshwater residence.

The augmented flows in the Russian River create the need to periodically breach the mouth of the sandbar during the summer and fall months to prevent local flooding around the estuary. The estuary is important for adult and juvenile passage for all three protected species. Some estuaries and lagoons also provide important rearing habitat for salmonids, including ones within the same steelhead and chinook ESUs as the Russian River, although other estuaries apparently provide little habitat for salmonid rearing (see *Interim Report 8: Estuary Management Plan*). For adults to begin their upstream migration, the mouth of the estuary must first be open. Under natural conditions, this opening is governed by oceanic conditions and river flow. The periodic breaching of the estuary allows adult salmonid, and particularly chinook, to enter the estuary earlier than they would be able to if it were not artificially breached. This may adversely affect the ability of these species to reach their upstream spawning areas, and the success of their reproductive effort. This periodic breaching also prevents the estuary from setting up as either a freshwater lagoon or a completely estuarine one. This may have adverse effects on the estuary's water quality and benthic foodbase (Smith 1990), and therefore, potentially pose adverse effects on rearing salmonids.

2.1.2 EVALUATION

2.1.2.1 Russian River System Model

Representative streamflow conditions were determined through the use of models that provide a tool for simulating operational characteristics of the reservoirs and resulting streamflow conditions. The models were designed to illustrate the range of streamflow characteristics resulting from a given flow regime by using the historic period of hydrologic events as a basis and overlaying current minimum streamflow requirements, water demand and operations on this hydrology. The model predicts the streamflow at various nodes along the Russian River and Dry Creek. The hydrologic model has the advantage of being flexible. Operational conditions at each dam can be modified in the models so that streamflow conditions may be simulated and the resulting potential change on fish habitat evaluated. This is extremely useful when considering potential alternatives to minimum instream flow requirements, as it allows different operational scenarios to be compared using the same baseline information and the same operational modifications handling.

For this report, the results of the Russian River System Model (RRSM) were used in conducting the analyses (Flugum 1996). The RRSM was originally developed in the late 1980s to quantify relationships between streamflow, water demand, instream flow requirements, and water supply needs, and has been periodically updated by SCWA staff. The RRSM is divided into two components. One component simulates conditions from the PVP inflow to Lake Mendocino to just above the mouth of Dry Creek. The second component simulates conditions in Dry Creek from Warm Springs Dam downstream to its confluence with the Russian River and for the Russian River from below the Dry Creek confluence to Guerneville. The model provides average daily flow at various locations along the mainstem Russian River between Coyote Valley Dam and Guerneville, and on Dry Creek downstream of Warm Springs Dam for water years 1929 to 1995. The Russian River model output is given in acre-feet per day (AFD). In this report, model output values have been converted to cubic feet per second.

The RRSM integrates numerous factors that influence flows in the Russian River and Dry Creek, regardless of whether or not they are related to project operations. Thus, loss of flow due to transpiration, groundwater, or other diverters, as well as inflow from tributaries not controlled by project operations, are all included in the flow level estimates provided. This enabled the formulation of an overall picture of flow-related habitat conditions for the three protected species. Where flow levels appear to result in impaired conditions for salmonids, the level to which the project would contribute to this impairment was evaluated.

For this analysis, the Russian River has been divided into three segments following those of Winzler and Kelly (1976) (Figure 1-5). These segments include the upper Russian River from Cloverdale to the Forks, the middle Russian River from Dry Creek to Cloverdale, and the lower Russian River from the estuary to Dry Creek. Flow within each segment is modeled based on the flows at the upstream end of the segment. Thus, the flows in the upper Russian River are from the Ukiah Station within the upper RRSM; those in the middle Russian River are from the Cloverdale Station; and those for the lower Russian River are from the Healdsburg Station. Dry Creek flows are represented from the lower RRSM based on two stations, one immediately below Warm Springs Dam called “Lake Sonoma Releases” within the model, and the other near the mouth called “Dry Creek Flow” within the model. In addition to these stations, flow in the estuary is estimated from the Guerneville Station in the lower RRSM, which is the most downstream flow node that included in the model.

Two statistics are reported for each station, the 50 percent exceedance mean daily flow for each station across all years combined and the 50 percent exceedance mean daily flow by month based on water supply condition (defined in Section 1.5.1). These results are provided for both Year 2000 and Year 2020 demand levels.

2.1.2.2 Evaluation of Flow

In this report, a summary of flow conditions in the Russian River and Dry Creek is provided based on RRSM simulations of current and future demand levels (Year 2000 and 2020, respectively). A qualitative description of the potential effects of these flows on the species and lifestages is provided. This description is based on field observations and discussions with people who are knowledgeable about the systems, including Bill Cox of CDFG, and Sean White and Shawn Chase of SCWA.

USACE and SCWA have undertaken additional data collection cooperatively with CDFG and NMFS to develop flow-habitat relationships based on empirical evidence and professional judgement (USACE letter to NMFS, May 15, 2001). This study was conducted during the late summer/fall of 2001 and the results will be used to develop scoring criteria that will enable a more quantitative evaluation of current conditions and alternatives in the Draft BA. A final determination of the effects on habitat of current project operations related to flow will be made after this study is completed.

During review of available information, habitat flow relationships developed by Winzler and Kelly (1976) and Barracco (1978) were evaluated. While these relationships may have some utility in the lower end of flows, they lack sufficient resolution for the detailed analysis and do not accurately represent current habitat conditions under higher flow regimes in the range now most common.

2.2 WATER QUALITY

2.2.1 ISSUES OF CONCERN

Flow regulation by the two dams can affect water quality. Two water quality parameters of particular importance are temperature and DO. Salmonids require cool water with high DO concentrations. The quantity of flow determines how quickly water temperatures respond to ambient air temperatures. It also affects the rate and turbulence of the water moving downstream, which in turn influences the level of DO. These factors affect the growth and survival of salmonids.

Temperature and DO can also be influenced by the depth from which water is released from the reservoirs. Lake Mendocino has only one release port located near the bottom of the reservoir, and therefore, releases from this reservoir cannot be altered to improve temperature or DO conditions. Water releases from Lake Sonoma are made from a multiport outlet facility within Lake Sonoma, which can be manipulated to influence temperature and DO of the release water. The water quality of the releases made from Lake Sonoma are governed by the water quality requirements of the DCFH, which are discussed in *Interim Report 2: Fish Facility Operations*.

2.2.1.1 Temperature

Salmonids are unable to metabolically regulate their body temperature. Therefore, water temperature influences their metabolism, growth, and feeding rates. Unsuitable temperatures can lead to stress, which can result in disease, altered timing of migration, and accelerated or retarded maturation. Salmon and steelhead may delay upstream migration to spawning areas if water temperatures are too warm. While fish do have some natural flexibility in migration schedules, human-induced changes may produce unfavorable conditions to which native stocks cannot adapt. Warm stream temperatures can adversely affect the development of eggs, both within the female during her upstream migration, and in the gravel after they are laid.

Salmonid metabolism, and therefore growth, is related to temperature. There are optimum temperature ranges for growth, but even at slightly higher temperatures, fish can grow given an adequate food supply (Smith and Li 1983). However, at elevated temperatures without plentiful food, fish can experience a slower growth rate, or lose weight.

2.2.1.2 Dissolved Oxygen

Dissolved Oxygen (DO) requirements vary with species, age, temperature, water velocity, activity level, and concentration of substances in the water (McKee and Wolf 1963). Salmonids typically need DO concentrations near the saturation level to be successful. As temperatures increase, DO saturation levels in the water decrease while the oxygen needs of the fish increase.

Reduced DO levels can affect swimming ability, egg development and viability, food conversion efficiency, growth, and survival.

2.2.2 Evaluation

2.2.2.1 Russian River Water Quality Model

Water quality under existing conditions was evaluated using the results of the Russian River Water Quality Model (RRWQM). This model was developed for SCWA by RMA (Resource Management Associates 2001).

The RRWQM predicts temperature and DO concentrations at nodes located along the Russian River and Dry Creek. Two daily periods are predicted for each day from January 1, 1929 to September 30, 1995: one at 6:00 a.m. and the other at 6:00 p.m. In this analysis, the 6:00 a.m. temperature was used to represent minimum temperature and DO values and the 6:00 p.m. temperature was used to represent maximum temperature and DO values. The mean of these values was used to represent the average daily temperature and DO.

It is recognized that salmonids can withstand short-term exposure to temperatures higher than those required on average without significant adverse effects. For this analysis, scores were based on modeled average, daily water quality values to represent the conditions that salmonids are mostly likely to experience over the 96-hour exposure time upon which the criteria were based.

For evaluation, nodes were selected at the top and bottom of each reach of the Russian River and Dry Creek to represent the range of conditions present within each reach. The average temperature and DO values for each station were then scored based on the evaluation criteria described in *Section 2.2.2.2 Water Quality Evaluation Criteria* for the period when each species and lifestage use the river. The number of scoring periods that received a given score (0-5) from both stations was then counted for the species and lifestage of interest. The percentage of periods within each scoring category is presented in the report. When scores were low for a particular life history stage, the frequency of scores by month was examined to more precisely describe when and where adverse conditions occur.

2.2.2.2 Water Quality Evaluation Criteria

Temperature

Temperature requirements found in published literature are characterized as “preferred,” “optimum,” or “tolerable.” “Preferred” refers to the temperature a particular lifestage prefers, while “optimum” temperatures are the temperatures at which a specific activity is most efficient. “Tolerable” temperature ranges are those in which fish can live and grow. To determine upper lethal temperatures, two basic methods are used in studies: (1) critical thermal maximum (CTM) and (2) incipient lethal temperature (ILT). The CTM method slowly heats fish to find the upper tolerance levels, while the ILT method abruptly transfers fish to hotter water. Temperatures above the tolerable range but below the ILT cause stress that may lead to sublethal effects, such as reduced growth rate or disorientation.

Evaluation criteria for temperature is based on peer reviewed literature values. Values based on California stocks are given preference. Preferred temperatures are given the highest value or score. Values for ILT are given a score of 0, despite the fact that these are the lowest magnitude temperatures that can result in mortality (*i.e.*, UIL_{50}). As much as possible, score values are extrapolated between literature values based on USFWS Habitat Suitability Index (HSI) curves. Scoring categories for temperature based upon these literature values for each species and life history stage are given in Table 2-1.

Most literature values of temperature tolerance have been based on studies conducted in the Pacific Northwest and may not reflect upper temperature limits of salmonids in the southern portion of their range. Salmonids in the warmer portion of their range may have local adaptations to their regional temperature. For example, steelhead can survive in higher summer temperatures if food is plentiful enough to support a higher metabolic rate (Smith and Li 1983). If primary and secondary production is high, salmonids can tolerate and even thrive in temperatures that are higher than those indicated by temperature tolerance research that is based in colder climates. However, if habitat and food production are insufficient, higher temperatures could be detrimental (RWQCB 2000). Increases in water temperature and fish size should increase standard metabolism and food demand. By utilizing higher water velocity, shallower and coarser substrate microhabitat, steelhead in Uvas Creek (in the Pajaro River watershed) take advantage of portions of the stream that are substantially faster and more productive than at their resting positions. This faster water provides larger amounts of drifting invertebrate food (Smith and Li 1983). Thus, steelhead eat more and maintain higher growth rates than they would in areas of slower velocity. In warmer streams (19 to 23ºC), density of trout was strongly dependent on water velocity, while in cooler streams (13 to 17ºC), trout density was unrelated to water velocity (Smith 1982).

Temperature criteria are applied to the predicted temperatures from the water quality model developed by RMA Inc. and the RWQCB (RMA 2001). Because the ILT_{50} values reviewed are based on a 96-hour exposure, an average score is calculated for a four-day period using a model value for each 24-hour period. Temperature scores were applied to each successive four-day period. The score was assigned to the fourth day of the period. If a score of 0 occurred within a four-day period, a score of 0 was used for the entire period. At the beginning of a month or life history stage, the three days immediately prior to the first day of that period were used to compute the initial scores. Thus, in a 45-day life history stage, there would be 45 scores contributing to the average score for that period.

Scores for each life history stage were counted across years, and the percent of periods within each scoring category were calculated based on the total number of scoring periods. These percentages give the reader a sense of the distribution of scores for a given species and lifestage. An average score across all the years for each life history stage is also presented, although the evaluation focused more on the frequency and distribution of scores.

When scores were low for a particular life history stage, a table of the frequency of scores by month is presented to more precisely describe when adverse conditions occur. For each month, the number of periods in each scoring category over all years modeled is presented.

Table 2-1 Temperature Evaluation Criteria by Species and Lifestage

Coho	Nov 1 to Jan 31	Dec 1 to Feb 15	Dec 1 to Mar 31	All Year
Habitat Score	**T (°C) Up migration**	**T (°C) Spawning**	**T (°C) Incubation**	**T (°C) Rearing/ Down Migration**
0	≤ 3.0	≤1.7	≤ 0	≤1.7
1	> 3.0 ≤ 4.0	> 1.7 ≤ 3.0	> 0 ≤ 3.0	> 1.7 ≤ 4
2	> 4.0 ≤ 5.0	> 3.0 ≤ 4.0	> 3.0 ≤ 3.5	> 4.0 ≤ 7.0
3	> 5.0 ≤ 6.0	> 4.0 ≤ 6.0	> 3.5 ≤ 4.0	> 7.0 ≤ 8.0
4	> 6.0 ≤ 7.2	> 6.0 ≤ 7.0	> 4.0 ≤ 4.4	> 8.0 ≤ 12.0
5	> 7.2 ≤ 12.7	> 7.0 ≤ 13.0	> 4.4 ≤ 13.3	≥ 12.0 ≤ 14.0
4	> 12.7 ≤ 14	> 13.0 ≤ 14.0	> 13.3 ≤ 14.0	> 14.0 ≤ 15.0
3	> 14.0 ≤ 15.0	> 14.0 ≤ 15.0	> 14.0 ≤ 15.0	> 15.0 ≤ 16.0
2	> 15.0 ≤ 16.0	> 15.0 ≤ 16.0	> 15.0 ≤ 16.0	> 16.0 ≤ 20.0
1	> 16.0 ≤ 21.1	> 16.0 ≤ 17.0	> 16.0 ≤ 18.0	> 20.0 ≤ 26.0
0	> 21.1	> 17.0	> 18.0	> 26.0

Steelhead	Oct 1 to Sept 30	Dec 1 to Apr 30	Jan 1 to May 31	All Year
Habitat Score	**T (°C) Up migration**	**T (°C) Spawning**	**T (°C) Incubation**	**T (°C) Rearing/ Down Migration**
0	≤ 4.0	≤ 4.0	≤ 1.5	≤ 0.0
1	> 4.0 ≤ 5.0	> 4.0 ≤ 5.0	> 1.5 ≤ 3.0	> 0.0 ≤ 2.0
2	> 5.0 ≤ 6.0	> 5.0 ≤ 6.0	> 3.0 ≤ 4.5	> 2.0 ≤ 4.0
3	> 6.0 ≤ 7.0	> 6.0 ≤ 7.0	> 4.5 ≤ 6.0	> 4.0 ≤ 8.0
4	> 7.0 ≤ 7.8	> 7.0 ≤ 7.8	> 6.0 ≤ 7.8	> 8.0 ≤ 12.8
5	> 7.8 ≤ 11.0	> 7.8 ≤ 11.1	>7.8 ≤ 11.1	> 12.8 ≤ 15.6
4	> 11.0 ≤ 13.0	> 11.1 ≤ 14.0	> 11.1 ≤ 13.0	> 15.6 ≤ 18.0
3	> 13.0 ≤ 15.0	> 14.0 ≤ 16.0	> 13.0 ≤ 15.0	> 18.0 ≤ 20.0
2	> 15.0 ≤ 17.0	> 16.0 ≤ 18.0	> 15.0 ≤ 17.0	> 20.0 ≤ 23.9
1	> 17.0 ≤ 21.1	> 18.0 ≤ 20.0	> 17.0 ≤ 20.0	> 23.9 ≤ 26.0
0	> 21.1	> 20.0	> 20.0	> 26.0

Chinook	Aug 15 to Jan 15	Nov 1 to Jan 31	Nov 1 to Mar 31	Feb 1 to May 31
Habitat Score	**T (°C) Up migration**	**T (°C) Spawning**	**T (°C) Incubation**	**T (°C) Rearing/ Down Migration**
0	≤ 0.8	≤ 1.0	≤ 1.0	≤ 1.0
1	> 0.8 ≤ 3.0	> 1.0 ≤ 2.5	> 1.0 ≤ 2.0	> 1.0 ≤ 4.0
2	> 3.0 ≤ 5.2	> 2.5 ≤ 3.5	> 2.0 ≤ 3.0	> 4.0 ≤ 6.0
3	> 5.2 ≤ 7.9	> 3.5 ≤ 4.5	> 3.0 ≤ 4.0	> 6.0 ≤ 8.0
4	> 7.9 ≤ 10.6	> 4.5 ≤ 5.6	> 4.0 ≤ 5.0	> 8.0 ≤ 12.0
5	> 10.6 ≤ 15.6	> 5.6 ≤ 13.9	> 5.0 ≤ 12.8	> 12.0 ≤ 14.0
4	> 15.6 ≤ 17.0	> 13.9 ≤ 14.5	> 12.8 ≤ 14.2	> 14.0 ≤ 17.0
3	> 17.0 ≤ 18.4	> 14.5 ≤ 15.2	> 14.2 ≤ 15.0	> 17.0 ≤ 20.0
2	> 18.4 ≤ 19.8	> 15.2 ≤ 16.0	> 15.0 ≤ 15.8	> 20.0 ≤ 23.0
1	> 19.8 ≤ 21.1	> 16.0 ≤ 16.7	> 15.8 < 16.7	> 23.0 ≤ 26.0
0	> 21.1	> 16.7	> 16.7	> 26.0

Criteria based on: Anonymous 1971; Bell 1986; Bjornn and Reiser 1991; Boles *et al*. 1988; Brett 1952, Brett *et al*. 1982; CDFG 1991; California Resources Agency 1989; Cramer 1992; Fryer and Pilcher 1974; Hallock *et al.* 1970; Hanel 1971; McMahon 1983; Raleigh *et al.* 1984; Rich 1987; Seymour 1956; and USEPA 1974.

Dissolved Oxygen

DO requirements vary with species, lifestage, and temperature. Generally, as temperatures increase, DO saturation levels in the water decrease while the oxygen needs of the fish increase. Optimal oxygen levels for rainbow trout (the nonanadromous form of steelhead) appear to be ≥7 mg/l at $<15^{\circ}$X and ≥9 mg/l at $>15^{\circ}$C (Raleigh *et al.* 1984). Incipient lethal levels of DO for adult and juvenile rainbow trout are approximately 3 mg/l, depending primarily on temperature.

Reduced concentrations of DO can reduce the swimming performance of migrating adult salmonids (Davis *et al*. 1963). For embryos, the amount of oxygen available is influenced by the flow of water through redds. DO concentrations can affect the length of the incubation period, the survival and development of the eggs, and the size and strength of the alevins (larval salmonids prior to their emergence from the gravel) (Bjornn and Reiser 1991; Silver *et al.* 1963; Coble 1961; Phillips and Campbell 1961; and Raleigh *et al.* 1986).

Evaluation Scores for DO are given in Table 2-2. They are based on the literature cited in this report and in the HSI models developed by the USFWS. DO scores were derived by applying the criteria below to the average DO concentrations calculated from the output of the RRWQM for each day in the simulation period that a species and lifestage would be present in the area being discussed.

Table 2-2 Dissolved Oxygen Evaluation Criteria by Species and Lifestage

Coho	Nov 1 to Jan 31	Dec 1 to Mar 31	Oct 1 to Sept 30	Feb 1 to May 15
Habitat Score	**DO (mg/l) Up migration**	**DO (mg/l) Spawning/ incubation**	**DO (mg/l) Rearing**	**DO (mg/l) Down migration**
5	> 6.5	> 8.0	> 8.0	> 8.0
4	> 6.0 ≤ 6.5	> 6.8 ≤ 8.0	> 6.5 ≤ 8.0	> 6.0 ≤ 8.0
3	> 5.5 ≤ 6.0	> 6.2 ≤ 6.8	> 6.0 ≤ 6.5	> 5.5 ≤ 6.0
2	> 5.2 ≤ 5.5	> 5.5 ≤ 6.2	> 5.2 ≤ 6.0	> 5.2 ≤ 5.5
1	> 4.8 ≤ 5.2	> 4.5 ≤ 5.5	> 4.5 ≤ 5.2	> 4.6 ≤ 5.2
0	≤ 4.8	≤ 4.5	≤ 4.5	≤ 4.6

Steelhead	Jan 1 to Mar 31	Jan 1 to May 31	Oct 1 to Sept 30	Feb 1 to June 30
Habitat Score	**DO (mg/l) Up migration**	**DO (mg/l) Spawning/ incubation >15°C**	**DO (mg/l) Rearing**	**DO (mg/l) Down migration**
5	> 6.5	> 9 .0	> 8.0	> 8.0
4	> 6.0 ≤ 6.5	> 7.3 ≤ 9.0	> 6.5 ≤ 8.0	> 6.0 ≤ 8.0
3	> 5.5 ≤ 6.0	> 6.5 ≤ 7.3	> 6.0 ≤ 6.5	> 5.5 ≤ 6.0
2	> 5.2 ≤ 5.5	> 5.9 ≤ 6.5	> 5.2 ≤ 6.0	> 5.2 ≤ 5.5
1	> 4.8 ≤ 5.2	> 5.4 ≤ 5.9	> 4.5 ≤ 5.2	> 4.6 ≤ 5.2
0	≤ 4.8	≤ 5.4	≤ 4.5	≤ 4.6

Chinook	Aug 15 to Jan 15	Nov 1 to Mar 31	Feb 1 to May 31	Feb 1 to May 31
Habitat Score	**DO (mg/l) Up migration**	**DO (mg/l) Spawning/ incubation[1] > 10°C**	**DO (mg/l) Rearing**	**DO (mg/l) Down migration**
5	> 6.5	> 13.0	> 8.0	> 8.0
4	> 6.0 ≤ 6.5	> 11.3 ≤ 13.0	> 6.5 ≤ 8.0	> 6.0 ≤ 8.0
3	> 5.5 ≤ 6.0	> 9.5 ≤ 11.3	> 6.0 ≤ 6.5	> 5.5 ≤ 6.0
2	> 5.2 ≤ 5.5	> 8.0 ≤ 9.5	> 5.2 ≤ 6.0	> 5.2 ≤ 5.5
1	> 4.8 ≤ 5.2	> 6.0 ≤ 8.0	> 4.5 ≤ 5.2	> 4.6 ≤ 5.2
0	≤ 4.8	≤ 6.0	≤ 4.5	≤ 4.6

[1] Bell 1990, Bjornn & Reiser 1991, Davis *et al*. 1963, Davis 1975, Philips & Campbell 1961, Raleigh *et al.* 1984, Raleigh *et al.* 1986.

3.0
EVALUATION OF EFFECTS ON PROTECTED SPECIES

The previous section identifies issues and concerns regarding the effect that flows may have on protected species and their critical habitat. It also describes the evaluation criteria that are used to assess these effects. This section describes the specific flow, temperature and DO conditions as output by the RRSM and the RRWQM. The potential effects of these conditions on the suitability of flow-related habitat for coho salmon, steelhead, and chinook salmon are evaluated and discussed. When one of these parameters appears to constrain a life history stage, the location and timing of this constraint is determined and the contribution of project operations to this constraint is evaluated.

The primary effect associated with water supply, flood control, and D1610 releases is enhanced flows during the summer season. Releases are made from Lake Mendocino and Lake Sonoma to meet minimum instream flow requirements and water supply needs augment the flow in all reaches of the Russian River downstream of Coyote Valley Dam, and in Dry Creek downstream of Warm Springs Dam. Augmented summer flows implemented under D1610 have the potential to affect several components of salmonid rearing habitat, including both the area and quality of available habitat. Minimum instream flow requirements and releases from the project dams vary by water supply conditions (normal, dry spring, dry, and critical), described in Section 1.5.1.1. The intent of the flow analyses is to identify those species and lifestages that are most likely to be affected by factors related to instream flow.

During the winter months, project operations have a much lower magnitude of effect, and these effects are within the normal range of variability associated with storm and runoff events that occur regularly in the basin and are beyond the control of the project. Flood control operations at Coyote Valley and Warm Springs dams tend to flatten the storm runoff peaks and spread these flows out over a longer period of time (several days). However, the two dams each control only a small portion of the total watershed. Therefore, flow in the river during the winter months is largely controlled by natural runoff, and flood control operations only have a minor effect on the total volume of flow.

The water quality analyses focus on the suitability of temperature and DO concentrations for the protected species and lifestages. These analyses use the criteria described in Section 2.0 to evaluate the predictions of the RRWQM and describe the potential effects of these temperatures and DO concentrations. This analysis is used to evaluate conditions in those portions of the Russian River and Dry Creek that salmonids are thought to occupy.

In the estuary, flows resulting from natural runoff and project operations may influence water quality (including temperature, DO and salinity), primary productivity, the availability of aquatic invertebrates, availability of shallow water habitat, and the concentration of nutrients and toxic runoff. Another effect associated with augmented flows is the need to artificially breach the sandbar at the mouth of the river periodically to prevent flooding of local properties. Some of the potential effects of this breaching on habitat are discussed in *Interim Report 8: Estuary Management Plan*. *Interim Report 8* limits the evaluation of the Estuary Management Plan to the direct effects of the artificial breaching program. It does not address the effects of augmented flow on estuarine habitat, or effects due to the need for artificial breaching. These analyses are included in this report.

3.1 REGULATED FLOWS UNDER D1610

3.1.1 WATER SUPPLY CONDITIONS

In discussing the flow levels that occur on the Russian River, it is important to understand not only the water supply conditions that define the minimum flow requirements under D1610, but also the frequency with which these conditions occur. This allows an evaluation of the relative importance of the particular flow regime, as well as the effect it is likely to have on populations over extended periods of time (decades). The same water supply conditions apply to the entire watershed.

In the Russian River, the vast majority of months (70 to nearly 90 percent) are classified as having normal water supply conditions, while between 9 and 13 percent are classified as dry, and 1.5 to 6 percent as critical (Table 3.1). Seven years had one or more months with critical water supply conditions. In four of these years, conditions improved to normal, and in two other years, conditions improved to dry. Only 1977 had critical water supply conditions for the entire year. Therefore, the lower flows that occur during critical conditions persist only for one or two months and not for an entire season or year. The short duration further reduces the importance of these events. Also, because of the relative infrequency of these events, the flow statistics generated for this water supply condition in any month may not be truly representative of those conditions.

Often, as will be seen in the following paragraphs, a storm will occur during one month that increases flows above what one would expect for a critically dry month. Water supply conditions are determined at the beginning of the month, and any runoff occurring during that month contributes to improving the water supply condition of the following month.

Table 3-1 Number and Percent of Months by Water Condition Type Based on RRSM Output (Water Years 1929 to 1995) under the D1610/2000 Scenario

Number of Months												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Normal	47	47	47	55	54	59	58	58	47	47	47	47
Dry Spring	11	11	11						11	11	11	11
Dry	8	8	8	8	9	6	8	8	8	8	8	8
Critical	1	1	1	4	4	2	1	1	1	1	1	1
Total	67	67	67	67	67	67	67	67	67	67	67	67
Percent of Months												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Normal	70.1	70.1	70.1	82.1	80.6	88.1	86.6	86.6	70.1	70.1	70.1	70.1
Dry Spring	16.4	16.4	16.4						16.4	16.4	16.4	16.4
Dry	11.9	11.9	11.9	11.9	13.4	9.0	11.9	11.9	11.9	11.9	11.9	11.9
Critical	1.5	1.5	1.5	6.0	6.0	3.0	1.5	1.5	1.5	1.5	1.5	1.5

Table 3-2 Number and Percent of Months by Water Condition Type Based on RRSM Output (Water Years 1929 to 1995) under the D1610/2020 Scenario

Number of Months												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Normal	43	43	43	55	54	59	58	58	43	43	43	43
Dry Spring	15	15	15						15	15	15	15
Dry	8	8	8	8	9	6	8	8	8	8	8	8
Critical	1	1	1	4	4	2	1	1	1	1	1	1
Total	67	67	67	67	67	67	67	67	67	67	67	67
Percent of Months												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Normal	64.2	64.2	64.2	82.1	80.6	88.1	86.6	86.6	64.2	64.2	64.2	64.2
Dry Spring	22.4	22.4	22.4						22.4	22.4	22.4	22.4
Dry	11.9	11.9	11.9	11.9	13.4	9.0	11.9	11.9	11.9	11.9	11.9	11.9
Critical	1.5	1.5	1.5	6.0	6.0	3.0	1.5	1.5	1.5	1.5	1.5	1.5

Sections 3.1.2 through 3.1.7 summarize the flows that were present in the different reaches of the Russian River and Dry Creek between 1926 and 1995 based on the output of the RRSM. Section 3.2 discusses the temperature and DO levels that would have been present in these same reaches from 1929 to 1995 based on the output of the RRWQM. Sections 3.3 through 3.7 describe the likely effect of these conditions on the different life history stages of coho salmon, steelhead, and chinook salmon in the different portions of the watershed.

3.1.2 UPPER RUSSIAN RIVER

The mean daily flow that was equaled or exceeded 50 percent of the time (the 50 percent Exceedance Flow), in the upper Russian River (below the Forks), ranged from 575 cfs in February to 152 cfs in November under current operations of Coyote Valley Dam (Table 3-3) based on Year 2000 demand levels. The 20 percent exceedance flow was greater than 1,400 cfs in January and February and reached a low flow of 180 cfs in October. The 80 percent exceedance flows generally reached a low of about 152 cfs from October through January and a high of 319 cfs in February.

During dry year water supply conditions, the 50 percent exceedance flow is 212 cfs in February and 90 cfs in December. During critical water supply conditions, the 50 percent exceedance flow ranged from 195 cfs in December to 18 cfs in October.

Table 3-3 Exceedance Flows for the Russian River below the Forks by Water Supply Conditions under the D1610/2000 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20%	180	192	784	1418	1402	928	727	428	289	314	259	195
50%	172	152	199	468	575	327	427	242	248	275	234	183
80%	152	152	152	152	319	152	187	187	203	238	191	169
50 Percent Exceedance by Water Supply Condition												
Normal	174	166	303	568	643	414	458	249	253	283	245	186
Dry Spring	174	152	168	270	267	194	189					
Dry	102	92	90	99	212	109	119	148	194	194	127	122
Critical[2]	18	19	195	43	44	84	87	159	170	157	79	22

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

Under normal water supply conditions, the D1610/2020 scenario simulation indicated that flows would have been slightly lower than under the D1610/2000 scenario from December through April, and slightly higher from May through November. The differences in flow during normal water supply conditions were slight. The largest difference was a 17 percent reduction in flow in December (Table 3-4). During dry water supply conditions, flows under the D1610/2020 scenario tended to be somewhat higher than those under the D1610/2000 scenario in most months. This difference was generally about 12 percent. February was the exception, when there was a 17 percent decrease in flow from the D1610/2000 scenario.

Table 3-4 Exceedance Flows for the Russian River below the Forks by Water Supply Conditions under the D1610/2020 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	184	198	710	1333	1366	909	721	422	308	331	270	204
50	173	152	175	435	568	289	422	256	262	291	240	186
80	152	152	152	152	223	152	187	187	221	251	189	167
50 Percent Exceedance by Water Supply Condition												
Normal	176	167	250	531	637	394	453	268	264	296	254	193
Dry Spring	171	152	152	286	290	201	187					
Dry	107	96	111	116	176	109	135	175	223	222	137	132
Critical[2]	18	19	195	61	70	84	112	25	0	0	0	22

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

3.1.3 Middle Russian River

At Cloverdale, the 50 percent exceedance flow ranged from 964 cfs in February to 166 cfs in September, with higher flow results from tributary inputs downstream of the Forks (Table 3-5). In 20 percent of years, flows in this portion of the river were greater than 2,894 cfs in January and February, which was more than twice the flow at the Forks. Minimum daily flows were less than 170 cfs from August through December during 20 percent of the time.

In dry water supply conditions, 50 percent exceedance flows were 531 cfs in February and 94 cfs from September through November. While in critical water supply conditions, flows were absent (0 cfs) in September and 688 cfs in December. The higher flow in critical water supply conditions relative to dry conditions was a statistical anomaly resulting from the low frequency with which critical conditions have occurred (1.5 percent of months).

Table 3-5 Exceedance Flows for the Russian River near Cloverdale by Water Supply Conditions under the D1610/2000 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	174	417	1665	2985	2894	2099	1328	619	253	248	213	171
50	167	173	414	813	964	786	624	278	225	226	204	166
80	161	160	168	244	494	338	279	209	200	200	166	162
50 Percent Exceedance by Water Supply Condition												
Normal	168	179	467	970	1101	838	692	314	232	231	208	168
Dry Spring	167	171	417	210	206	168	166					
Dry	94	94	115	315	531	316	192	152	144	138	95	94
Critical[2]	9	24	688	66	81	226	67	117	107	91	49	0

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

Table 3-6 Exceedance Flows for the Russian River near Cloverdale by Water Supply Conditions under the D1610/2020 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	177	379	1624	2898	2883	2084	1317	604	256	252	217	175
50	168	179	372	774	960	772	618	283	226	228	206	168
80	156	159	177	231	445	332	280	212	199	196	163	161
50 Percent Exceedance by Water Supply Condition												
Normal	170	184	453	951	1089	829	685	310	236	235	212	170
Dry Spring	167	182	321	211	207	170	166					
Dry	96	108	121	289	532	312	196	167	150	145	100	98
Critical[2]	6	23	687	72	78	223	77	21	0	0	0	0

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

3.1.4 Lower Russian River

In the Russian River below the Dry Creek confluence, the 50 percent exceedance flow ranged from about 1,922 cfs in February to 248 cfs in September (Table 3-7). Flows exceeded 6,000 cfs approximately 20 percent of the time in January and February and were less than 244 cfs about 20 percent of the time in September.

In dry water supply conditions, the 50 percent exceedance flow was 1,114 cfs in February and 176 cfs in September. In critical conditions, the 50 percent exceedance flow ranged from 1,677 in December and 108 cfs in November.

Table 3-7 Exceedance Flows for the Russian River below Dry Creek by Water Supply Conditions under the D1610/2000 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	270	738	3311	6120	6443	4369	2250	892	363	296	288	260
50	252	300	720	1478	1922	1683	977	446	298	285	282	248
80	243	272	291	496	814	713	498	315	257	250	247	244
50 Percent Exceedance by Water Supply Condition												
Normal	253	314	777	1878	2288	1802	1105	502	313	288	284	249
Dry Spring	253	305	791	257	252	248	248					
Dry	180	185	220	741	1114	729	282	204	190	203	181	176
Critical	125	108	1677	269	265	576	118	163	153	164	135	130

[1] All water conditions

Table 3-8 Exceedance Flows for the Russian River below Dry Creek by Water Supply Conditions under the D1610/2020 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	281	724	3146	5891	6115	4237	2190	864	378	368	346	294
50	263	289	673	1403	1811	1639	942	432	329	347	323	280
80	251	270	273	417	746	682	474	318	296	322	303	260
50 Percent Exceedance by Water Supply Condition												
Normal	265	298	740	1741	2178	1746	1075	477	338	348	325	284
Dry Spring	267	305	606	326	358	327	285					
Dry	225	204	214	683	1073	691	295	278	288	313	286	245
Critical[2]	2	26	1651	245	229	545	132	165	189	207	178	149

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

3.1.5 ESTUARY – RUSSIAN RIVER AT GUERNEVILLE

The Guerneville station was used to estimate the flows entering the estuary, as this was the furthest downstream point for which the RRSM predicts flows. At this station, the 50 percent exceedance flow ranged from a high of 2,571 cfs in February to 169 cfs in September (Table 3-9). A flow of 8,570 cfs occurred 20 percent of the time in February, while flows of 151 cfs or less occurred 20 percent of the time in October.

Under dry conditions, the 50 percent exceedance flow ranged from 1,535 cfs in February to 92 cfs in August. In critical conditions, these flows ranged from 2,617 cfs in December to 43 cfs in July.

Table 3-9 Exceedance Flows in the Russian River near Guerneville by Water Supply Conditions under the D1610/2000 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	197	860	4472	8393	8682	5785	2755	1050	359	208	205	196
50	171	252	809	1947	2571	2227	1180	491	238	188	192	169
80	151	202	235	544	953	882	572	288	184	145	158	154
50 Percent Exceedance by Water Supply Condition												
Normal	174	269	891	2454	2952	2377	1372	572	269	196	198	173
Dry Spring	175	267	1094	187	150	161	167					
Dry	95	128	161	985	1535	990	342	148	112	95	92	95
Critical	46	59	2617	257	202	1011	43	79	54	43	44	43

[1] All water conditions

Table 3-10 Exceedance Flows for the Russian River near Guerneville by Water Supply Conditions under the D1610/2020 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	163	813	4344	8100	8264	5573	2660	950	261	170	160	152
50	140	206	715	1812	2414	2128	1099	396	170	142	134	138
80	125	164	178	463	840	811	497	212	125	125	125	125
50 Percent Exceedance by Water Supply Condition												
Normal	142	213	835	2286	2806	2253	1276	475	190	147	138	141
Dry Spring	146	233	697	155	144	136	143					
Dry	97	110	107	892	1513	878	276	140	124	103	97	97
Critical[2]	0	0	2556	205	157	971	41	52	45	45	41	46

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

3.1.6 DRY CREEK BELOW WARM SPRINGS DAM

The 50 percent exceedance flows in Dry Creek immediately below Warm Springs Dam ranged from 125 cfs in March to 77 cfs in January, February, and April (Table 3-11). The high flow in February exceeded 821 cfs 20 percent of the time, while flows of 75 cfs or more were maintained 80 percent of the time in all months.

The highest monthly 50 percent exceedance flow under dry conditions occurred in July (122 cfs), while the lowest was 27 cfs in April. Critical water supply conditions had a high flow of 134 cfs in July and a low flow of 73 cfs in April.

Table 3-11 Exceedance Flows on Dry Creek below Lake Sonoma by Water Supply Conditions under the D1610/2000 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	82	107	107	590	821	675	190	87	100	104	90	87
50	82	107	107	77	77	125	77	82	94	100	89	86
80	82	107	107	77	77	77	75	82	86	97	86	82
50 Percent Exceedance by Water Supply Condition												
Normal	82	107	107	77	139	167	78	82	93	100	89	86
Dry Spring	82	107	107	97	102	89	86					
Dry	81	77	77	77	77	77	27	45	96	122	91	88
Critical	118	77	77	77	77	77	73	80	120	134	121	128

[1] All water conditions

Table 3-12 Exceedance Flows for Dry Creek below Lake Sonoma by Water Supply Conditions under the D1610/2020 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	119	111	107	250	617	574	167	93	181	222	184	144
50	99	107	107	77	77	77	77	82	121	175	147	123
80	86	107	107	77	77	77	77	82	95	146	126	102
50 Percent Exceedance by Water Supply Condition												
Normal	97	107	107	77	77	93	77	82	101	161	134	120
Dry Spring	102	107	107	175	220	175	130					
Dry	130	105	82	77	77	77	27	116	192	237	202	160
Critical[2]	2	5	77	77	77	77	91	160	211	225	190	155

[1] All water conditions
[2] Flows less than minimum flow releases are predicted by the RRSM based on the availability of water in the reservoirs. In actuality, releases would always meet D1610 minimum flow requirements.

3.1.7 Dry Creek above Mouth

The 50 percent exceedance flows in Dry Creek near the mouth typically ranged from 333 cfs in February to 85 cfs from August through October (Table 3-13). The flow in February exceeded 1,466 cfs about 20 percent of the time, and minimum flows were less than 83 cfs in October 20 percent of the time.

In dry conditions, the 50 percent exceedance flow ranged from 193 cfs in February to 52 cfs in April. In critical conditions, they ranged from 250 cfs in December to 72 cfs in April.

Table 3-13 Exceedance Flows on Dry Creek above Mouth by Water Supply Conditions under the D1610/2000 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	91	148	468	1334	1466	1071	358	122	91	90	86	87
50	85	113	146	210	333	313	136	95	87	86	85	85
80	83	108	112	106	131	132	100	86	85	85	85	84
50 Percent Exceedance by Water Supply Condition												
Normal	84	115	153	269	413	343	154	98	87	86	85	85
Dry Spring	88	117	159	86	87	85	86					
Dry	85	80	87	136	193	146	52	56	82	109	89	87
Critical	119	90	250	96	93	173	72	74	101	119	116	127

[1] All water conditions

The flows described in the subsequent sections (3-3 through 3-7), evaluating the effects of flow on the various lifestages of coho salmon, steelhead and chinook salmon, refer to the 50 percent exceedance flows provided in the tables above, unless otherwise stated. For brevity, and to increase the readability of this document, the terms “flow” and “50 percent exceedance flows” are used interchangeably in these sections of this report.

Table 3-14 Exceedance Flows for Dry Creek above Mouth by Water Supply Conditions under the D1610/2020 Scenario

Exceedance Level[1]	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20	119	151	434	1094	1261	1001	325	130	163	202	176	139
50	99	113	146	204	281	293	132	96	107	156	140	119
80	86	110	114	106	130	132	99	86	87	127	117	100
50 Percent Exceedance by Water Supply Condition												
Normal	97	111	152	242	352	321	145	94	91	143	125	115
Dry Spring	101	124	157	154	198	169	126					
Dry	133	107	116	135	183	145	77	114	171	218	195	155
Critical	0	6	248	104	112	172	83	145	189	207	178	148

[1] All water conditions

3.2 Results of Water Quality Model

3.2.1 Temperature

The average daily water temperature from 1929 to 1995, as predicted by the RRWQM, for each day of the year are shown in Figures 3-1 and 3-2. These plots show that the lowest temperatures observed tend to be about 9°C and therefore would not have been stressful to salmonids. Summer water temperatures were often quite warm, and all three reaches had water temperatures that could have been stressful to rearing salmonids. However, the water temperatures were generally cooler in the upper Russian River than they were in the middle and lower reaches, and would have been suitable for salmonids during the summer months if an adequate supply of food were available. Water temperatures in Dry Creek were considerably cooler than in the Russian River, due to the hypolimnetic releases from Warm Springs Dam. Immediately below the dam, water temperatures were less than 14°C throughout the summer.

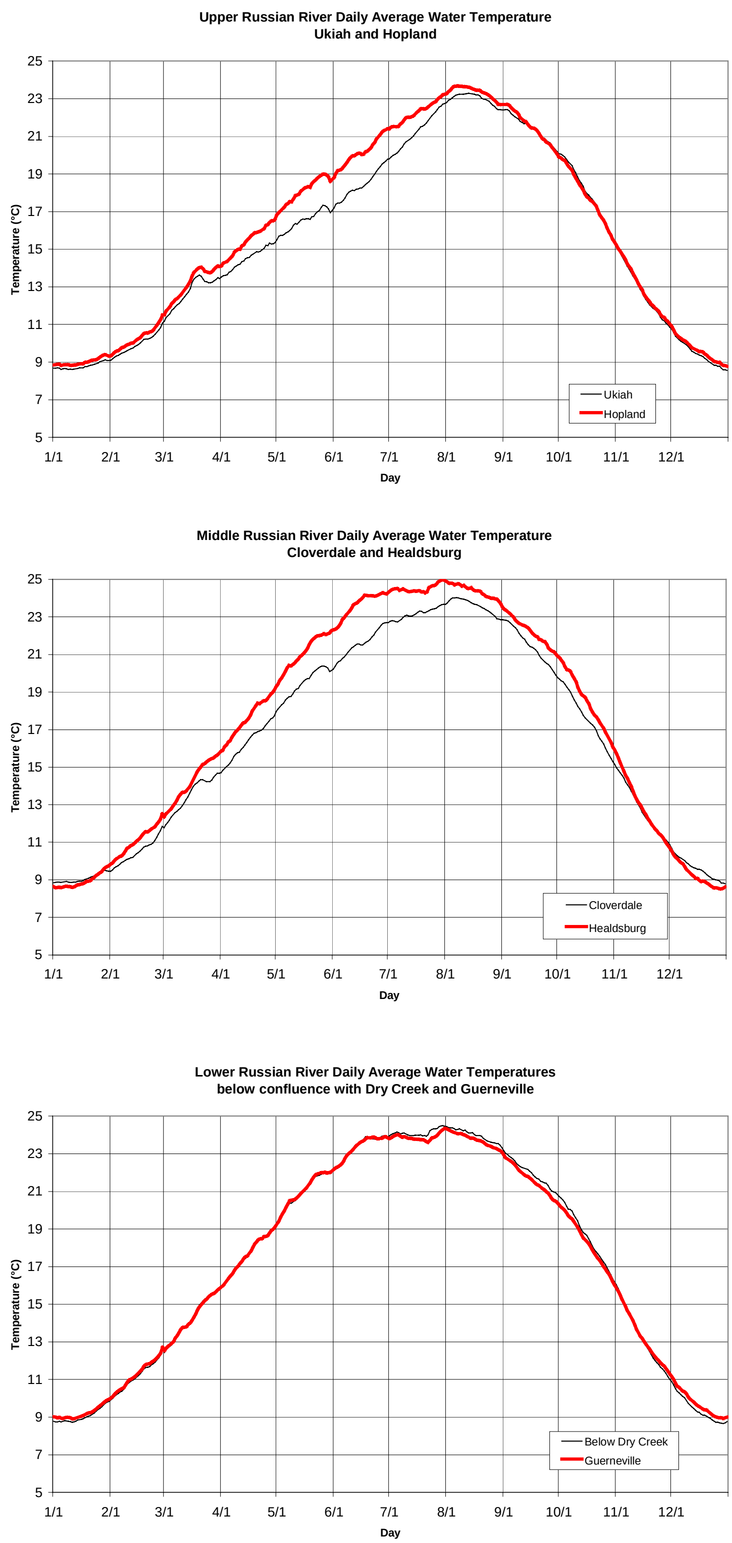


Figure 3-1 Daily Water Temperatures Averaged over the Years Modeled (Water Years 1930 to 1995) in the Russian River at Six Stations

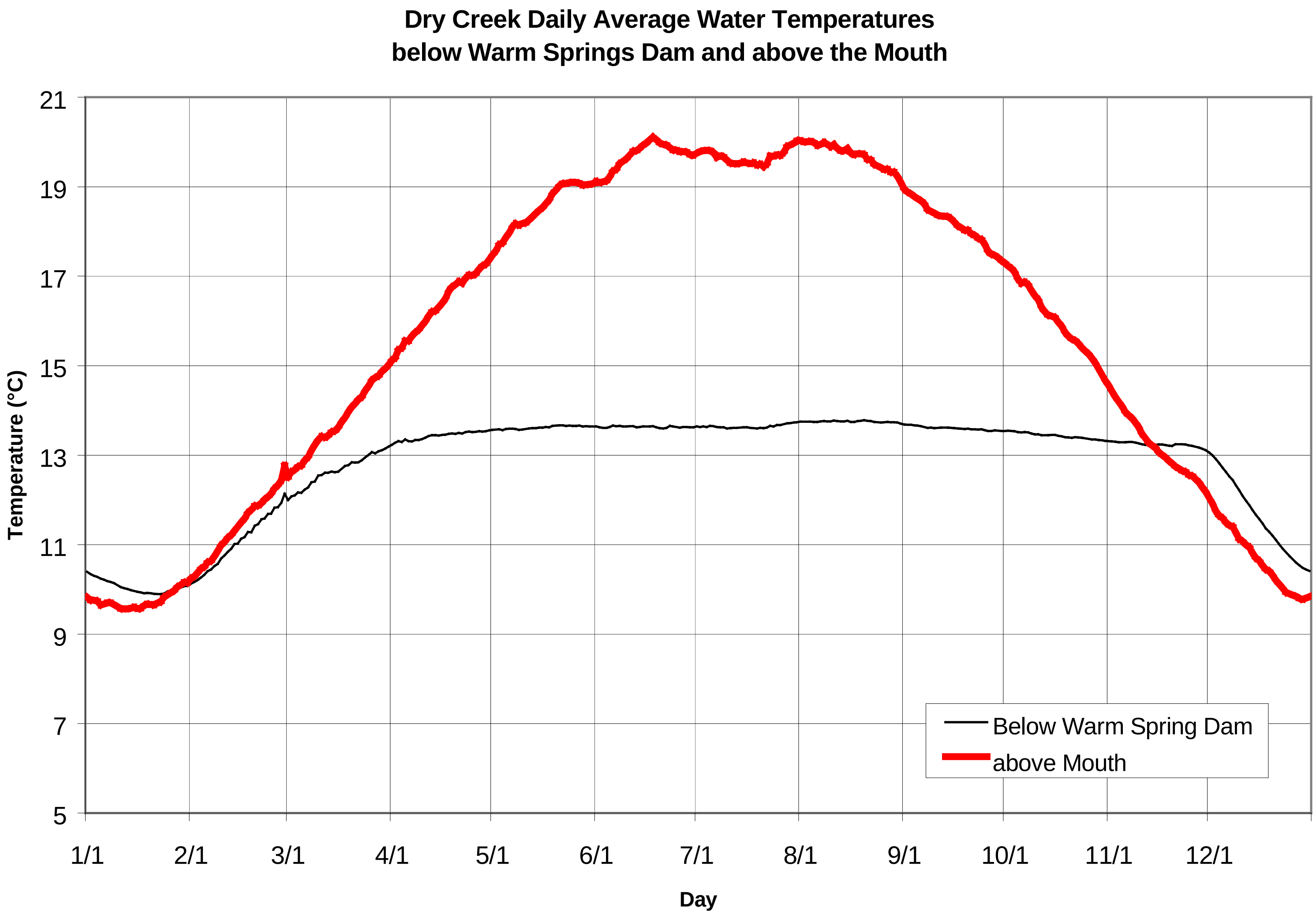


Figure 3-2 **Daily Water Temperatures Averaged over the Years Modeled (Water Years 1930 to 1995) in Dry Creek at Warm Springs Dam (River Mile [RM] 113.1) and Near the Mouth (RM 101.5)**

3.2.2 DISSOLVED OXYGEN

Average monthly and mean minimum monthly DO values for each of the years that were modeled (water years 1930 to 1995) are shown in Figures 3-3 and 3-4 for some of the sites used in this analysis.

The two upper Russian River sites near Ukiah and Hopland had similar trends over the course of the year, with the lowest DO values in the late summer and highest values in the late winter/early spring (Figure 3-3). The lowest DO values (less than 7.0 mg/l) occurred mostly in 1977 during late spring, summer and fall (critically dry conditions), with occasional low values in 1959 and 1994 (normal to dry conditions).

The middle Russian River sites had similar trends over the year, and low minimum DO values occurred in a few additional years. The lower Russian River sites at Dry Creek and the Hacienda Bridge had slightly lower DO values during the summer and fall than the upper Russian River sites. The lowest values occurred in the same few years, generally those with low flows.

Dry Creek, below Warm Springs Dam, had slightly lower DO levels than the middle and lower Russian River (Figure 3-4). However, in the summer near the mouth of Dry Creek, DO levels were higher than those in the Russian River.

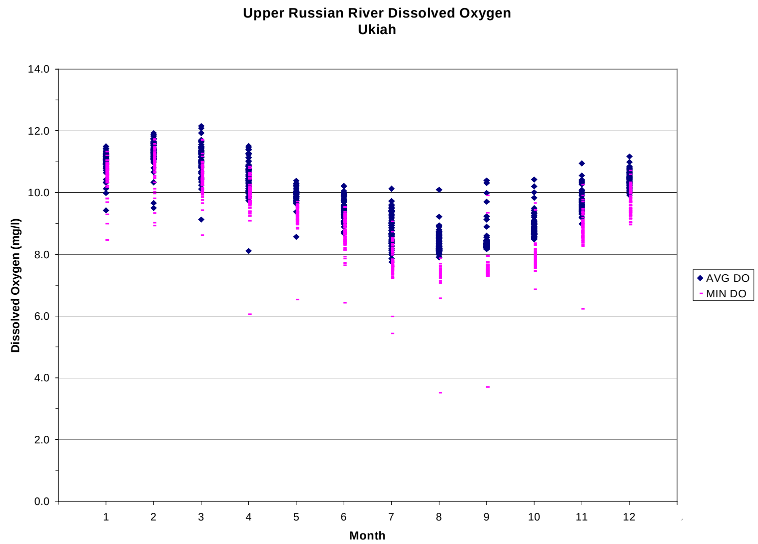
3.3 UPPER RUSSIAN RIVER

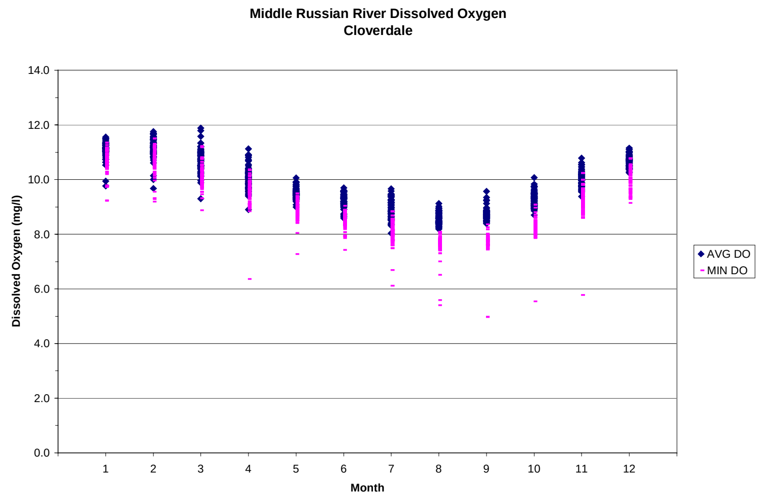
The following section addresses potential effects of flow, temperature and DO in the upper, middle, and lower reaches of the Russian River, and in Dry Creek (based on model values) on coho salmon, steelhead, and chinook salmon.

3.3.1 COHO SALMON

3.3.1.1 Flow

Coho salmon use the Russian River primarily for passage. Spawning and rearing occur in the tributaries. Under the D1610/2000 scenario during November through January, the coho migration period, 50 percent exceedance flows typically ranged from 152 to 468 cfs (Table 3-3). Under normal water supply conditions, 80 percent exceedance ranged from 152 to 316 cfs. These flows were sufficient to pass coho over shallow riffles (critical riffles) (pers. comm. B. Cox 5-21-01, S. White and S. Chase 5-21-01), which are the only natural obstacles in the mainstem. There are several small dams that may be obstacles as well. Wohler inflatable dam was the only dam included in this consultation. Passage at this facility is discussed in *Interim Report 4: Water Supply and Diversion Facilities*. Healdsburg Dam is addressed in a separate Section 7 Consultation. The discussion of flows for passage in this report is restricted to those flows needed to allow adult salmonids to move past critical riffles.





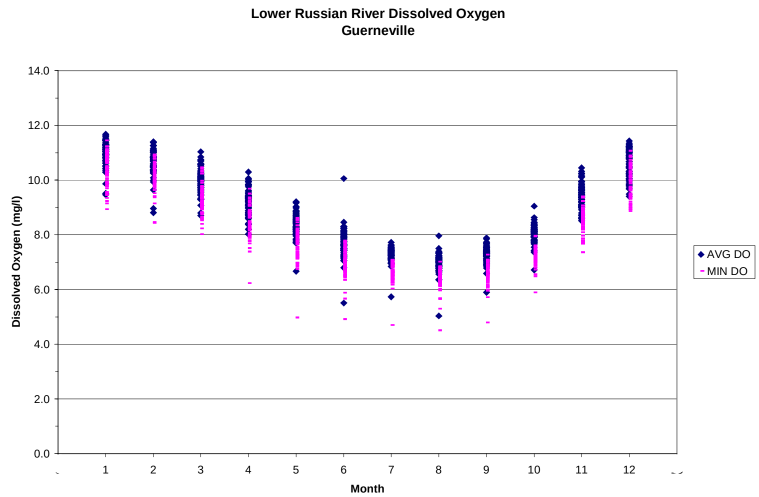
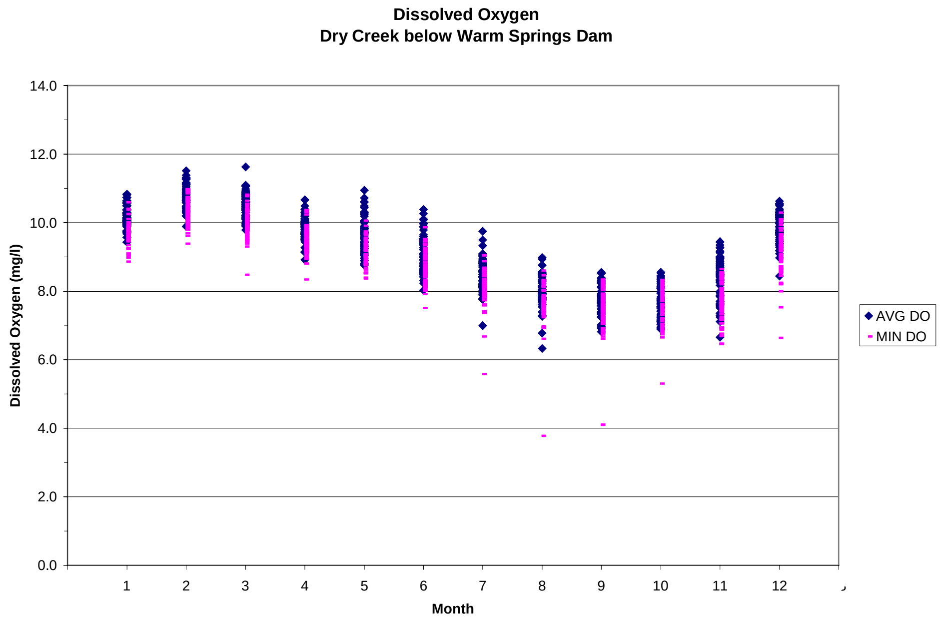


Figure 3-3 Monthly Average and Monthly Mean Minimum Dissolved Oxygen in Russian River Based on Model Data for Water Years 1930 to 1995



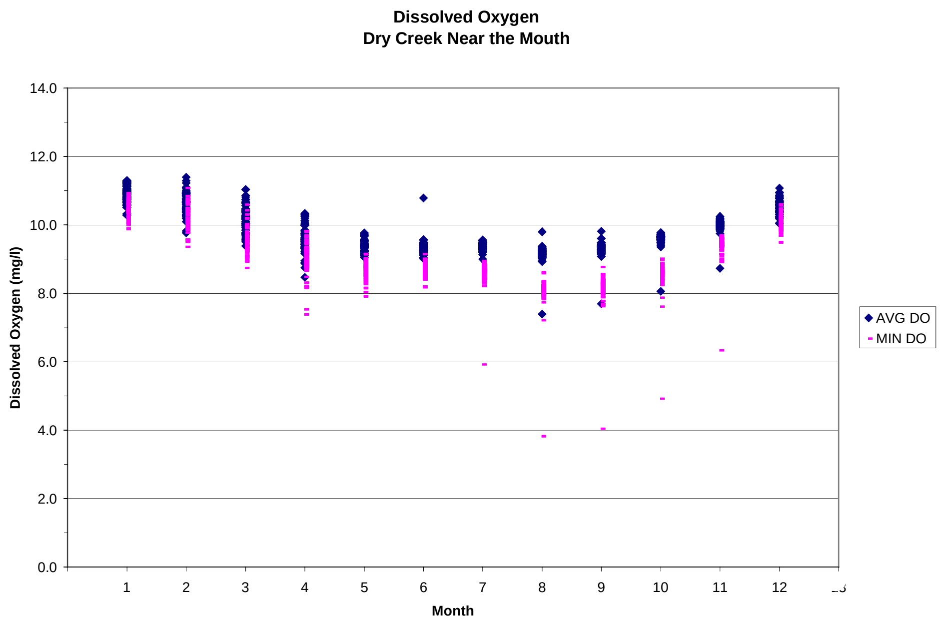


Figure 3-4 Monthly Average and Monthly Mean Minimum Dissolved Oxygen in Dry Creek Based on Model Data for Water Years 1930 to 1995

Under dry water supply conditions, the 50 percent exceedance flows during the coho immigration period ranged from 92 to 99 cfs, the 80 percent exceedance flow ranged from 77 to 90 cfs. Coho salmon would be able to migrate upstream with little or no impediment about half the time, and would experience a substantial impediment or perhaps a barrier the other half of the time under dry water conditions. However, passage was likely completely unimpeded during and immediately following storm events. In critical water supply conditions, 50 percent exceedance flows ranged as low as 19 cfs (November 1977) and 90 percent exceedance flows were as low as 10 cfs. In these rare critical water supply conditions (1.5 percent of days in November and December), passage past most riffles would have been impossible. During these conditions, passage would have been restricted to storm events that caused brief spikes in flow levels (pers. comm. B. Cox 11-2-01). Critical water supply conditions generally do not persist for the entire length of the migration period. Historically, critical water supply conditions persisted for three consecutive months only in 1977, which was a very dry year.

Young coho emigrate from the Russian River from February to mid-May. During the emigration, water depth is not as important as water velocity in facilitating the downstream migrants. Throughout this time of year, juvenile fish actively swim downstream to the ocean aided by the current. These fish are much smaller than adults and consequently need less depth to pass downstream. Generally speaking, more flow is better for emigrating salmonids as this increases velocities and moves these smolts downstream more quickly (Sandercock 1991).

During normal water supply conditions, the flows between February and May typically ranged from 249 to 643 cfs. In dry water supply conditions, flows during this period typically ranged from 109 to 212 cfs, and in critical water supply conditions, they ranged from 44 to 159 cfs. There was sufficient depth for the fish to move downstream past natural obstacles in all water supply conditions. The reduced velocities in dry and critical water supply conditions may have slowed the emigration of these fish, increasing their exposure to adverse water temperatures and predation while in the mainstem.

Under the D1610/2020 scenario, changes in flow during the upstream and downstream migration periods under normal and dry water supply conditions were insufficient to materially affect passage opportunities for coho salmon (Table 3-4). In critical water supply conditions, flows were substantially increased downstream in February, and slightly increased in April, which would have tended to aid downstream migration, as compared to the D1610/2000 scenario. In May, however, flows were greatly decreased (from 159 to 25 cfs), which would have hindered downstream migration by slowing water velocities.

3.3.1.2 Water Quality

Temperature

Table 3-15 summarizes the percentage of temperature scores for each evaluation category for coho salmon upstream migration.

Table 3-15 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Upper Russian River under D1610 Requirements with Year 2000 Demand

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	8549	72.4	2146	15.8
4	1794	15.2	6663	49.1
3	761	6.4	2067	15.2
2	366	3.1	2617	19.3
1	334	2.8	68	0.5
0	0	0.0	5	0.0
Sum	11,804		13,566	
Average		4.5		3.6

Temperature scores for coho salmon during adult upstream migration were high; scores of 5 occurred 72.4 percent of the time, and scores of 3 or better occurred 94.0 percent of the time. The average score across all years was 4.5. Only in rare instances were there modeled water temperatures high enough to stress fish (scores of 2 or 1), and these occurred during the early portion of the coho salmon migration period.

Table 3-16 Monthly Temperature Scores for Coho Salmon Upstream Migration by Month under the D1610/2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month											
Nov	0	0	0	0	22	884	381	331	189	173	0
Dec	0	0	0	12	127	1839	65	3	0	0	0
Jan	0	0	0	0	164	1692	14	6	0	0	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Nov	0	0	0	0	6	859	432	354	167	162	0
Dec	0	0	0	0	97	1879	66	4	0	0	0
Jan	0	0	0	0	140	1701	26	8	1	0	0

Coho juveniles utilize the mainstem Russian River for downstream migration from February through mid-May. About 80 percent of the time, temperatures during this period scored a 3 or better (Table 3-15). The remaining 20 percent of the time, temperatures scored a 2 or less, indicating some stressful conditions did occur. Temperatures less than 2 were very infrequent. Table 3-17 shows the frequency of scores by month for all the years modeled. Near Hopland, 85 percent of the periods in May scored 2 in the lower portion of the reach and 35 percent of the periods in April as well. Near Ukiah, temperatures were generally lower. Earlier months in both reaches generally had higher scores. Therefore, the water quality model suggests that coho juveniles are likely to experience suitable water temperatures for most of the downstream migration period in the upper Russian River, but stressful conditions may be present in the last few weeks of the migration period.

Table 3-17 Frequency of Temperature Scores by Month for Coho Juveniles in the Upper Russian River During Downstream Migration

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month											
Feb	0	0	13	115	1698	64	2	0	0	0	0
Mar	0	0	0	0	653	1000	270	120	34	0	0
Apr	0	0	0	0	28	709	586	427	260	0	0
May	0	0	0	0	0	25	145	297	333	4	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Feb	0	0	9	90	1646	130	16	1	0	0	0
Mar	0	0	0	0	539	870	376	208	84	0	0
Apr	0	0	0	0	17	360	425	500	704	4	0
May	0	0	0	0	0	1	18	102	662	19	2

Model results indicated that under D1610 requirements with Year 2020 demand levels, water temperatures would have remained similar to those having occurred under the Year 2000 demand level.

Table 3-18 Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Upper Russian River under D1610 Requirements with Year 2000 Demand

	Upstream Migration Nov 1 to Jan 31		**Downstream Migration** Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	8925	75.6	2016	14.9
4	1907	16.2	6651	49.0
3	540	4.6	2091	15.4
2	260	2.2	2727	20.1
1	172	1.5	76	0.6
0	0	0.0	5	0.0
Sum	11,804		13,566	
Average		4.6		3.6

Dissolved Oxygen

Table 3-19 summarizes the percentage of DO evaluation scores for each evaluation category for the migration of coho salmon. DO scores for all life history stages of coho salmon were optimal, with all periods receiving scores of 5. Table 3-20 indicates that similar DO levels would be expected under D1610 under the Year 2020 scenario.

Table 3-19 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Upper Russian River under D1610/ 2000 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12,206	100.0	13,947	99.8
4	0	0.0	21	0.2
3	0	0.0	0	0.0
2	0	0.0	0	0.0
1	0	0.0	0	0.0
0	0	0.0	0	0.0
Sum	12,206		13,968	
Average		5.0		5.0

Table 3-20 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Upper Russian River under D1610/ 2000 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12,206	100.0	13,925	99.7
4	0	0.0	39	0.3
3	0	0.0	4	0.0
2	0	0.0	0	0.0
1	0	0.0	0	0.0
0	0	0.0	0	0.0
Sum	12,206		13,968	
Average		5.0		5.0

3.3.2 STEELHEAD

3.3.2.1 Flow

Steelhead use the Russian River primarily as a migration corridor to tributaries and areas further upstream above the Forks. However, steelhead adults have been observed spawning in the mainstem (pers. comm. R. Coey 2000). Therefore, potential effects to all lifestages in this portion of the river is evaluated. Steelhead have similar passage requirements to coho salmon, but their primary migration season is somewhat later, occurring from January through March. During this period, 50 percent exceedance flows ranged from 327 to 575 cfs (Table 3-3). The 90 percent exceedance flows ranged from 152 to 517 cfs. These flows would have provided unimpeded passage for adult steelhead to migrate upstream (pers. comm. B. Cox per comm. 2001, S. White and S. Chase 2001). During dry water supply conditions, 50 percent exceedance flows ranged from 99 to 212 cfs. These flows may have somewhat impeded passage (pers. comm. S. White 10/24/01, B. Cox 11/2/01), but steelhead were still likely able to migrate. The

80 percent exceedance flows ranged from 77 to 173 cfs during dry water supply conditions. These lower flows would likely impair upstream passage and perhaps block it, particularly near the Forks where there is less tributary contribution to flow. Passage would be available during and following storm events. During critical water supply conditions, the 50 percent exceedance flows ranged from 43 to 84 cfs and the 80 percent exceedance flows ranged from 31 to 45 cfs during the steelhead upstream migration period. It is likely that flows of this magnitude would have blocked, or at least substantially impaired, passage most of the time. Pulses of flow from storms may have provided passage opportunities periodically under critical water supply conditions.

Spawning, incubation, and emergence occur from January through May. The 50 percent exceedance flow for this period ranged from a high of 642 cfs in February to a low of 240 cfs (Table 3-3) in May. Given the morphology of the river and the abundance of suitable spawning gravels, it is likely the flows present during this time of year provided adequate spawning habitat for steelhead. During dry water supply conditions, 50 percent exceedance flows ranged from 99 to 212 cfs. These flows likely provided spawning habitat for steelhead in the upper Russian River mainstem.

Generally, steelhead rear in freshwater for one to two years before emigrating to the ocean. The flows resulting from current operations generally provided a substantial amount of habitat for the rearing lifestages of steelhead (pers. comm. B. Cox 5-21-01, S. White and S. Chase 5-21-01). In the upper river, this habitat is enhanced by stands of riparian vegetation that trail branches into the stream margins, as well as emergent vegetation, and occasional rocky outcrops and boulders.

Under dry water supply conditions, flows were substantially lower than under normal conditions. During the first two to three months (April, May, June) of the rearing period, this might have been beneficial to newly emerged fry from the standpoint of providing some areas of lower velocity in the river. During the summer months, the reduction in streamflow was less pronounced, and there was probably ample space available for steelhead rearing at current population levels. Under critical water supply conditions, flows became lower still, and loss of habitat area may have outweighed the benefit of lower velocities for newly emerged fry. Habitat may have been particularly constrained during the late summer and early fall, when model results indicated that the flows may have been less than 20 cfs from September through November in the upper portion of the reach near Ukiah, and may have ceased completely near Hopland. Under these conditions, habitat quality would have been substantially reduced and steelhead may have been stranded or concentrated into pools where they would have been more vulnerable to predators.

Under the D1610/2020 scenario, flow changes were small during normal and dry years (Table 2-4) and were unlikely to provide substantial changes in habitat quantity or quality, relative to the D1610/2000 scenario. Flows were generally increased during dry water supply conditions relative to the D1610/2000 scenario, but generally by less than 20 percent. During critical water supply conditions, flows may have been substantially reduced from the D1610/2000 scenario from May through August, and may have been completely eliminated from June through September. This would have resulted in even greater compression of habitat into pools, with its associated risks, as described above.

3.3.2.2 Water Quality

Temperature

Table 3-21 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for steelhead.

Table 3-21 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Upper Russian River under D1610/ 2000 Scenario

	Upstream Migration Jan 1 to Mar 31		Spawning Jan 1 to Apr 30		Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	5707	48.8	5887	37.5	5887	29.6	5924	12.2	3906	24.5
4	3299	28.2	5057	32.2	3669	18.5	21010	43.1	7176	45.0
3	2099	18.0	3432	21.8	3545	17.8	7891	16.2	2919	18.3
2	557	4.8	1157	7.4	3675	18.5	10561	21.7	1820	11.4
1	28	0.2	164	1.0	2735	13.8	2999	6.2	116	0.7
0	0	0.0	13	0.1	353	1.8	367	0.8	9	0.1
Sum	11,690		15,710		19,864		48,752		15,946	
Average		4.2		4.0		3.3		3.3		3.8

Temperature scores for steelhead spawning runs were generally good to excellent, with scores of 3 or better for 95 percent of upstream migration scores (average score of 4.2) and for 91.5 percent of spawning scores (average score of 4.0).

Temperature scores for egg incubation were good, with scores of 3 or better for 65.9 percent of the time. The average score over all years for egg incubation was 3.3. Table 3-12 shows that stressful egg incubation scores due to high water temperature were most likely to occur from March through May in the lower portion of the upper reach, and potentially lethal conditions could have occurred by May.

Evaluation scores suggest water temperatures were good for steelhead rearing (a score of 3 or higher) over 70 percent of the time (Table 3-21). Temperature for growth was good to optimal between fall and spring. Modeled water temperatures that were high enough to stress rearing steelhead could occur from June through October, with higher temperatures being more prevalent near Hopland than near Ukiah (Table 3-13). During July through September, temperatures throughout the reach were usually high enough to stress rearing steelhead, with scores of 2 or less over 85 percent of the time (Table 3-13). In a small proportion of the days, scores of 0 suggested modeled summer water temperatures may have been high enough to kill rearing steelhead. During the summer and early fall months, scores of 3 or higher were relatively infrequent. However, by utilizing coarse substrates and fast water, steelhead may have tolerated higher temperatures than published criteria would suggest (Smith and Li, 1983). The highest average daily temperatures were generally less than 25ºC (Figure 3-1). During this time, steelhead may have been limited to refuge areas. They may only have been able to survive or grow if abundant food and fast water were available.

Table 3-22 Frequency of Temperature Scores by Month for Steelhead Incubation in Upper Russian River

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month	0	0	0	0	410	1594	58	15	0	0	0
Jan	0	0	0	0	90	1512	266	24	0	0	0
Feb	0	0	0	0	0	352	838	733	152	2	0
Mar	0	0	0	0	0	0	257	1066	617	70	0
Apr	0	0	0	0	0	0	2	230	1062	558	24
May											
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Jan	0	0	0	0	348	1626	80	22	1	0	0
Feb	0	0	0	0	63	1392	389	47	1	0	0
Mar	0	0	0	0	0	263	679	843	274	18	0
Apr	0	0	0	0	0	0	93	709	908	296	4
May	0	0	0	0	0	0	0	21	433	1259	163

The steelhead downstream migration period extends from March through June. The majority of the downstream migration period was rated good to optimal, with an average score of 3.8. Near Hopland in June, stressful temperatures may have occurred about half the time (Table 3-24). These temperatures reached very stressful levels less than 3 percent of the time in June.

Table 3-23 Frequency of Temperature Scores by Month for Steelhead Rearing in Upper Russian River under D1610/ 2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month											
Jan	0	0	0	511	1545	21	0	0	0	0	0
Feb	0	0	0	128	1735	29	0	0	0	0	0
Mar	0	0	0	0	1071	935	71	0	0	0	0
Apr	0	0	0	0	158	1466	356	30	0	0	0
May	0	0	0	0	1	537	1259	246	34	0	0
Jun	0	0	0	0	0	102	813	678	386	31	0
Jul	0	0	0	0	0	22	259	461	901	330	104
Aug	0	0	0	0	16	28	24	102	1087	770	50
Sep	0	0	0	0	99	32	18	68	1745	45	0
Oct	0	0	0	7	106	196	537	696	504	0	0
Nov	0	0	0	63	872	813	223	9	0	0	0
Dec	0	0	0	368	1617	61	0	0	0	0	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Jan	0	0	0	457	1584	36	0	0	0	0	0
Feb	0	0	0	99	1737	56	0	0	0	0	0
Mar	0	0	0	0	845	1076	156	0	0	0	0
Apr	0	0	0	0	74	1024	809	99	4	0	0
May	0	0	0	0	0	79	956	845	185	10	2
Jun	0	0	0	0	0	1	167	852	919	67	4
Jul	0	0	0	0	0	0	30	286	1271	415	75
Aug	0	0	0	0	0	9	6	49	1196	773	44
Sep	0	0	0	0	2	58	57	177	1616	97	0
Oct	0	0	0	0	45	301	613	716	371	0	0
Nov	0	0	0	22	871	874	203	10	0	0	0
Dec	0	0	0	308	1672	66	0	0	0	0	0

Table 3-24 Frequency of Temperature Scores by Month for Steelhead Downstream Migration in Upper Russian River under D1610/ 2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month											
Mar	0	0	0	0	1071	935	71	0	0	0	0
Apr	0	0	0	0	158	1466	356	30	0	0	0
May	0	0	0	0	1	537	1259	246	34	0	0
Jun	0	0	0	0	0	102	760	618	310	19	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Mar	0	0	0	0	845	1076	156	0	0	0	0
Apr	0	0	0	0	74	1024	809	99	4	0	0
May	0	0	0	0	0	79	956	845	185	10	2
Jun	0	0	0	0	0	1	167	807	780	53	1

Under the D1610/2020 scenario temperature, scores were very similar to those under the D1610/2000 scenario. There was a very slight downward shift in the scores for the incubation and downstream migration lifestages.

Table 3-25 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Upper Russian River under D1610/ 2020 Scenario

	Upstream Migration		Spawning		Incubation		Rearing		Downstream Migration	
	Jan 1 to Mar 31		Jan 1 to Apr 30		Jan 1 to May 31		Oct 1 to Sept 30		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	5635	48.2	5777	36.8	5777	29.1	5642	11.6	3802	23.8
4	3311	28.3	4973	31.7	3760	18.9	21418	43.9	6904	43.3
3	2105	18.0	3582	22.8	3409	17.2	7810	16.0	2952	18.5
2	604	5.2	1208	7.7	3732	18.8	8772	18.0	2032	12.7
1	35	0.3	155	1.0	2782	14.0	4072	8.4	181	1.1
0	0	0.0	15	0.1	404	2.0	1038	2.1	75	0.5
Sum	11,690		15,710		19,864		48,752		15,946	
Average		4.2		4.0		3.2		3.3		3.7

Dissolved Oxygen

Table 3-26 summarizes the percentage of DO evaluation scores for each evaluation category and each life history stage for steelhead. DO scores were optimal for all life history stages of steelhead under D1610/2000 scenario. Under the 2020 scenario, there was a very slight downward shift in scores. This shift affected only a small proportion of days, and the vast majority of days still scored 4 or 5, with only a few days scoring 3. No days scored less than 3 under either scenario, thus DO conditions for steelhead were always good.

Table 3-26 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Upper Russian River under D1610/ 2000 Scenario

	Upstream Migration		Spawning/Incubation		Rearing		Downstream Migration	
	Jan 1 to Mar 31		Jan 1 to May 31		Oct 1 to Sept 30		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12092	100.0	20146	99.4	48349	99.2	16324	99.9
4	0	0.0	108	0.5	409	0.8	24	0.1
3	0	0.0	12	0.1	0	0.0	0	0.0
2	0	0.0	0	0.0	0	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,092		20,266		48,758		16,348	
Average		5.0		5.0		5.0		5.0

Table 3-27 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Upper Russian River under D1610/ 2020 Scenario

	Upstream Migration Jan 1 to Mar 31		Spawning/Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30		
	Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12092	100.0	20049	98.9	47679	97.8	16263	99.5	
4	0	0.0	201	1.0	1073	2.2	81	0.5	
3	0	0.0	10	0.0	2	0.0	4	0.0	
2	0	0.0	6	0.0	4	0.0	0	0.0	
1	0	0.0	0	0.0	0	0.0	0	0.0	
0	0	0.0	0	0.0	0	0.0	0	0.0	
Sum	12,092		20,266		48,758		16,348		
Average		5.0		5.0		5.0		5.0	

3.3.3 Chinook Salmon

3.3.3.1 Flow

Chinook salmon use habitats in the mainstem and Dry Creek for all freshwater lifestages. Adult chinook salmon migrate upstream from late-August through late-December with the vast majority of migrants moving between late October and mid-December. Based on the D1610/2000 scenario simulations, the 50 percent exceedance flows range between 152 to 234 cfs between August and December (Table 3-3) and the 80 percent exceedance flows range from 152 to 230 cfs. The flows provide adequate passage conditions for adult migration through the stream (pers. comm. B. Cox 11-02-01 and S. White 10-24-01). Under dry water supply conditions, the 50 percent exceedance flows during this period ranged from 90 to 127 cfs, with flows highest in August and lowest in December. These flows would have somewhat restricted upstream migration, but were unlikely to completely block it. The 80 percent exceedance flows ranged from 77 to 113 cfs, with the lowest flows corresponding to the peak migration season. The lower flows in this range would probably block migration at some riffles and substantially impair passage at others. Flows were quite low during critical water supply conditions. The 80 percent exceedance flows during September through November were less than 45 cfs. With these flows, it was unlikely that adult chinook could have migrated upstream, except following significant storm events.

Spawning occurs from October through January, when 50 percent exceedance flows ranged from 152 to 468 cfs (Table 3-3). Given the morphology of the river, the availability of suitable gravels, the length of river available, and the low number of chinook present, it is likely that there was sufficient spawning area available for chinook salmon. Under dry water supply conditions, the 50 percent exceedance flows were between 90 and 99 cfs. The amount of suitable available space under these flow conditions may have been somewhat constrained. However, spawning was still likely to occur. In critical water supply conditions, flows dropped to less than half this level, which would have further constrained the available area for spawning, and decreased the quality of this habitat as well.

Chinook salmon juveniles emerge from the gravels in February and March and may spend from a few weeks to a few months rearing in the river prior to emigration. The emigration of chinook appeared to tail off in June (Chase *et al.* 2000, Chase *et al.* 2001). During this period, flows ranged from 242 to 575 cfs (Table 3-3) under the D1610/2000 scenario. The effect of these flows on chinook juveniles was likely to be similar to that on steelhead fry, but these higher flows probably assisted the chinook juveniles with their emigration. To some extent, the lower flows (109 to 212 cfs) under dry water supply conditions may have improved conditions for juvenile rearing because water velocities were reduced. However, even at the higher flows present under normal water supply conditions, there appeared to be sufficient low velocity area available for juvenile salmonids (pers. comm. B. Cox 11-02-01). The lower flows may have also reduced the available area and slowed juvenile emigration through reduction of velocities. This may mean that juveniles remained in the Russian River longer when dry water supply conditions prevailed, and thus, they may have been exposed to potentially stressful temperatures and predation for a longer period of time. In critical water supply conditions, flows dropped a bit further, but only slightly (except in February). Thus, conditions for chinook juveniles may have been slightly less suitable than under dry water supply conditions.

Under the D1610/2020 scenario, flows during normal water supply conditions were generally changed by less than 8 percent and would have had the same value for all lifestages of chinook salmon. The only exception occurred in December, when flows decreased 17 percent from 303 to 250 cfs. During this time, adult chinook upstream migration and spawning occur. However, given the magnitude the flows, this change was very unlikely to have affected either life history event.

In dry water supply conditions, flows increased slightly (4 to 23 percent) in every month over the D1610/2000 scenario, except in February when flows would have decreased from 212 to 176 cfs. It is unlikely that these flow changes substantially affected habitat for chinook salmon, but may have resulted in slightly improved conditions relative to the D1610/2000 scenario. In dry water supply conditions, flows were substantially increased in January and February and decreased between May and August. This change in flows may have enhanced conditions for spawning and incubation during January and February, and substantially reduced the suitability of conditions for rearing and emigration in May and June. Upstream migration might also have been substantially affected by the lack of flow in August, but under these water supply conditions, it is likely that conditions in the lower river would have prevented upstream migration to this area in August.

3.3.3.2 Water Quality

Temperature

Table 3-28 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for chinook salmon.

Table 3-28 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook Salmon in Upper Russian River under D1610/ 2000 Scenario

	Upstream Migration		Spawning		Incubation		Rearing		Downstream Migration	
	Aug 15 to Jan 15		Nov 1 to Jan 31		Nov 1 to Mar 31		Feb 1 to May 31		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	4039	20.2	10271	87.0	14819	75.1	2146	13.7	2146	10.9
4	5549	27.7	536	4.5	2496	12.6	10194	64.9	10658	54.0
3	2444	12.2	416	3.5	1207	6.1	3019	19.2	4964	25.2
2	1184	5.9	252	2.1	644	3.3	330	2.1	1750	8.9
1	1475	7.4	137	1.2	329	1.7	16	0.1	203	1.0
0	5353	26.7	192	1.6	247	1.3	5	0.0	9	0.0
Sum	20,044		11,804		19,742		15,710		19,730	
Average		2.7		4.7		4.5		3.9		3.6

Temperature scores for chinook salmon during the adult upstream migration ranged from potentially lethal to optimal (0 to 5) (Table 3-28), but all scores lower than 3 occurred between August and October (Table 3-16). During the peak of chinook upstream migration, late October through mid-December, water temperatures nearly always scored 4 or 5 (Table 3-29). Temperature scores for spawning and incubation were generally excellent, with scores of 4 or better for over 90 percent of the time for spawning, and nearly 88 percent of the time for egg incubation. The average scores for spawning and egg incubation over all years were 4.7 and 4.5, respectively. In only about 3 percent of evaluation periods were model water temperatures high enough to severely stress or kill chinook salmon eggs.

Rearing scores for chinook salmon in the upper Russian River were generally rated good to optimal. Nearly 98 percent of the time, temperature scores were 3 or better. Scores of 2 or 1 occurred less than 3 percent of time (Table 3-28). These stressful conditions occurred in the latter part of the rearing season (May), and they were more likely to occur near Hopland than near Ukiah (Table 3-29). Scores of 2 were much more prevalent than scores of 1.

Table 3-29 Frequency of Temperature Scores by Month for Chinook Upstream Migration in Upper Russian River under D1610/ 2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month											
Jan	0	0	0	221	546	37	0	0	0	0	0
Aug	0	0	0	0	1	35	9	7	29	47	1011
Sep	0	0	0	0	16	115	4	16	42	248	1566
Oct	0	0	0	7	61	241	283	381	487	479	107
Nov	0	0	0	55	345	1348	168	59	5	0	0
Dec	0	0	0	343	1236	467	0	0	0	0	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Jan	0	0	0	194	544	66	0	0	0	0	0
Aug	0	0	0	0	0	9	4	7	26	32	1061
Sep	0	0	0	0	0	60	38	27	130	363	1389
Oct	0	0	0	0	9	337	333	414	517	366	70
Nov	0	0	0	19	315	1433	160	51	2	0	0
Dec	0	0	0	280	1191	575	0	0	0	0	0

Table 3-30 Frequency of Temperature Scores by Month for Chinook Rearing in Upper Russian River

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Ukiah (RM 88.53, Forks Q)**										
Month											
Feb	0	0	0	128	1698	64	2	0	0	0	0
Mar	0	0	0	0	653	1000	422	2	0	0	0
Apr	0	0	0	0	28	709	1203	70	0	0	0
May	0	0	0	0	0	25	1269	558	24	0	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**										
Month											
Feb	0	0	0	99	1646	130	17	0	0	0	0
Mar	0	0	0	0	539	870	650	18	0	0	0
Apr	0	0	0	0	17	360	1333	296	4	0	0
May	0	0	0	0	0	1	453	1259	148	13	2

Temperatures under the D1610/2020 scenario were generally similar to those observed under the D1610/2000 scenario, with slight improvements in the scores for upstream migration, spawning, and egg incubation.

Table 3-31 Frequency of Temperature Scores by Month for Chinook Upstream Migration in Upper Russian River under D1610/ 2020 Scenario

Score	Upstream Migration Aug 15 to Jan 15		Spawning Nov 1 to Jan 31		Incubation Nov 1 to Mar 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent
5	4048	20.2	10763	91.2	15388	77.9	2016	12.8	2016	10.2
4	6272	31.3	383	3.2	2331	11.8	10231	65.1	10545	53.4
3	2762	13.8	313	2.7	1027	5.2	3065	19.5	4864	24.7
2	1144	5.7	177	1.5	587	3.0	365	2.3	1930	9.8
1	1068	5.3	98	0.8	273	1.4	28	0.2	300	1.5
0	4750	23.7	70	0.6	136	0.7	5	0.0	75	0.4
Sum	20,044		11,804		19,742		15,710		19,730	
Average		2.8		4.8		4.6		3.9		3.6

Dissolved Oxygen

Table 3-32 summarizes the percentage of DO scores for each evaluation category and each life history stage for chinook salmon.

Table 3-32 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Upper Russian River under D1610/2000 Scenario

Score	Upstream Migration Aug 15 to Jan 15		Spawning/Incubation Nov 1 to Mar 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent
5	20452	100.0	0	0.0	16088	99.9	20108	99.9
4	0	0.0	4010	19.9	24	0.1	24	0.1
3	0	0.0	15036	74.6	0	0.0	0	0.0
2	0	0.0	1091	5.4	0	0.0	0	0.0
1	0	0.0	7	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	20,452		20,144		16,112		20,132	
Average		5.0		3.1		5.0		5.0

DO scores were optimal for adult upstream migration, juvenile rearing, and downstream migration. Egg incubation is the life history stage most sensitive to low DO, and for this lifestage, scores were 3 or better over 90 percent of the time. About 5.4 percent of the time, DO levels would have been expected to drop low enough to begin to stress chinook eggs. The average score over all years for egg incubation was 3.1. Lower DO scores occurred in all months, but were most common in November (Table 3-33).

Table 3-33 Frequency of Modeled Dissolved Oxygen Scores by Month in Each Evaluation Category for Chinook Salmon Egg Incubation in Upper Russian River under D1610/2000 Scenario

Score	0	1	2	3	4	5
Location	**RR near Ukiah (RM 88.53, Forks Q)**					
Month						
Jan	0	0	0	50	1359	434
Feb	0	0	0	0	285	703
Mar	0	0	0	0	3	80
Nov	0	0	0	0	0	1
Dec	0	0	31	1998	17	0
Location	**RR near Hopland (RM 80.5, Hopland Q)**					
Month						
Jan	0	0	17	1620	440	0
Feb	0	0	16	1120	756	0
Mar	0	0	32	1568	477	0
Nov	0	4	260	1715	1	0
Dec	0	0	15	1999	32	0

Under the D1610/2020 scenario, DO scores would have been similar to those expected under the 2000 scenario, with a slight improvement in the overall score for spawning and incubation from 3.1 to 3.2.

Table 3-34 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Upper Russian River under D1610/2020 Scenario

	Upstream Migration Aug 15 to Jan 15		Spawning/Incubation Nov 1 to Mar 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	20452	100.0	0	0.0	16069	99.7	20040	99.5
4	0	0.0	4023	20.0	37	0.2	88	0.4
3	0	0.0	15233	75.6	2	0.0	4	0.0
2	0	0.0	869	4.3	4	0.0	0	0.0
1	0	0.0	19	0.1	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	20,452		20,144		16,112		20,132	
Average		5.0		3.2		5.0		5.0

3.4 MIDDLE RUSSIAN RIVER

The portion of the middle Russian River from Asti upstream to Cloverdale has been used by steelhead and chinook salmon for spawning and rearing (pers. comm. B. Coey 2000), although, primary habitat for steelhead spawning and rearing is probably in tributary streams. Steelhead use the mainstem mainly as a migration corridor. Coho salmon use this portion of the mainstem exclusively as a migration corridor between the ocean, and spawning and rearing areas in the tributaries. The Russian River below Asti is not thought to be used by salmonids to any great extent except as a migration corridor. It does not provide summer rearing habitat because of poor habitat conditions. These habitat conditions result from a variety of factors. These factors include historic gravel mining activities, encroachment on the channel by agricultural development, channel straightening and other practices related to flood control, loss of the riparian corridor, and warm environmental conditions. Flow releases from the project reservoirs are not a primary cause of the poor habitat in the Russian River below Asti. Both dams release water from their cool hypolimnions during the summer months. This water is the coolest water available for release, and is colder than the waters flowing into the reservoirs during the summer months. These releases create the suitable temperature conditions that occur in the upper Russian River and on Dry Creek. The water temperature increases due to warm atmospheric conditions and the lack of shade as it moves downstream.

3.4.1 Coho Salmon

3.4.1.1 Flow

During the coho salmon migration period, flows in this segment of the Russian River under the D1610/2000 scenario typically ranged from 173 to 813 cfs (Table 3-5). The 80 percent exceedance flows for normal water supply conditions ranged from 166-482 cfs. Under these flows, migration through the middle Russian River was unlikely to be impeded past critical riffles in the mainstem. Under dry water supply conditions, 50 percent exceedance flows ranged from 94 to 315 cfs and 80 percent exceedance flows ranged from 89 to 130 cfs. Upstream passage during November and December may be somewhat impeded at some critical riffles, but it is likely that passage would be possible. In January, flows were sufficient to provide unimpeded passage. During critical water supply conditions, flows may be reduced less than 20 cfs. During critical water supply conditions, upstream passage is possible about 50 percent of the time in November and January. These opportunities are likely occur immediately during or following storm events.

Conditions for coho emigration were good during normal water supply conditions and became more impaired as water supply conditions worsened. This impairment resulted from the reduction of velocities, which would have slowed the emigration of coho smolts and increased their exposure to potentially stressful water temperatures (discussed in Section 3.4.1.2.1) and predators.

Under the D1610/2020 scenario (Table 3-6), flow conditions in this reach were very similar to those simulated using the D1610/2000 scenario, with most changes being less than 10 percent. The largest change was a 15 percent increase in flow in November, which would improve conditions for the upstream migration of coho. Given that the change in flow was from 94 to 108 cfs, this improvement was probably modest.

3.4.1.2 Water Quality

Temperature

Table 3-35 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for coho salmon.

Table 3-35 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	8674	73.5	1485	10.9
4	1752	14.8	5183	38.2
3	680	5.8	1366	10.1
2	386	3.3	4323	31.9
1	312	2.6	1209	8.9
0	0	0.0	0	0.0
Sum	11,804		13,566	
Average		4.5		3.1

Generally, temperature scores for coho salmon during adult upstream migration were nearly optimal, with scores of 5 for 73.5 percent of the time, and scores of 3 or better for 94.1 percent of the time (Table 3-35).

Table 3-36 shows the frequency of temperature scores by month for coho juvenile emigration. Temperature scores for juvenile emigration were generally poor in April and May, but good in February and March. Some days in March were scored 2; most days in April were scored 2; and by May, scores were mostly 1. Therefore, the scores suggest coho juveniles were likely to experience stressful water temperatures in the second half of their downstream migration period.

Table 3-36 Frequency of Temperature Scores by Month for Coho Juveniles in the Middle Russian River

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**Russian River near Cloverdale (RM 68.0)**										
Month											
Feb	0	0	9	88	1586	185	23	1	0	0	0
Mar	0	0	0	0	458	785	395	257	182	0	0
Apr	0	0	0	0	10	188	267	407	1064	0	0
May	0	0	0	0	0	0	2	36	544	0	0
Location	**Russian River near Healdsburg (RM 34.0)**										
Month											
Feb	0	0	10	40	1359	434	36	13	0	0	0
Mar	0	0	0	0	285	703	350	342	394	0	0
Apr	0	0	0	0	3	80	125	191	1270	0	0
May	0	0	0	0	0	0	0	4	231	0	0

Under the D1610/2020 scenario, temperature scores were similar to those that occurred under the 2000 scenario. There was a slight improvement in the upstream passage scores, while downstream migration scores shifted slightly downward (Table 3-37).

Table 3-37 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Middle Russian River under the D1610/2020 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	8826	74.8	1508	11.1
4	1800	15.2	5108	37.7
3	594	5.0	1349	9.9
2	349	3.0	4380	32.3
1	235	2.0	1221	9.0
0	0	0.0	0	0.0
Sum	11,804		13,566	
Average		4.6		3.1

3.4.1.3 Dissolved Oxygen

Table 3-38 summarizes the percentage of DO evaluation scores for coho salmon migration under the D1610/2000 scenario. DO scores were optimal; the upstream and downstream migration periods received a score of 5. The scores for the D1610/2020 scenario differed from the D1610/2000 scenario by only the score on a single day, which shifted from a score of 5 to a score of 4.

Table 3-38 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12206	100.0	13947	99.8
4	0	0.0	21	0.2
3	0	0.0	0	0.0
2	0	0.0	0	0.0
1	0	0.0	0	0.0
0	0	0.0	0	0.0
Sum	12,206		13,968	
Average		5.0		5.0

Table 3-39 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Nov 1 to Jan 31		**Downstream Migration** Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12206	100.0	13946	99.8
4	0	0.0	22	0.2
3	0	0.0	0	0.0
2	0	0.0	0	0.0
1	0	0.0	0	0.0
0	0	0.0	0	0.0
Sum	12,206		13,968	
Average		5.0		5.0

3.4.2 STEELHEAD

3.4.2.1 Flow

The 50 percent exceedance flows during the primary steelhead migration season was greater than 700 cfs in all months and the 80 percent exceedance flow was greater than 250 cfs. These flows provide unimpeded upstream passage for steelhead under normal water supply conditions. In the upper portion of the reach, spawning, incubation, emergence, rearing, and emigration occurred between January and May (emigration extended into June and occurred throughout the reach), with flows that ranged from 964 cfs in February to 278 cfs in May (June flow is 225 cfs). It is likely that these flows were sufficient to provide an adequate quantity and quality of habitat for these lifestages under normal water supply conditions.

In dry water supply conditions, the 50 percent exceedance flow during the upstream migration period ranged from 315 to 531 cfs, which still provided adequate flow for unimpeded passage over 50 percent of the time. The 80 percent exceedance flow ranged as low as 99 cfs, which may have created a minor impediment at some riffles. In critical water supply conditions, the 50 percent exceedance flow for migration ranged as low as 66 cfs and the 80 percent exceedance flow was never greater than 74 cfs. Flows at this magnitude would have severely impaired or blocked passage at natural barriers. Under these conditions, steelhead could have likely migrated upstream only during or immediately after significant rainfall. Upstream migration would have been possible 20 to 50 percent of the time in January and February, and between 50 and 80 percent of the time in March.

Flows for spawning and incubation during dry years appear to have been adequate to support these lifestages, ranging from 152 to 531 cfs. In critical water supply conditions, 50 percent exceedance flows dropped to 66 to 226 cfs, which likely resulted in a substantial decrease in the quantity and quality of available spawning and incubation habitat.

Effects on steelhead rearing were similar to that described for the upper Russian River segment. Flows were likely suitable under existing conditions for steelhead rearing in the current flow regime under normal and dry water supply conditions. In critical water supply conditions, flows were very low from August through November and approached 0 in September. These flows would have severely limited the amount of suitable habitat available for steelhead fry and juveniles.

The flows under the D1610/2020 scenario were very similar to those occurring under the D1610/2000 scenario and would not substantially affect the quantity or quality of habitat available for steelhead relative to the latter scenario (Table 3-6). In dry water supply conditions, however, there was a substantial reduction in flows during the summer and fall, with flows approaching 0 cfs from June through October. The minimal amount of flows during this time of year would have forced rearing steelhead into pools and reduced habitat quality and availability. This may have stressed juvenile steelhead and increased their exposure to predators. Flows from November through March were quite similar and would have resulted in similar conditions as the D1610/2000 scenario.

3.4.2.2 Water Quality

Temperature

Table 3-40 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for steelhead.

Table 3-40 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Jan 1 to Mar 31		Spawning Jan 1 to Apr 30		Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**		**Percent**	**Periods**	**Percent**		**Periods**	**Percent**
5	4609	39.4	4790	30.5	4790	24.1	4017	8.2	2194	13.8
4	3560	30.5	4595	29.2	3770	19.0	18261	37.5	4605	28.9
3	2172	18.6	2692	17.1	2349	11.8	6691	13.7	2525	15.8
2	1121	9.6	2250	14.3	2519	12.7	12227	25.1	5192	32.6
1	228	2.0	1079	6.9	3588	18.1	6513	13.4	1160	7.3
0	0	0.0	304	1.9	2848	14.3	1043	2.1	270	1.7
Sum	11,690		15,710		19,864		48,752		15,946	
Average		4.0		3.6		2.8		3.0		3.0

Temperature scores for steelhead upstream migration were generally excellent, with scores of 4 or better nearly 70 percent of the time and scores of 3 or better 88.5 percent of the time (average score of 4). Approximately 11.6 percent of the time scores were stressful, but they never reached lethal levels. Stressful temperatures occurred primarily in March.

Scores for spawning were 3 or better nearly 77 percent of the time, with an average score of 3.6. Nearly two thirds of the remaining days scored a 2. The higher scores tended to occur in the early part of the season, while the lower scores tended to be prevalent in May. In May, water temperatures were stressful nearly half the time at the upper end of the reach and nearly 80 percent of the time at the downstream end of the reach (Table 3-41). Temperatures in the lethal

Table 3-41 Frequency of Temperature Scores by Month for Steelhead Spawning in Middle Russian River

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Jan	0	0	0	117	247	1574	130	9	0	0	0
Feb	0	0	0	9	50	1230	579	24	0	0	0
Mar	0	0	0	0	0	215	1028	652	182	0	0
Apr	0	0	0	0	0	0	198	650	711	225	25
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Jan	0	0	2	122	258	1585	110	0	0	0	0
Feb	0	0	0	10	27	943	863	49	0	0	0
Mar	0	0	0	0	0	90	898	692	366	31	0
Apr	0	0	0	0	0	0	83	311	729	544	142

range occurred infrequently in May near Cloverdale and occurred about 8 percent of the time near Healdsburg. Temperature scores for egg incubation were relatively evenly distributed among all score categories, resulting in an average score of 2.8. Scores of 3 or more were somewhat more prevalent than scores less than 3. Scores of 3 or better generally occurred from January into March, (Table 3-42). Temperatures began to reach stressful levels in March and were usually stressful in April and May. In the lower portion of the middle Russian River, potentially lethal temperatures were prevalent in May.

Table 3-42 Frequency of Temperature Scores by Month for Steelhead Incubation in Middle Russian River

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Jan	0	0	0	0	364	1574	110	29	0	0	0
Feb	0	0	0	0	59	1230	534	68	1	0	0
Mar	0	0	0	0	0	215	593	830	412	27	0
Apr	0	0	0	0	0	0	60	405	852	658	35
May	0	0	0	0	0	0	0	2	133	1127	614
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Jan	0	0	0	2	380	1585	106	4	0	0	0
Feb	0	0	0	0	37	943	764	135	13	0	0
Mar	0	0	0	0	0	90	521	727	578	161	0
Apr	0	0	0	0	0	0	17	191	525	1083	194
May	0	0	0	0	0	0	0	2	36	475	1363

Evaluation scores suggested that water temperatures were generally good for rearing steelhead, with scores of 3 or higher nearly 60 percent of the time with an average score of 3. However, this average score is deceptive. Examination of Table 3-43 shows that during June through

September temperatures were at least somewhat stressful for rearing steelhead the majority of time in the upper portion of the middle Russian River. In the lower portion of this reach, temperatures were somewhat stressful from May through September, and tended to be very stressful for most of July and August, generally exceeding 25° C. The prevalence of low temperature scores for a prolonged period in the summer months indicates that this area does not provide the quality of rearing habitat suggested by the average score. Steelhead rearing in this area during the spring may need to seek out cool water refugia or to migrate to cooler areas to over-summer. Some limited rearing may occur in the upper portion of the middle Russian River, however temperature conditions in the lower portion may preclude its use as a major rearing area.

The steelhead downstream migration period extends from March through June. Approximately 60 percent of the time during this period, temperature scores for steelhead smolts were 3 or better. Most of the remaining time scored 2, although approximately 9 percent of the time scores were 1 or 0. Scores were generally good in March and April and warmed to stressful levels in May. Near Healdsburg, temperatures were predominantly in the stressful range in May. By June, stressful temperatures were the norm, and in the lower portion of the reach, very stressful temperatures (score of 1) were common. Temperatures reached potentially lethal levels about 7 percent of the time in the lower portion of the reach in June.

Table 3-43 Frequency of Temperature Scores by Month for Steelhead Rearing in Middle Russian River

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Jan	0	0	0	459	1583	35	0	0	0	0	0
Feb	0	0	0	97	1710	85	0	0	0	0	0
Mar	0	0	0	0	726	1067	284	0	0	0	0
Apr	0	0	0	0	45	645	983	302	35	0	0
May	0	0	0	0	0	19	375	965	699	19	0
Jun	0	0	0	0	0	0	11	279	1585	126	9
Jul	0	0	0	0	0	0	0	49	1318	630	80
Aug	0	0	0	0	0	0	8	22	1149	838	60
Sep	0	0	0	0	0	14	61	279	1497	156	0
Oct	0	0	0	0	28	341	671	730	276	0	0
Nov	0	0	0	23	905	851	195	6	0	0	0
Dec	0	0	0	321	1674	51	0	0	0	0	0
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Jan	0	0	0	468	1599	10	0	0	0	0	0
Feb	0	0	0	50	1642	196	4	0	0	0	0
Mar	0	0	0	0	549	1012	485	31	0	0	0
Apr	0	0	0	0	13	296	872	635	193	1	0
May	0	0	0	0	2	6	106	420	1437	98	8
Jun	0	0	0	0	21	0	1	22	1080	747	139
Jul	0	0	0	0	0	0	0	0	576	1350	151
Aug	0	0	0	0	0	0	0	16	642	1277	142
Sep	0	0	0	0	0	1	16	94	1646	233	17
Oct	0	0	0	0	0	99	682	758	507	0	0
Nov	0	0	0	3	952	790	234	1	0	0	0
Dec	0	0	0	385	1648	13	0	0	0	0	0

Table 3-44 Frequency of Temperature Scores by Month for Steelhead Emigration in Middle Russian River under D1610/2000

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Mar	0	0	0	0	726	1067	284	0	0	0	0
Apr	0	0	0	0	45	645	983	302	35	0	0
May	0	0	0	0	0	19	375	965	699	19	0
Jun	0	0	0	0	0	0	11	277	1420	95	6
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Mar	0	0	0	0	549	1012	485	31	0	0	0
Apr	0	0	0	0	13	296	872	635	193	1	0
May	0	0	0	0	2	6	106	420	1437	98	8
Jun	0	0	0	0	21	0	1	22	1001	635	129

The percent of periods in each temperature score category for steelhead in middle Russian River under the D1610/2020 scenario were very similar to those under the D1610/2000 scenario. There was a slight decrease in the average scores for upstream migration, incubation, and rearing. Direct comparison of the frequency of scores within each scoring category for each lifestage shows that there was less than a 0.5 percent change in any scoring category. Thus, conditions for steelhead were similar under the two scenarios.

Table 3-45 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Jan 1 to Mar 31		Spawning Jan 1 to Apr 30		Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	4561	39.0	4729	30.1	4729	23.8	4027	8.3	2161	13.6
4	3552	30.4	4623	29.4	3776	19.0	18344	37.6	4569	28.7
3	2192	18.8	2658	16.9	2341	11.8	6793	13.9	2543	15.9
2	1146	9.8	2296	14.6	2526	12.7	11248	23.1	5145	32.3
1	239	2.0	1099	7.0	3599	18.1	6953	14.3	1225	7.7
0	0	0.0	305	1.9	2893	14.6	1387	2.8	303	1.9
Sum	11,690		15,710		19,864		48,752		15,946	
Average		3.9		3.6		2.7		2.9		3.0

Dissolved Oxygen

Table 3-46 summarizes the percentage of DO scores for each evaluation category and each life history stage for steelhead under the D1610/2000 scenario. Table 3-47 provides the same information for the D1610/2020 scenario. The scores for both scenarios were similar, and DO scores were optimal for all life history stages of steelhead.

Table 3-46 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Jan 1 to Mar 31		Spawn/Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to June 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12092	100.0	19110	94.3	48105	98.7	16197	99.1
4	0	0.0	1155	5.7	653	1.3	151	0.9
3	0	0.0	1	0.0	0	0.0	0	0.0
2	0	0.0	0	0.0	0	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,092		20,266		48,758		16,348	
Average		5.0		4.9		5.0		5.0

Table 3-47 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Middle Russian River under the D1610/2020 Scenario

	Upstream Migration		Spawn/Incubation		Rearing		Downstream Migration	
	Jan 1 to Mar 31		Jan 1 to May 31		Oct 1 to Sept 30		Feb 1 to June 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12092	100.0	19010	93.8	47869	98.2	16158	98.8
4	0	0.0	1252	6.2	889	1.8	190	1.2
3	0	0.0	4	0.0	0	0.0	0	0.0
2	0	0.0	0	0.0	0	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,092		20,266		48,758		16,348	
Average		5.0		4.9		5.0		5.0

3.4.3 Chinook Salmon

3.4.3.1 Flow

The conditions for chinook salmon were similar to those described for the upper Russian River. Upmigration occurs between August and January. The 50 percent exceedance flows ranged from a low of 166 cfs in September to 813 cfs in January (Table 3-5) while 80 percent exceedance flows ranged from 165 to 482 cfs during normal water supply conditions. These flows were likely sufficient to allow adult chinook to obtain passage past natural obstructions. Under dry water supply conditions, 50 percent exceedance flows ranged from 93 to 312 cfs and 80 percent exceedance flows ranged from 85 to 130 cfs under these flows, upstream passage likely would have been somewhat impeded most of the time between August and December, and passage in some locales may have been limited to periods during or after storm events. In critical water supply conditions, upstream passage is likely to be possible except during brief intervals following storm events, as 50 percent exceedance flows were less than 50 cfs from August through November and the 80 percent exceedance flows were even lower. Passage opportunities in critical water supply conditions would occur less than 10 percent of the time from August through October, between 20 and 50 percent of the time in November and January, and between 50 and 80 percent of the time in December. Fortunately, critical water supply conditions occur only 1.5 percent of the time.

During November through March, when chinook spawning, incubation and emergence occur, normal water supply condition flows ranged from 414 to 964 cfs (Table 3-5). These flows were likely adequate to support these lifestages in the reach above Asti where spawning has been observed. In dry years, 50 percent exceedance flows during this period have ranged from 115 to 531 cfs. These flows were again likely to support the spawning and incubation but at somewhat reduced habitat levels. In critical water supply conditions, the 50 percent exceedance flows were 66 cfs in January and 81 cfs in February, but exceeded 220 cfs in December and March. These lower flows probably supported some spawning area given the large availability of suitable spawning gravels in this portion of the Russian River.

Between February and July, when emigration occurs, 50 percent exceedance flows ranged from 964 to 225 cfs (Table 3-5). These flows provided sufficient depth and velocity to assist chinook smolts in their downstream migration. During dry water supply conditions, flows ranged from 152 to 531 cfs, with flow being progressively lower later in the year. The lower flows during this water supply condition would likely have slowed emigration rates, which may have caused emigrant chinook to be exposed to warm river temperatures for a prolonged period of time. In critical water supply conditions, 50 percent exceedance flows during this period were as low as 66 cfs, which would have further lengthened the amount of time it takes for a juvenile chinook to migrate out of the river.

Under the D1610/2020 scenario, habitat conditions for chinook salmon would have been similar to those under the D1610/2000 scenario, as the flows were quite similar throughout the year. The reduced flows under the D1610/2020 scenario during the summer and fall would have likely blocked chinook upstream migration, except for during and immediately after storm events. During May and June, these reduced flows would have tended to slow juvenile emigration. Dry water supply condition flows during November through April were largely unchanged, and habitat conditions would have been similar to those under the D1610/2000 scenario.

3.4.3.2 Water Quality

Temperature

Table 3-48 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for chinook salmon.

Table 3-48 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook Salmon in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Aug 15 to Jan 15		**Spawning** Nov 1 to Jan 31		**Incubation** Nov 1 to Mar 31		**Rearing** Feb 1 to May 31		**Downstream Migration** Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	3825	19.1	10338	87.6	14091	71.4	1485	9.5	1485	7.5
4	5500	27.4	535	4.5	2432	12.3	7607	48.4	7629	38.7
3	2492	12.4	366	3.1	1289	6.5	3771	24.0	3977	20.2
2	1275	6.4	262	2.2	827	4.2	2418	15.4	4228	21.4
1	1319	6.6	165	1.4	625	3.2	412	2.6	2141	10.9
0	5633	28.1	138	1.2	478	2.4	17	0.1	270	1.4
Sum	20,044		11,804		19,742		15,710		19,730	
Average		2.6		4.7		4.4		3.5		3.1

Temperature scores for chinook salmon during the adult upstream migration were 3 or better 59 percent of the time but were 0 for 28 percent of the time. Scores were never less than 3 from October through January anywhere in the middle Russian River, overlapping the peak chinook migration season. Scores of 0 primarily occurred in August and September, although a few 0 scores were observed in October in the lower portion of the middle Russian River. Generally, about half the temperatures in October were stressful (Table 3-49). Scores for spawning were generally optimal, with scores of 5 for 87.6 percent of the time, but poor scores did occasionally occur. The average score over all years for spawning was 4.7.

Egg incubation scores were optimal (score of 5) for 71.4 percent of the time and better than 3 over 90 percent of the time. The average score over all years was 4.4. Stressful temperatures for incubation rarely occurred and were generally at the beginning or end of the incubation period (November or March). Even in these months however, stressful temperatures occurred only about 20 percent of the time in March and 12 percent of the time in November. Table 3-50 shows the frequency of chinook incubation scores by month. Peak chinook spawning occurs after late November, and this corresponds to the time when temperatures for chinook egg incubation were optimum. Further analysis on daily temperature scores indicated that water temperatures were generally rated excellent in November and optimal in December through February in all years.

Table 3-49 Frequency of Temperature Scores by Month for Chinook Upstream Migration in Middle Russian River under the D1610/2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Jan	0	0	0	210	521	73	0	0	0	0	0
Aug	0	0	0	0	0	0	0	8	32	69	1030
Sep	0	0	0	0	0	11	48	122	268	406	1152
Oct	0	0	0	0	7	553	389	442	422	187	46
Nov	0	0	0	25	342	1483	107	23	0	0	0
Dec	0	0	0	316	1254	476	0	0	0	0	0
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Jan	0	0	0	210	554	40	0	0	0	0	0
Aug	0	0	0	0	0	0	0	5	6	10	1118
Sep	0	0	0	0	0	1	15	10	73	322	1586
Oct	0	0	0	0	0	116	345	499	525	347	214
Nov	0	0	0	2	250	1523	172	33	0	0	0
Dec	0	0	0	364	1380	302	0	0	0	0	0

Table 3-50 Frequency of Temperature Scores by Month for Chinook Incubation in Middle Russian River under the D1610/2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Jan	0	0	0	0	0	2042	28	7	0	0	0
Feb	0	0	0	0	0	1798	68	20	6	0	0
Mar	0	0	0	0	0	708	526	274	183	140	45
Nov	0	0	0	0	0	1046	523	183	117	80	31
Dec	0	0	0	0	0	2026	20	0	0	0	0
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Jan	0	0	0	0	0	2064	13	0	0	0	0
Feb	0	0	0	0	0	1671	179	28	10	4	0
Mar	0	0	0	0	0	537	473	259	246	202	159
Nov	0	0	0	0	0	983	419	226	185	109	58
Dec	0	0	0	0	0	2036	9	1	0	0	0

Rearing scores were good to excellent, with scores of 3 or better occurring nearly 82 percent of the time. Scores of 2 were observed an additional 15 percent of the time. These temperatures were somewhat stressful to rearing chinook. Very stressful temperatures or potentially lethal temperatures (scores of 1 or 0) occurred 2.7 percent of the time. Stressful temperatures occurred primarily in May with a few stressful periods in April, while very stressful temperatures were confined to May and primarily to the lower portion of the reach (Table 3-51).

During February through June, when chinook emigrate from the system, the average score was 3.1. About one third of the period experienced stressful scores (Table 3-52). The temperature scores in Table 3-52 indicate that temperatures for this lifestage were generally 3 or higher until March. Stressful temperatures became more frequent in April at the downstream end of the reach, but still generally fell in the good range. Stressful temperatures became the norm in May at the downstream end of the middle Russian River. In the upper portion of this reach, the frequency of somewhat stressful (scores of 2) temperatures increased substantially in May. In June, very stressful temperature conditions predominated in the lower portion of the reach, and somewhat stressful temperatures predominated in the upper portion of the reach. Temperatures that might be expected to cause mortalities rarely occurred in this reach.

Table 3-51 Frequency of Temperature Scores by Month for Chinook Rearing in Middle Russian River under the D1610/2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Feb	0	0	0	97	1560	204	31	0	0	0	0
Mar	0	0	0	0	454	781	808	34	0	0	0
Apr	0	0	0	0	10	185	1116	667	32	0	0
May	0	0	0	0	0	0	121	1221	689	46	0
Jun	0	0	0	0	0	0	1	267	1209	309	23
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Feb	0	0	0	51	1340	450	51	0	0	0	0
Mar	0	0	0	0	282	704	922	169	0	0	0
Apr	0	0	0	0	3	78	641	1094	188	6	0
May	0	0	0	0	2	2	34	480	1291	260	8
Jun	0	0	0	0	21	0	1	24	516	1114	133

Table 3-52 Frequency of Temperature Scores by Month for Chinook Emigration in Middle Russian River under the D1610/2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR near Cloverdale (RM 67.98, Cloverdale Q)**										
Month											
Feb	0	0	0	97	1560	204	31	0	0	0	0
Mar	0	0	0	0	454	781	808	34	0	0	0
Apr	0	0	0	0	10	185	1116	667	32	0	0
May	0	0	0	0	0	0	121	1221	689	46	0
Jun	0	0	0	0	0	0	1	267	1209	309	23
Location	**RR near Healdsburg (RM 33.99, Healdsburg ADC Q)**										
Month											
Feb	0	0	0	51	1340	450	51	0	0	0	0
Mar	0	0	0	0	282	704	922	169	0	0	0
Apr	0	0	0	0	3	78	641	1094	188	6	0
May	0	0	0	0	2	2	34	480	1291	260	8
Jun	0	0	0	0	21	0	1	24	516	1114	133

Under the D1610/2020 scenario, temperature scores were very similar to those that occurred under the D1610/2000 scenario. All scores agreed to within 1 percent for any life history stage and scoring category. There was a very slight improvement in average score for upstream migration and spawning under the D1610/2020 scenario.

Table 3-53 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook in Middle Russian River under the D1610/2020 Scenario

	Upstream Migration Aug 15 to Jan 15		Spawning Nov 1 to Jan 31		Incubation Nov 1 to Mar 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	3874	19.3	10540	89.3	14212	72.0	1508	9.6	1508	7.6
4	5615	28.0	480	4.1	2484	12.6	7529	47.9	7551	38.3
3	2626	13.1	302	2.6	1195	6.1	3781	24.1	3976	20.2
2	1278	6.4	256	2.2	813	4.1	2456	15.6	4171	21.1
1	1242	6.2	126	1.1	589	3.0	419	2.7	2221	11.3
0	5409	27.0	100	0.8	449	2.3	17	0.1	303	1.5
Sum	20,044		11,804		19,742		15,710		19,730	
Average		2.7		4.8		4.4		3.5		3.1

Dissolved Oxygen

Table 3-54 summarizes the percentage of DO evaluation scores for each evaluation category and each life history stage for chinook salmon under the D1610/2000 scenario. The DO scores under the D1610/2020 scenario are provided in Table 3-55.

Table 3-54 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Middle Russian River under the D1610/2000 Scenario

	Upstream Migration Aug 15 to Jan 15		Spawn/Incubation Nov 1 to March 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	20452	100.0	0	0.0	16084	99.8	19981	99.2
4	0	0.0	3809	18.9	28	0.2	151	0.8
3	0	0.0	15895	78.9	0	0.0	0	0.0
2	0	0.0	436	2.2	0	0.0	0	0.0
1	0	0.0	4	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	20,452		20,144		16,112		20,132	
Average		5.0		3.2		5.0		5.0

Table 3-55 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Middle Russian River under the D1610/2020 Scenario

	Upstream Migration		Spawn/Incubation		Rearing		Downstream Migration	
	Aug 15 to Jan 15		Nov 1 to March 31		Feb 1 to May 31		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	20452	100.0	0	0.0	16084	99.8	19942	99.1
4	0	0.0	3873	19.2	28	0.2	190	0.9
3	0	0.0	15728	78.1	0	0.0	0	0.0
2	0	0.0	537	2.7	0	0.0	0	0.0
1	0	0.0	6	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	20,452		20,144		16,112		20,132	
Average		5.0		3.2		5.0		5.0

DO scores were optimal for adult upstream migration, juvenile rearing and downstream migration. The spawning and egg incubation life history stages were generally good or excellent. Only rarely, (less than 3 percent of the time) did scores drop low enough to stress (score of 2) egg incubation. The average score for all years for egg incubation was 3.2. Low DO levels may have occurred during dry years when flows were low.

3.5 LOWER RUSSIAN RIVER

The lower Russian River segment serves as a passage corridor between the ocean and upstream tributary spawning and rearing areas (including Dry Creek) for coho salmon, steelhead, and chinook salmon. This portion of the river is not used for spawning and provides poor quality rearing habitat; therefore, flow and water quality analyses focused on upstream and downstream passage.

3.5.1 COHO SALMON

3.5.1.1 Flow

The 50 percent exceedance flows in the segment ranged from 300 to 1,478 cfs and the 80 percent exceedance flows ranged from 211 to 595 cfs during the coho migration period (November through January) under the D1610/2000 scenario. In dry water supply conditions, the 50 percent exceedance flows during this period ranged from 185 to 741 cfs (Table 3-7) and the 80 percent exceedance flows ranged between 119 and 228 cfs above the Wohler Diversion. These flows are sufficient to pass these fish over natural barriers within this reach (pers. comm. B. Cox 2001). Below Wohler Diversion, the 80 percent exceedance flows drop as low as 92 cfs in December in dry water conditions. These flows may begin to impair migration, but are unlikely to stop coho from migrating past critical riffles. In critical water supply conditions, November 80 percent exceedance flows of 104 cfs above Wohler Diversion would have likely begun to impede passage conditions for coho salmon adults, but flows in December and January were adequate to provide passage. Below Wohler Diversion, the 80 percent exceedance flows in November and January (39 and 71 cfs respectively) would likely block migration. Passage would be unimpeded in December based on an 80 percent exceedance flow of 187 cfs and would be possible between 50 and 80 percent of the time in January, and 20 and 50 percent of the time in November.

Flows for downstream passage (February through mid-May) during normal water supply conditions ranged from 1,922 cfs in February to 446 cfs in May. In dry water supply conditions, flows during this period ranged from 1,114 to 491 cfs, and in critical water supply conditions, they ranged from 265 to 118 cfs. In normal and dry water supply conditions, flows were sufficient to help coho emigration. In critical water supply conditions, flows during the early part of the season were likely sufficient to move coho juveniles downstream quickly. As flows recede, velocities within the river diminish, and it may take longer for emigrant fish to exit the system. This may have prolonged the exposure of these fish to potentially stressful water temperatures and predators. This potential effect was most pronounced in critical water supply conditions when flows got as low as 118 cfs in April above Wohler Diversion, and 43 cfs below this point. Flows of this low magnitude may have increased the amount of time fish would have been in the river. Fortunately, critical water supply conditions occurred infrequently (1.5 to 6 percent of the time), and historically have spanned the entire emigration period only during one year. Even in this year, flows during March were approximately 1,000 cfs, which would have provided a good opportunity for smolts to leave the system.

Under the D1610/2020 scenario, flows were largely unchanged relative to the D1610/2000 scenario during the upstream and downstream migration season above Wohler inflatable dam in normal water supply conditions. In dry water supply conditions, flows were increased between 10 and 58 percent between August and November, which would have improved upstream passage conditions for chinook and coho salmon. Flows during May and June were also increased over the D1610/2000 scenario by 36 and 52 percent, respectively. This would have improved emigration conditions for all three species.

In critical water supply conditions, flows would have been increased by 32 and 15 percent in August and September, above Wohler inflatable dam. This would not have benefited upstream migrant chinook salmon, however, as there was already sufficient flow present to allow unimpaired migration. Flows would have been decreased to less than 30 cfs in October and November, which would have created a significant impairment for the upstream migration of chinook and coho salmon. During the remainder of the year, flows would not have changed substantially from those present under D1610/2000 scenario.

In normal water supply conditions under the D1610/2020 scenario, flows below Wohler inflatable dam were decreased year round, although the decrease was less than 10 percent from December through April. Flows, however, remained high enough to allow adult and juvenile salmonids to migrate without impairment relative to the D1610/2000 scenario. The largest changes in flow under dry water supply conditions below Wohler inflatable dam occurred in November and December, when flows were reduced by 14 and 39 percent, respectively. This reduction may have caused some impairment of upstream migration for chinook and coho salmon during these months. Flow changes during the rest of the year in this situation were insufficient to materially affect the suitability of flow conditions for salmonid migration. In critical water supply conditions, flows were reduced by 34 percent in May, which would have impaired emigration for all species relative to the D1610/2000 scenario. In October and November, flows were largely eliminated, which would have certainly blocked migration.

However, under the D1610/2000 scenario, flows were less than 60 cfs in these months, which likely blocked migration anyway.

3.5.1.2 Water Quality

Temperature

Table 3-56 summarizes the percentage of temperature periods for each evaluation score for each life history stage for coho salmon.

Temperature scores for coho salmon during the adult upstream migration were generally excellent to optimal, with scores of 3 or greater for 93.1 percent of the time, and 73 percent scored a 5. The average score over all years was 4.5. Low scores for water temperature occurred infrequently during the early portion of the coho upstream migration period (November).

Table 3-56 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Lower Russian River under the D1610/2000 Scenario

	Upstream Migration Nov 1 to Jan 31		**Downstream Migration** Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	8640	73.2	1695	12.5
4	1673	14.2	4452	32.8
3	682	5.8	1169	8.6
2	485	4.1	4379	32.3
1	324	2.7	1871	13.8
0	0	0.0	0	0.0
Sum	11,804		13,566	
Average		4.5		3.0

Temperatures for juvenile emigration scored 3 or better about 54 percent of the time and averaged 3. Table 3-57 shows the frequency of temperature scores by month. Temperatures were generally good in February and March, and generally stressful in April and May. Most days in April were scored 2, and by May all scores were 2 or less. Therefore, coho downstream migrants were likely to have experienced stressful water temperatures in about the second half of their migration period in this reach.

Table 3-57 Frequency of Temperature Scores by Month for Coho Juveniles Emigration in Lower Russian River under the D1610/2000 Scenario

Score	0 Cold	1 Cold	2 Cold	3 Cold	4 Cold	5	4 Warm	3 Warm	2 Warm	1 Warm	0 Warm
Location	**RR at Hacienda Bridge (RM 20.85, Guerneville Q)**										
Month											
Feb	0	0	5	29	1270	524	48	16	0	0	0
Mar	0	0	0	0	246	721	368	349	393	0	0
Apr	0	0	0	0	2	77	120	192	1408	211	0
May	0	0	0	0	0	0	0	2	343	459	0
Location	**RR below Dry Creek (RM 31, Healdsburg Q)**										
Month											
Feb	0	0	7	39	1312	470	48	16	0	0	0
Mar	0	0	0	0	267	693	361	335	421	0	0
Apr	0	0	0	0	3	71	121	188	1440	187	0
May	0	0	0	0	0	0	0	4	347	453	0

Temperature scores in the D1610/2020 scenario were very similar to those for the D1610/2000 scenario in this reach. Thus, under the increased demand schedule, conditions for the upstream and downstream migration for coho salmon would have remained largely unchanged.

Table 3-58 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Lower Russian River under the D1610/2020 Scenario

	Upstream Migration Nov 1 to Jan 31		**Downstream Migration** Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	8669	73.4	1699	12.5
4	1646	13.9	4397	32.4
3	667	5.7	1182	8.7
2	515	4.4	4403	32.5
1	307	2.6	1885	13.9
0	0	0.0	0	0.0
Sum	11,804		13,566	
Average		4.5		3.0

Dissolved Oxygen

Table 3-59 summarizes the percentage of DO periods for each score for each life history stage of coho salmon under the D1610/2000 scenario. This information is provided in Table 3-60 for the D1610/2020 scenario. Scores under both scenarios were excellent with an average score of 5 for both upstream and downstream migration.

Table 3-59 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Lower Russian River under the D1610/2000 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12202	100.0	13767	98.6
4	4	0.0	200	1.4
3	0	0.0	1	0.0
2	0	0.0	0	0.0
1	0	0.0	0	0.0
0	0	0.0	0	0.0
Sum	12,206		13,968	
Average		5.0		5.0

Table 3-60 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Lower Russian River under the D1610/2020 Scenario

	Upstream Migration Nov 1 to Jan 31		Downstream Migration Feb 1 to May 15	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12191	99.9	13698	98.1
4	13	0.1	248	1.8
3	2	0.0	22	0.2
2	0	0.0	0	0.0
1	0	0.0	0	0.0
0	0	0.0	0	0.0
Sum	12,206		13,968	
Average		5.0		5.0

3.5.2 Steelhead

3.5.2.1 Flow

Under D1610/2000 scenario, in normal water supply conditions, the 50 percent exceedance flows above Wohler Diversion ranged from 1,478 to 1,922 cfs (Table 3-7) during the steelhead migration period (January through March). In dry water supply conditions, these flows were 729 to 1,114 cfs, and in critical water supply conditions 265 to 576 cfs. The 50 percent exceedance flows were greater than 130 cfs for all water supply conditions. These flows would be sufficient for the unimpaired passage of adult steelhead.

Below Wohler Diversion, in normal and dry water supply conditions, the 80 percent exceedance flows were sufficient to allow adult steelhead unimpaired passage. In critical water supply conditions, steelhead would have unimpaired passage in March, but passage could be blocked or impeded between 20 and 50 percent of the time in January and February.

The D1610/2020 scenario would result in similar upstream passage conditions to the D1610/2000 scenario. The only exception would be in March under critical water supply conditions, where passage would be impaired or perhaps blocked between 20 and 50 percent of the time.

Steelhead emigration overlaps that of coho salmon from February 1 through May 15, so during this time, steelhead smolts would have experienced the same suite of conditions. Flows would have been suitable for emigration in normal and dry water supply conditions, but decreased flows in critical water supply conditions would have resulted in an impairment relative to the other water supply conditions under the D1610/2000 scenario. Under the D1610/2020 scenario, emigration would not have been impaired relative to the D1610/2000 scenario in normal and dry water supply conditions. In critical water supply conditions, flows were reduced in May which would have reduced the suitability of conditions for emigration relative to the D1610/2000 scenario. In late May and June, conditions for steelhead emigration would have been good under normal and dry water supply conditions for both scenarios. In critical water supply conditions, emigration conditions would have been reduced from those present under the other water supply conditions. These conditions were described in Section 3.5.1.1.

Under critical water supply conditions during the D1610/2020 scenario, flows were increased over those in the D1610/2000 scenario by more than 25 percent in June. These enhanced flows would have provided a modest benefit to emigrating steelhead smolts.

Below the Wohler Diversion under D1610/2020 scenario, flows were reduced by 17 to 29 percent in normal water supply conditions in May and June. In both months, flows remained high enough to assist these smolts out of the river. In dry water supply conditions, flow changes during the portion of the year when steelhead would have been in the lower Russian River were small enough that they were unlikely to affect habitat. The largest change occurred in April when flows decreased from 342 to 276 cfs. However, both flows were high enough to help the smolts out of the system. In critical water supply conditions, flow changes were likewise small enough that no appreciable change in habitat would have been anticipated.

3.5.2.2 Water Quality

Temperature

Table 3-61 summarizes the percentage of evaluation periods for each score category and each life history stage for steelhead. During the upstream migration period for adult steelhead, temperatures were generally good to optimal, with scores being 3 or better about 86 percent of the time. During about 15 percent of the periods, temperatures scored 2 or less indicating that water temperatures were stressful to upstream migrants. These stressful periods tended to occur during March.

Steelhead smolts experienced good temperature scores (3 or better) during about half the evaluation periods (Table 3-61). Good temperatures were prevalent in March and April, but stressful temperatures became more frequent in May and June. Scores were mainly 2, but scores of 1 occurred about a third of the time in June. Thus, steelhead smolts would have experienced increasingly more stressful conditions the later in the season they emigrated.

Table 3-61 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Lower Russian River under the D1610/2000 Scenario

	Upstream Migration Jan 1 to Mar 31		**Downstream Migration** Feb 1 to Jun 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	4299	36.8	1800	11.3
4	3453	29.5	4109	25.8
3	2240	19.2	2259	14.2
2	1293	11.1	5678	35.6
1	405	3.5	1775	11.1
0	0	0.0	325	2.0
Sum	11,690		15,946	
Average		3.9		2.8

Table 3-62 Frequency of Temperature Scores by Month for Steelhead Upstream Migration in Lower Russian River under the D1610/2000 Scenario

Score	**0 Cold**	**1 Cold**	**2 Cold**	**3 Cold**	**4 Cold**	**5**	**4 Warm**	**3 Warm**	**2 Warm**	**1 Warm**	**0 Warm**
Location	**RR at Hacienda Bridge (RM 20.85, Guerneville Q)**										
Month											
Jan	0	0	0	62	196	1638	177	4	0	0	0
Feb	0	0	0	5	25	807	835	204	16	0	0
Mar	0	0	0	0	0	63	499	708	484	122	0
Location	**RR below Dry Creek (RM 31, Healdsburg Q)**										
Month											
Jan	0	0	1	105	235	1583	143	10	0	0	0
Feb	0	0	0	7	26	865	812	166	16	0	0
Mar	0	0	0	0	0	71	510	672	497	126	0

Table 3-63 Frequency of Temperature Scores by Month for Steelhead Downstream Migration in Lower Russian River under the D1610/2000 Scenario

Score	**0 Cold**	**1 Cold**	**2 Cold**	**3 Cold**	**4 Cold**	**5**	**4 Warm**	**3 Warm**	**2 Warm**	**1 Warm**	**0 Warm**
Location	**RR at Hacienda Bridge (RM 20.85, Guerneville Q)**										
Month											
Mar	0	0	0	0	512	1024	502	39	0	0	0
Apr	0	0	0	0	13	284	852	650	211	0	0
May	0	0	0	0	2	3	100	412	1468	85	7
Jun	0	0	0	0	22	1	1	21	1093	594	77
Location	**RR below Dry Creek (RM 31, Healdsburg Q)**										
Month											
Mar	0	0	0	0	519	1011	509	38	0	0	0
Apr	0	0	0	0	13	283	851	676	187	0	0
May	0	0	0	0	3	5	100	424	1464	75	6
Jun	0	0	0	0	21	1	2	24	1116	560	85

Temperatures scores under the D1610/2020 scenario were very similar to those under the D1610/2000 scenario, with changes in the frequency of periods falling into particular scoring categories being less than 0.5 percent. This indicates that the conditions for upstream and downstream migration were the same under the two scenarios.

Table 3-64 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Lower Russian River under the D1610/2020 Scenario

	Upstream Migration Jan 1 to Mar 31		**Downstream Migration** Feb 1 to Jun 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	4239	36.3	1797	11.3
4	3434	29.4	4067	25.5
3	2267	19.4	2307	14.5
2	1344	11.5	5747	36.0
1	406	3.5	1719	10.8
0	0	0.0	309	1.9
Sum	11,690		15,946	
Average		3.8		2.8

Dissolved Oxygen

Table 3-65 summarizes the percentage of DO evaluation scores for each evaluation category during the migration period of steelhead under the D1610/2000 scenario. Table 3-66 provided the same information for the D1610/2020 scenario. DO scores under both scenarios were similar, although the D1610/2000 scenario had a slightly higher average score for downstream migration. Under both scenarios, DO scores were generally excellent with both life history stages receiving scores of nearly 5. While a few scores of 2 did occur, they were very infrequent, comprising less than 0.1 percent of the time periods evaluated. It was unlikely that DO levels constrained steelhead migration through this reach.

Table 3-65 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Lower Russian River under the D1610/2000 Scenario

	Upstream Migration Jan 1 to Mar 31		**Downstream Migration** Feb 1 to June 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12092	100.0	14038	85.9
4	0	0.0	2271	13.9
3	0	0.0	20	0.1
2	0	0.0	11	0.1
1	0	0.0	8	0.0
0	0	0.0	0	0.0
Sum	12,092		16,348	
Average		5.0		4.9

Table 3-66 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Lower Russian River under the D1610/2020 Scenario

	Upstream Migration Jan 1 to Mar 31		Downstream Migration Feb 1 to June 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	12055	99.7	13940	85.3
4	25	0.2	2352	14.4
3	12	0.1	30	0.2
2	0	0.0	13	0.1
1	0	0.0	13	0.1
0	0	0.0	0	0.0
Sum	12,092		16,348	
Average		5.0		4.8

3.5.3 Chinook Salmon

3.5.3.1 Flow

Above the Wohler Diversion the 50 percent exceedance flows for the D1610/2000 scenario under normal water supply conditions ranged from 248 to 1,478 cfs during the chinook migration period (August through January) (Table 3-7), while the 80 percent exceedance flows ranged from 244 to 595 cfs. In dry water supply conditions, these flows were 176 to 741 cfs and the 80 percent exceedance flows ranged from 167 to 228 cfs. These flows were likely sufficient to pass fish over natural barriers within this reach (pers. comm. B. Cox 5/21/01). In critical water supply conditions, the 50 percent exceedance flows during the chinook upstream migration season have ranged down to108 cfs and the 80 percent exceedance flow is as low as 104 cfs. Under these conditions, passage may be slightly impeded at some critical riffles through November, but would not be blocked.

Below the Wohler Diversion under D1610/2000 scenario, flows would have been lower than above the diversion, however, there were a few natural barriers in this portion of the river. The 50 percent exceedance flow for normal water supply conditions ranged from 173 to 2454 cfs. The corresponding 80 percent exceedance flow ranged from 163 to 649 cfs. In dry water supply conditions 80 percent exceedance flows would have ranged from 85 to 214 cfs. Chinook salmon would probably have unimpeded upstream passage under normal water supply conditions and somewhat impaired upstream passage under dry water supply conditions. Under critical water supply conditions the 50 percent exceedance flows ranged from 43 to 2617 cfs and the 80 percent exceedance flow ranged from 35 to 187 cfs. Upstream passage would likely be blocked the majority of the time until November. Passage would be possible 20 to 50 percent of the time in November, over 90 percent of the time in December, and between 50 and 80 percent of the time in January.

Both above and below Wohler Diversion under the D1610/2020 scenario, flows were reduced relative to the D1610/2000 scenario in normal water supply conditions during the chinook upstream migration period, but not to the extent that would prevent chinook adults from migrating upstream. Under dry water supply conditions, flows were not changed significantly, and the same conditions would have been present under either scenario. In critical water supply conditions, flows both above and below Wohler Diversion, were greatly reduced in October and November. This substantially reduced the likelihood of successful passage for adult chinook salmon above the diversion during these months, but is unlikely to have reduced the potential for passage below the diversion as it was already blocked.

Chinook salmon would have emigrated during the same period as coho salmon and steelhead, and therefore would have encountered the same conditions described in Section 3.5.1.1.

3.5.3.2 Water Quality

Temperature

Table 3-67 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for chinook salmon.

Temperature scores for chinook salmon during the adult upstream migration period were 3 or better 58.1 percent of the time, but 0 for 28.1 percent of the time, resulting in an average score of 2.6. Most of the low scores occurred in August and September. During this period, the scores were most frequently 0. Scores improved dramatically in October, with scores of 0 becoming rare and almost half the evaluation periods scoring 3 or better. In November through January, all evaluation periods scored 3 or better (Table 3-68), and the vast majority of periods scored 4 or 5. Some scores of 3 and 4 that occurred in the winter were associated with water temperatures cooler than optimum values. The high temperature scores corresponded with the period of peak chinook salmon migration from late October to mid-December (Chase 2000, Chase 2001).

Table 3-67 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook Salmon in Lower Russian River under the D1610/2000 Scenario

	Upstream Migration Aug 15 to Jan 15		**Downstream Migration** Feb 1 to Jun 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	3719	18.6	1695	8.6
4	5535	27.6	6631	33.6
3	2393	11.9	3607	18.3
2	1331	6.6	4254	21.6
1	1441	7.2	3218	16.3
0	5625	28.1	325	1.6
Sum	20,044		19,730	
Average		2.6		2.9

Table 3-68 Frequency of Temperature Scores by Month for Chinook Upstream Migration in Lower Russian River

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**RR at Hacienda Bridge (RM 20.85, Guerneville Q)**										
Month											
Jan	0	0	0	136	601	67	0	0	0	0	0
Aug	0	0	0	0	0	0	0	9	8	4	1118
Sep	0	0	0	0	0	0	11	21	130	506	1339
Oct	0	0	0	0	0	93	381	613	551	311	97
Nov	0	0	0	0	120	1635	199	26	0	0	0
Dec	0	0	0	216	1264	566	0	0	0	0	0
Location	**RR below Dry Creek (RM 31, Healdsburg Q)**										
Month											
Jan	0	0	0	186	563	55	0	0	0	0	0
Aug	0	0	0	0	0	0	0	6	11	12	1110
Sep	0	0	0	0	0	1	11	19	103	360	1513
Oct	0	0	0	0	0	83	331	525	572	356	179
Nov	0	0	0	2	208	1500	230	40	0	0	0
Dec	0	0	0	313	1329	404	0	0	0	0	0

Table 3-69 shows the frequency of scores for juvenile chinook downstream migration. Scores were generally 4 or 5 in February and March, and primarily 3 in April (Table 3-69). Higher temperatures in May and June lowered temperature scores to 2 and 1, respectively. The model results suggested that chinook salmon migrating in May may have experienced some stressful temperatures, while those emigrating in June may have experienced very stressful temperature conditions.

Table 3-69 Frequency of Temperature Scores by Month for Chinook Downstream Migration in the Lower Russian River under the D1610/2000 Scenario

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**RR at Hacienda Bridge (RM 20.85, Guerneville Q)**										
Month											
Feb	0	0	0	34	1270	524	64	0	0	0	0
Mar	0	0	0	0	246	721	932	178	0	0	0
Apr	0	0	0	0	2	77	624	1096	205	6	0
May	0	0	0	0	2	2	29	484	1306	247	7
Jun	0	0	0	0	22	0	1	22	653	1034	77
Location	**RR below Dry Creek (RM 31, Healdsburg Q)**										
Month											
Feb	0	0	0	46	1312	470	64	0	0	0	0
Mar	0	0	0	0	267	693	941	176	0	0	0
Apr	0	0	0	0	3	71	628	1121	182	5	0
May	0	0	0	0	2	2	36	492	1298	241	6
Jun	0	0	0	0	21	0	1	26	636	1040	85

Temperature scores under the D1610/2020 scenario were similar to those under the D1610/2000 scenario. The increased demand under this scenario would have resulted in similar effects to chinook salmon in this reach relative to the D1610/2000 scenario.

Table 3-70 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook Salmon in Lower Russian River under the D1610/2020 Scenario

	Upstream Migration Aug 15 to Jan 15		**Downstream Migration** Feb 1 to Jun 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	3720	18.6	1699	8.6
4	5508	27.5	6597	33.4
3	2511	12.5	3639	18.4
2	1294	6.5	4261	21.6
1	1595	8.0	3225	16.3
0	5416	27.0	309	1.6
Sum	20,044		19,730	
Average		2.6		2.9

Dissolved Oxygen

The D1610/2000 scenario resulted in optimal DO scores for adult upstream migration with scores of 5 for 98 percent of the time (average score of 5). Scores for juvenile downstream migration were excellent. Juvenile downstream migration had scores of 5 for 88 percent of the time (Table 3-71). Similar scores were obtained for the D1610/2020 scenario. Under either scenario, it appeared unlikely that DO conditions would have been a constraint on chinook migration.

Table 3-71 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Lower Russian River under the D1610/2000 Scenario

	Upstream Migration Aug 15 to Jan 15		**Downstream Migration** Feb 1 to Jun 30	
Score	**Frequency**	**Percent**	**Frequency**	**Percent**
5	20235	98.9	17822	88.5
4	157	0.8	2271	11.3
3	39	0.2	20	0.1
2	2	0.0	11	0.1
1	17	0.1	8	0.0
0	2	0.0	0	0.0
Sum	20,452		20,132	
Average		5.0		4.9

Table 3-72 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Lower Russian River under the D1610/ 2020 Scenario

	Upstream Migration Aug 15 to Jan 15		**Downstream Migration** Feb 1 to Jun 30		
	Score	**Frequency**	**Percent**	**Frequency**	**Percen**
5	20132	98.4	17704	87.9	
4	188	0.9	2362	11.7	
3	79	0.4	40	0.2	
2	32	0.2	13	0.1	
1	16	0.1	13	0.1	
0	5	0.0	0	0.0	
Sum	20,452		20,132		
Average		5.0		4.9	

3.6 DRY CREEK

3.6.1 COHO SALMON

3.6.1.1 Flow

Dry Creek provides habitat for all of the freshwater lifestages of all three salmonid species. Under the D1610/2000 scenario, the 50 percent exceedance flows immediately below Warm Springs Dam were very stable throughout the year, ranging from 77 to 125 cfs (Table 3-11). The 80 percent exceedance flows were similar, ranging from 77 to 107 cfs. These flows did not vary substantially by water supply condition (Tables 3-11and 3-13). Therefore, the following discusses habitat relationships among all year types for the area below Warm Springs Dam. Flows of this magnitude predicted by the RRSM were sufficient to allow the upstream migration of all species in virtually all years (pers. comm. B. Cox 2001). This is supported by the observed returns of these species to the DCFH (*Interim Report 2: Fish Facility Operations*).

These flows appeared to be suitable for all lifestages of all species. The stability of these flows indicated that redds were unlikely to become dewatered. Suitably-sized spawning gravels appeared to be relatively abundant in Dry Creek, and therefore sufficient spawning habitat should have been available for fish. Coho and steelhead rearing took place throughout the year, while chinook juveniles resided in the river for only a few months. The relatively high flows in Dry Creek, given its channel dimensions, may have resulted in velocities in some areas that are higher than what is optimal for salmonid juvenile rearing. Other areas with more suitable velocities would have been available, especially where cover was relatively abundant. Some velocity refuges may have been provided by the substantial amount of riparian vegetation, large woody debris, and larger substrate materials in places along the water. This would have provided a substantial amount of suitable flow-related rearing habitat for this species.

The 50 percent exceedance flows in the lower end of Dry Creek were generally higher than those immediately below the dam (Table 3-13), but were still very constant ranging from 85to 333 cfs, with 80 percent exceedance flows ranging from 85 to 132 cfs. The difference in flow resulted from inflow from tributaries such as Pena and Felta creeks downstream of the dam. These tributaries made their most significant contributions during the January through March period. Migration was possible for all species at these flows. Spawning habitat did not appear to be limited by flow-related factors in this reach. Scour of coho redds was identified as an issue of concern in *Report 1: Flood Control Operations*.

Under the D1610/2020 scenario, flows were increased in Dry Creek over those expected under the D1610/2000 scenario from July though October in normal water supply conditions. These increases were nearly 50 percent higher than the D1610/2000 scenario flows. These increased flows would have reduced the suitability of Dry Creek for rearing salmonids during these months. In dry water supply conditions, flows would have been increased over the D1610/2000 scenario by up to 158 percent. These flows would have exceeded those observed under normal water supply conditions under the D1610/2020 scenario. These increased flows would have diminished the value of Dry Creek for salmonid rearing during these periods. In critical water supply conditions under the D1610/2020 scenario, flows would have been increased over those in the same water supply conditions based on the D1610/2000 scenario. These flows would have closely approximated those that occurred in the D1610/2000 scenario, dry water supply conditions from June through September, and would have provided less suitable conditions for rearing salmonids than the D1610/2000 scenario flows. In October and November, flows in Dry Creek under the D1610/2020 scenario would have been reduced to less than 5 cfs, which would have likely constrained habitat for juvenile salmonids to pools, and would have severely impaired upstream migration for chinook and coho salmon. Flows during December through May would have been largely unchanged from the D1610/2000 scenario conditions.

3.6.1.2 Water Quality

Temperature

Table 3-73 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for coho salmon.

Temperature scores for coho salmon during the adult upstream migration, spawning and egg incubation seasons were generally excellent to optimal, with scores of 5 for 65 percent, 95 and 84 percent of the time, respectively. The average scores over all years were 4.6, 4.9 and 4.7, respectively. For each of these life history stages, scores of 3 or better occurred over 95 percent of the time, and scores as low as 3 were uncommon. Two periods in March received egg incubation scores of 0. These scores occurred during critical water supply conditions.

Scores for juvenile rearing were 4 or 5 nearly 70 percent of the time, but were 2 for 19.3 percent of the time. The average score over all years was 3.8. Review of the monthly temperature scores indicated that temperature conditions for rearing were almost always excellent to optimal near Warm Springs Dam. The stressful temperatures that occurred for rearing coho, were primarily in the lower reaches of Dry Creek. Near the mouth of Dry Creek scores of 2 were predominant from April through October, and scores of 1 were relatively common. Temperatures, however, did not appear to reach lethal levels anywhere in Dry Creek.

Table 3-73 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Coho Salmon in Dry Creek under the D1610/2000 Scenario

	Upstream Migration		Spawning		Incubation		Rearing		Downstream Migration	
	Nov 1 to Jan 31		Dec 1 to Feb 15		Dec 1 to Mar 31		All Year		Feb 1 to May 15	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	7715	65.4	9346	94.8	13192	83.6	20770	42.6	5612	41.4
4	3599	30.5	481	4.9	1554	9.8	13183	27.0	4680	34.5
3	408	3.5	27	0.3	479	3.0	1734	3.6	789	5.8
2	74	0.6	0	0.0	376	2.4	9408	19.3	2420	17.8
1	8	0.1	0	0.0	179	1.1	3657	7.5	65	0.5
0	0	0.0	0	0.0	2	0.0	0	0.0	0	0.0
Sum	11,804		9,854		15,782		48,752		13,566	
Average		4.6		4.9		4.7		3.8		4.0

The nearly optimal temperatures that occurred near Warm Springs Dam were likely due to cool releases from the lower levels of the reservoir. This water warmed as it moved downstream to reach stressful temperatures by the time it reached the mouth. The model water temperature results indicated that good temperatures for rearing occurred near Warm Springs Dam all year, but that juvenile coho salmon may have been stressed during most of the summer in downstream areas (Table 3-74).

Table 3-74 Frequency of Temperature Scores by Month for Coho Rearing in Dry Creek under the D1610/2000 Scenario

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q**										
Month											
Jan	0	0	0	0	2061	16	0	0	0	0	0
Feb	0	0	0	0	1474	418	0	0	0	0	0
Mar	0	0	0	0	475	1601	1	0	0	0	0
Apr	0	0	0	0	26	1966	18	0	0	0	0
May	0	0	0	0	0	2006	71	0	0	0	0
Jun	0	0	0	0	13	1967	30	0	0	0	0
Jul	0	0	0	0	0	2054	14	3	6	0	0
Aug	0	0	0	0	0	2040	6	0	7	24	0
Sep	0	0	0	0	0	1974	3	0	28	2	0
Oct	0	0	0	0	0	2027	2	8	9	0	0
Nov	0	0	0	0	22	1948	10	0	0	0	0
Dec	0	0	0	0	1241	799	6	0	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Jan	0	0	4	90	1944	39	0	0	0	0	0
Feb	0	0	4	19	1260	557	50	2	0	0	0
Mar	0	0	0	0	307	849	433	327	161	0	0
Apr	0	0	0	0	0	145	237	374	1242	12	0
May	0	0	0	0	4	2	8	50	1779	234	0
Jun	0	0	0	0	21	1	0	1	1194	793	0
Jul	0	0	0	0	0	0	0	0	1438	639	0
Aug	0	0	0	0	0	0	1	14	1336	726	0
Sep	0	0	0	0	0	0	11	28	1835	133	0
Oct	0	0	0	0	0	25	349	685	979	8	0
Nov	0	0	0	0	184	1381	346	60	9	0	0
Dec	0	0	6	24	1637	378	1	0	0	0	0

Under the D1610/2020 scenario, temperature scores remained unchanged from the D1610/2000 scenario, in spite of increased releases from Warm Springs Dam to meet the additional demand. As discussed previously, these additional releases would have been made primarily from June through September and thus affected the quality of rearing habitat. The temperature scores for coho rearing are presented in Table 3-75. Comparison of temperatures on a month by month basis revealed that the scores immediately below the dam were unchanged. Near the mouth of Dry Creek, temperatures improved slightly, with a shift from scores of 1 to scores of 2. This minor change in temperature scores, in spite of up to 75 percent increases in flow during some months, indicates the large influence of atmospheric warming on water temperatures in this region.

Table 3-75 Frequency and Percent of Modeled Temperature Scores in each Evaluation Category for Coho Rearing in Dry Creek under the D1610/2020 Scenario

	Upstream Migration		Spawning		Incubation		Rearing		Downstream Migration	
	Nov 1 to Jan 31		Dec 1 to Feb 15		Dec 1 to Mar 31		All Year		Feb 1 to May 15	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	7678	65.0	9262	94.0	12949	82.0	20754	42.6	5651	41.7
4	3567	30.2	536	5.4	1706	10.8	12903	26.5	4544	33.5
3	437	3.7	47	0.5	514	3.3	1979	4.1	806	5.9
2	73	0.6	9	0.1	429	2.7	11248	23.1	2510	18.5
1	49	0.4	0	0.0	182	1.2	1868	3.8	55	0.4
0	0	0.0	0	0.0	2	0.0	0	0.0	0	0.0
Sum	11,804		9,854		15,782		48,752		13,566	
Average		4.6		4.9		4.7		3.8		4.0

Table 3-76 Frequency of Temperature Scores by Month for Coho Rearing in Dry Creek under the D1610/2020 Scenario

Score	**0**	**1**	**2**	**3**	**4**	**5**	**4**	**3**	**2**	**1**	**0**
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**										
Month											
Jan	0	0	3	7	2049	18	0	0	0	0	0
Feb	0	0	0	1	1416	474	1	0	0	0	0
Mar	0	0	0	0	484	1584	8	1	0	0	0
Apr	0	0	0	0	28	1949	13	6	14	0	0
May	0	0	0	0	0	2018	31	5	16	7	0
Jun	0	0	0	0	13	1956	11	0	7	23	0
Jul	0	0	0	0	0	2044	2	0	0	31	0
Aug	0	0	0	0	0	2044	2	0	0	31	0
Sep	0	0	0	0	0	1954	7	4	40	2	0
Oct	0	0	0	0	0	1976	13	21	36	0	0
Nov	0	0	0	0	47	1895	16	2	20	0	0
Dec	0	0	21	6	1237	774	8	0	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Jan	0	0	6	99	1890	82	0	0	0	0	0
Feb	0	0	4	20	1217	561	80	10	0	0	0
Mar	0	0	0	0	291	822	448	347	169	0	0
Apr	0	0	0	0	0	149	219	354	1280	8	0
May	0	0	0	0	4	2	7	50	1822	192	0
Jun	0	0	0	0	21	1	0	6	1506	476	0
Jul	0	0	0	0	0	0	0	1	1876	200	0
Aug	0	0	0	0	0	0	8	16	1890	163	0
Sep	0	0	0	0	0	3	15	94	1827	68	0
Oct	0	0	0	0	0	24	440	799	767	16	0
Nov	0	0	0	0	191	1361	337	63	28	0	0
Dec	0	0	6	47	1598	393	2	0	0	0	0

Dissolved Oxygen

Table 3-77 summarizes the percentage of DO evaluation scores for each evaluation category and each life history stage for coho salmon under the D1610/2000 scenario, while Table 3-78 provides this information for the D1610/2020 scenario. Under both scenarios, DO scores for all life history stages of coho salmon were nearly always excellent or optimal, indicating that low DO levels were unlikely to be a problem for coho salmon in this reach.

Table 3-77 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Dry Creek under the D1610/2000 Scenario

	Upstream Migration Nov 1 to Jan 31		Spawn/Incubation Dec 1 to Mar 31		Rearing All Year		Downstream Migration Feb 1 to May 15	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12200	100.0	16163	99.9	43736	89.7	13967	100.0
4	6	0.0	19	0.1	4993	10.2	1	0.0
3	0	0.0	2	0.0	25	0.1	0	0.0
2	0	0.0	0	0.0	4	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,206		16,184		48,758		13,968	
Average		5.0		5.0		4.9		5.0

Table 3-78 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Coho Salmon in Dry Creek under the D1610/2020 Scenario

	Upstream Migration Nov 1 to Jan 31		Spawn/Incubation Dec 1 to Mar 31		Rearing All Year		Downstream Migration Feb 1 to May 15	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12206	100.0	16149	99.8	43141	88.5	13901	99.5
4	0	0.0	25	0.2	5513	11.3	67	0.5
3	0	0.0	10	0.1	98	0.2	0	0.0
2	0	0.0	0	0.0	6	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,206		16,184		48,758		13,968	
Average		5.0		5.0		4.9		5.0

3.6.2 STEELHEAD

3.6.2.1 Flow

As discussed in Section 3.6.1.1, flows in Dry Creek were very stable. These flows appeared to have been appropriate for all lifestages of steelhead regardless of water supply conditions at both the upstream and downstream end of Dry Creek.

Under the D1610/2020 scenario, flows would have been similar to the D1610/2000 scenario during the upstream migration, spawning and incubation seasons, but would have been raised substantially during the summer months under the dry and critical water supply conditions. These increases would have decreased the suitability of Dry Creek for rearing salmonids as a result of increased water velocities. In October and November, flows in Dry Creek under the D1610/2020 scenario would have been reduced to less than 5 cfs, which would substantially reduce habitat availability and likely have constrained juvenile steelhead to pools.

3.6.2.2 Water Quality

Temperature

Table 3-79 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for steelhead.

Table 3-79 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Dry Creek

	Upstream Migration Jan 1 to Mar 31		Spawning Jan 1 to Apr 30		Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	5016	42.9	5264	33.5	5264	26.5	20783	42.6	8186	51.3
4	3542	30.3	7398	47.1	3411	17.2	18080	37.1	3890	24.4
3	2559	21.9	1502	9.6	6850	34.5	6247	12.8	2481	15.6
2	543	4.6	1207	7.7	1607	8.1	3621	7.4	1384	8.7
1	30	0.3	326	2.1	2376	12.0	21	0.0	5	0.0
0	0	0.0	13	0.1	356	1.8	0	0.0	0	0.0
Sum	11,690		15,710		19,864		48,752		15,946	
Average		4.1		4.0		3.3		4.1		4.2

Temperature scores for steelhead upstream migration and spawning were generally good to excellent, with scores of 3 or better for 95 percent of upstream migration scores and for 90.2 percent of spawning scores, resulting in average scores of 4.1 and 4.0, respectively.

Temperature scores for egg incubation were generally good to optimal, with scores of 3 or better for 78.2 percent of the time. Scores of less than 3 never occurred in the upper portion of Dry Creek but were common near the mouth in April and May. This suggested that good egg incubation conditions occurred in the upper portion of Dry Creek, but that high water temperatures may have stressed egg incubation in the late portion of the period in downstream areas after March, and water temperatures may have been high enough in May to have reduced incubation success.

Table 3-80 Frequency of Temperature Scores by Month for Steelhead Incubation in Dry Creek under the D1610/2000 Scenario

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**										
Month											
Jan	0	0	0	0	0	1928	148	1	0	0	0
Feb	0	0	0	0	0	1057	707	128	0	0	0
Mar	0	0	0	0	0	184	776	1117	0	0	0
Apr	0	0	0	0	0	2	123	1885	0	0	0
May	0	0	0	0	0	0	0	1876	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Jan	0	0	0	0	58	1830	187	2	0	0	0
Feb	0	0	0	0	15	816	830	229	2	0	0
Mar	0	0	0	0	0	113	569	907	469	19	0
Apr	0	0	0	0	0	0	45	337	961	655	12
May	0	0	0	0	0	0	2	8	203	1476	187

Temperature scores for rearing were generally good to excellent, with scores of 3 or better for 92 percent of the time (average score of 4.1). Scores below Warm Springs Dam were excellent throughout the year. Near the mouth of Dry Creek, scores were generally 3 or higher from May through August (Table 3-81). Scores of 2 were common near the mouth from June through August, but scores of 1 were very rare. Overall, temperature scores for rearing in Dry Creek were good.

During the steelhead downstream migration period (March through June), water temperatures are rated excellent below Warm Springs Dam. Some days in May and June had scores of 2 near the mouth of Dry Creek, but most days had scores of 3 or better. Although there may have been stressful temperatures in some years in May and June in the lower portion of Dry Creek, most of the time temperatures for downstream migration were rated good to optimal. The average score for steelhead downstream migration was 4.2.

Table 3-81 Frequency of Temperature Scores by Month for Steelhead Rearing in Dry Creek

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**										
Month											
Jan	0	0	0	0	2075	2	0	0	0	0	0
Feb	0	0	0	0	1731	161	0	0	0	0	0
Mar	0	0	0	0	859	1218	0	0	0	0	0
Apr	0	0	0	0	101	1909	0	0	0	0	0
May	0	0	0	0	0	2077	0	0	0	0	0
Jun	0	0	0	0	15	1995	0	0	0	0	0
Jul	0	0	0	0	0	2070	5	2	0	0	0
Aug	0	0	0	0	0	2046	0	7	24	0	0
Sep	0	0	0	0	0	1977	23	5	2	0	0
Oct	0	0	0	0	5	2030	11	0	0	0	0
Nov	0	0	0	0	55	1925	0	0	0	0	0
Dec	0	0	0	0	1608	438	0	0	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Jan	0	0	0	94	1977	6	0	0	0	0	0
Feb	0	0	0	23	1579	290	0	0	0	0	0
Mar	0	0	0	0	605	1215	255	2	0	0	0
Apr	0	0	0	0	26	563	1155	254	12	0	0
May	0	0	0	0	5	27	643	1168	234	0	0
Jun	0	0	0	0	22	1	75	1119	791	2	0
Jul	0	0	0	0	0	0	11	1427	639	0	0
Aug	0	0	0	0	0	9	59	1283	713	13	0
Sep	0	0	0	0	0	22	889	963	133	0	0
Oct	0	0	0	0	0	731	1216	91	8	0	0
Nov	0	0	0	0	635	1328	17	0	0	0	0
Dec	0	0	0	30	1932	84	0	0	0	0	0

The scores for the D1610/2020 scenario were similar to those of the D1610/2000 scenario in spite of increased flow during the summer months (Table 3-82.). This reflected the large influence of ambient air temperatures on water temperatures in this region. The two scenarios would have provided equivalent temperature conditions for steelhead in Dry Creek.

Table 3-82 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Steelhead in Dry Creek under the D1610/2020 Scenario

Score	Upstream Migration Jan 1 to Mar 31		Spawning Jan 1 to Apr 30		Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30	
	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent
5	4920	42.1	5124	32.6	5124	25.8	20749	42.6	8087	50.7
4	3483	29.8	7449	47.4	3402	17.1	19142	39.3	4062	25.5
3	2653	22.7	1526	9.7	6882	34.6	7015	14.4	2768	17.4
2	597	5.1	1253	8.0	1692	8.5	1797	3.7	1013	6.4
1	37	0.3	344	2.2	2448	12.3	49	0.1	16	0.1
0	0	0.0	14	0.1	316	1.6	0	0.0	0	0.0
Sum	11,690		15,710		19,864		48,752		15,946	
Average		4.1		4.0		3.3		4.2		4.2

Dissolved Oxygen

Tables 3-83 and 3-84 summarize the percentage of DO evaluation scores for each evaluation category and each life history stage for steelhead under the D1610/2000 and D1610/2020 scenarios, respectively. Under both scenarios, DO scores were optimal for all life history stages of steelhead, and therefore DO was unlikely to be problematic to steelhead in Dry Creek.

Table 3-83 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Dry Creek under the D1610/2000 Scenario

Score	Upstream Migration Jan 1 to Mar 31		Spawn/Incubation Jan 1 to May 31		Rearing Oct 1 to Sept 30		Downstream Migration Feb 1 to Jun 30	
	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent
5	12092	100.0	19702	97.2	43736	89.7	16331	99.9
4	0	0.0	564	2.8	4993	10.2	17	0.1
3	0	0.0	0	0.0	25	0.1	0	0.0
2	0	0.0	0	0.0	4	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,092		20,266		48,758		16,348	
Average		5.0		5.0		4.9		5.0

Table 3-84 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Steelhead in Dry Creek under the D1610/2020 Scenario

	Upstream Migration		Spawn/Incubation		Rearing		Downstream Migration	
	Jan 1 to Mar 31		Jan 1 to May 31		Oct 1 to Sept 30		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12092	100.0	19473	96.1	43141	88.5	16184	99.0
4	0	0.0	767	3.8	5513	11.3	164	1.0
3	0	0.0	24	0.1	98	0.2	0	0.0
2	0	0.0	2	0.0	6	0.0	0	0.0
1	0	0.0	0	0.0	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	12,092		20,266		48,758		16,348	
Average		5.0		5.0		4.9		5.0

3.6.3 CHINOOK SALMON

3.6.3.1 Flow

As discussed in Section 3.6.1.1, flows in Dry Creek were very stable. These flows appeared to be appropriate for all lifestages of chinook salmon regardless of water supply conditions at both the upstream and downstream end of Dry Creek.

Under the D1610/2020 scenario, flows would have been increased in Dry Creek over those expected under the D1610/2000 scenario from August though November in normal and dry water supply conditions. This change was unlikely to have affected the suitability of conditions for the upstream migration of chinook salmon. In critical water supply conditions, flows under the D1610/2020 scenario would have been decreased to less than 5 cfs. These flows would have likely blocked the upstream migration of chinook salmon in Dry Creek and would have likely severely limited the availability and utility of spawning habitat during November. From December through June flows would have been unchanged or increased from those under the D1610/2000 scenario. The increased flows would have occurred during April, May and June when chinook were outmigrating. These increased flows would have benefited outmigrant chinook, but may have adversely affected the suitability of Dry Creek rearing habitat.

3.6.3.2 Water Quality

Temperature

Table 3-85 summarizes the percentage of temperature evaluation scores for each evaluation category and each life history stage for chinook salmon.

Table 3-85 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook Salmon in Dry Creek under the D1610/2000 Scenario

Score	Upstream Migration Aug 15 to Jan 15		Spawning Nov 1 to Jan 31		Incubation Nov 1 to Mar 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent	Periods	Percent
5	12257	61.2	11230	95.1	12383	62.7	6584	41.9	8511	43.1
4	4205	21.0	360	3.0	6065	30.7	6366	40.5	6474	32.8
3	1515	7.6	173	1.5	675	3.4	2406	15.3	3345	17.0
2	1271	6.3	33	0.3	388	2.0	350	2.2	1376	7.0
1	667	3.3	8	0.1	175	0.9	4	0.0	24	0.1
0	129	0.6	0	0.0	56	0.3	0	0.0	0	0.0
Sum	20,044		11,804		19,742		15,710		19,730	
Average		4.3		4.9		4.5		4.2		4.1

Temperature scores for chinook salmon during all lifestages were generally excellent. Scores for upstream migration were 3 or better over 89 percent of the time, resulting in the high average scores in Table 3-85. Low upstream migration scores generally occurred in August and September, with most of the low scores near the mouth of the Dry Creek (Table 3-86). Scores during the peak spawning run November/December were excellent throughout Dry Creek.

Scores for egg incubation were high, with scores of 4 or 5 over 90 percent of the time, and scores of less than 3 only 4 percent of the time. The average score over all years for egg incubation was 4.5. The few low egg incubation scores occurred near the mouth of Dry Creek in March and November (Table 3-87). Overall, modeled temperatures for spawning and egg incubation were very good.

Table 3-86 Frequency of Temperature Scores by Month for Chinook Upstream Migration in Dry Creek under the D1610/2000 Scenario

Score	**0**	**1**	**2**	**3**	**4**	**5**	**4**	**3**	**2**	**1**	**0**
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**										
Month											
Jan	0	0	0	0	589	215	0	0	0	0	0
Aug	0	0	0	0	0	1122	0	0	0	4	13
Sep	0	0	0	0	0	1977	3	21	3	3	0
Oct	0	0	0	0	0	2035	4	7	0	0	0
Nov	0	0	0	0	5	1975	0	0	0	0	0
Dec	0	0	0	0	431	1615	0	0	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Jan	0	0	0	30	657	117	0	0	0	0	0
Aug	0	0	0	0	0	9	10	71	639	365	45
Sep	0	0	0	0	0	22	230	1017	574	139	25
Oct	0	0	0	0	0	731	932	330	45	8	0
Nov	0	0	0	0	8	1955	17	0	0	0	0
Dec	0	0	0	25	916	1105	0	0	0	0	0

Table 3-87 Frequency of Temperature Scores by Month for Chinook Incubation in Dry Creek under the D1610/2000 Scenario

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**										
Month											
Jan	0	0	0	0	0	2075	2	0	0	0	0
Feb	0	0	0	0	0	1731	161	0	0	0	0
Mar	0	0	0	0	0	828	1047	1	0	0	0
Nov	0	0	0	0	0	55	1915	10	0	0	0
Dec	0	0	0	0	0	1608	437	1	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Jan	0	0	0	0	0	2071	6	0	0	0	0
Feb	0	0	0	0	0	1602	261	27	2	0	0
Mar	0	0	0	0	0	584	605	306	233	123	25
Nov	0	0	0	0	0	635	1040	236	58	11	0
Dec	0	0	0	0	0	1962	83	1	0	0	0

Temperature scores for rearing chinook were also generally good to excellent, with less than 92 percent of evaluation periods scoring less than 3 or higher. Scores were always 4 or 5 below Warm Springs Dam (Table 3-88). Near the mouth of Dry Creek, temperature scores for rearing chinook salmon were typically 3 or better through May. Overall, model water temperatures for chinook rearing in Dry Creek were very good.

Table 3-88 Frequency of Temperature Scores by Month for Chinook Rearing in Dry Creek under the D1610/2000 Scenario

Score	0	1	2	3	4	5	4	3	2	1	0
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**										
Month											
Feb	0	0	0	0	1474	418	0	0	0	0	0
Mar	0	0	0	0	475	1601	1	0	0	0	0
Apr	0	0	0	0	26	1966	18	0	0	0	0
May	0	0	0	0	0	1812	64	0	0	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**										
Month											
Feb	0	0	0	23	1260	557	52	0	0	0	0
Mar	0	0	0	0	307	849	902	19	0	0	0
Apr	0	0	0	0	0	145	1198	655	12	0	0
May	0	0	0	0	1	2	210	1476	186	1	0

Under the D1610/2020 scenario, water temperature scores were similar to those under the D1610/2000 scenario (Table 3-89). Under either scenario, chinook salmon would have experienced generally favorable temperature conditions in Dry Creek.

Table 3-89 Frequency and Percent of Modeled Temperature Scores in Each Evaluation Category for Chinook Salmon in Dry Creek under the D1610/2020 Scenario

Score	Upstream Migration Aug 15 to Jan 15		Spawning Nov 1 to Jan 31		Incubation Nov 1 to Mar 31		Rearing Feb 1 to May 31		Downstream Migration Feb 1 to Jun 30	
	Periods	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	12241	61.1	11172	94.6	12289	62.2	6674	42.5	8607	43.6
4	4443	22.2	395	3.3	6003	30.4	6242	39.7	6319	32.0
3	2085	10.4	153	1.3	742	3.8	2480	15.8	3757	19.0
2	1017	5.1	35	0.3	414	2.1	305	1.9	1016	5.1
1	200	1.0	12	0.1	188	1.0	9	0.1	31	0.2
0	58	0.3	37	0.3	106	0.5	0	0.0	0	0.0
Sum	20,044		11,804		19,742		15,710		19,730	
Average		4.4		4.9		4.5		4.2		4.1

Dissolved Oxygen

Tables 3-90 and 3-91 summarize the percentage of DO evaluation scores for each evaluation category and each life history stage for chinook salmon under the D1610/2000 and D1610/2020 scenarios, respectively.

DO scores were optimal for adult upstream migration, juvenile rearing and downstream migration, with each of these lifestages receiving an average score of 5.0 under both scenarios. The spawning and egg incubation life history stage generally had of scores of 3, with an average score of 2.9. The results of the temperature model indicated that stressful DO scores occurred predominantly in November, in the upper end of the reach. Some stressful DO scores were also observed in this reach in December (Table 3-92).

DO levels in Dry Creek in November typically are in the range of about 7 to 9.5 mg/l, concentrations. DO saturation for water at 13 °C (typical release temperature from Lake Sonoma in November) is 10.2 mg/l. The cause of the low DO scores for chinook incubation in November below Lake Sonoma are likely a joint function of algal die-off in Lake Sonoma and the high DO requirements for chinook salmon incubation. Algal die-off in Lake Sonoma occurs due to decreased daylength. The dying algae decays using oxygen, rather than creating it, resulting in a higher biological oxygen demand. This results in water with lower DO levels being released from the dam. Additionally, chinook salmon incubation has relatively high DO requirements, with a DO of greater than 13 mg/l being considered optimal and DO levles of less than 8 mg/l to being considered stressful. The corresponding DO requirements for coho salmon are 8 and 5.5 mg/l, respectively. Thus while chinook incubation receives stressful scores in this area, scores for coho salmon incubation are very good in the same area.

Modeled DO values were higher near the mouth of Dry Creek (RM 101.5) than below Warm Springs Dam (RM 111.3). DO values were generally lowest during the months of August through October, and increased during the winter, with the highest values in February. The values most likely to stress the egg incubation period were restricted to the early portion of the spawning season.

Table 3-90 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Dry Creek under the D1610/2000 Scenario

	Upstream Migration		Spawn/Incubation		Rearing		Downstream Migration	
	Aug 15 to Jan 15		Nov 1 to March 31		Feb 1 to May 31		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	20426	99.9	0	0.0	16111	100.0	20115	99.9
4	22	0.1	663	3.3	1	0.0	17	0.1
3	4	0.0	16903	83.9	0	0.0	0	0.0
2	0	0.0	1900	9.4	0	0.0	0	0.0
1	0	0.0	678	3.4	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	20,452		20,144		16,112		20,132	
Average		5.0		2.9		5.0		5.0

Table 3-91 Frequency and Percent of Modeled Dissolved Oxygen Scores in Each Evaluation Category for Chinook Salmon in Dry Creek under the D1610/2020 Scenario

	Upstream Migration		Spawn/Incubation		Rearing		Downstream Migration	
	Aug 15 to Jan 15		Nov 1 to March 31		Feb 1 to May 31		Feb 1 to Jun 30	
Score	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**	**Periods**	**Percent**
5	20385	99.7	0	0.0	16024	99.5	19957	99.1
4	62	0.3	771	3.8	86	0.5	175	0.9
3	5	0.0	16582	82.3	2	0.0	0	0.0
2	0	0.0	2059	10.2	0	0.0	0	0.0
1	0	0.0	732	3.6	0	0.0	0	0.0
0	0	0.0	0	0.0	0	0.0	0	0.0
Sum	20,452		20,144		16,112		20,132	
Average		5.0		2.9		5.0		5.0

Table 3-92 Frequency of DO Scores by Month for Chinook Spawning/Incubation in Dry Creek under the D1610/2000 Scenario

Score	**0**	**1**	**2**	**3**	**4**	**5**
Location	**Dry Creek below Warm Springs Dam (RM 113.1, L. Sonoma Q)**					
Month						
Jan	0	0	96	1965	16	0
Feb	0	0	2	1649	241	0
Mar	0	0	23	1936	118	0
Nov	0	657	1146	177	0	0
Dec	0	21	456	1569	0	0
Location	**Dry Creek near mouth (RM 101.53, Dry Creek Q)**					
Month						
Jan	0	0	0	1931	146	0
Feb	0	0	1	1789	102	0
Mar	0	0	150	1907	20	0
Nov	0	0	25	1955	0	0
Dec	0	0	1	2025	20	0

3.7 EFFECTS ON THE RUSSIAN RIVER ESTUARY

This interim report evaluates the effects of project-related flows on habitat conditions in the estuary. Project operations generally reduce peak flows during winter storms and then release water from these storms over a longer period of time. Project-related effects during the winter months are likely indistinguishable from background variability in the system due to the flashy nature of flows in the Russian River, and the great variability in the size and intensity of storms.

Augmented summer flows downstream of Mirabel implemented under D1610 have the potential to affect several components of salmonid rearing habitat in the estuary. These include: water quality, (including temperature, DO and salinity), primary productivity and the availability of aquatic invertebrates, availability of shallow water habitat, and the concentration of nutrients and toxic runoff.

An effect associated with augmented flows is the need to artificially breach the sandbar periodically to prevent flooding of local properties. Some of the potential effects of this breaching on habitat were discussed in *Report 8: Estuary Management Plan*.

Estuaries can be important for juvenile salmonid rearing. Studies conducted in other Central and North Coast estuaries have documented how water quality conditions are associated with invertebrate production and use by juvenile salmonids. Smith (1990) found that summertime breaching of sandbars severely alters habitat conditions in the small coastal lagoons. When these estuaries remain open, good water quality is maintained by tidal mixing or high river flows. When the estuary remains closed, good water quality develops when the system is converted to freshwater, and saline water is forced out of the system. Infrequent breaching of these lagoons, especially during the low-flow summer months, impairs water quality because it establishes a salinity stratification. A saltwater lens forms under the freshwater layer, traps heat, and through natural processes, depletes DO in the saline layer, and anoxic conditions can form. An increase in breaching frequency also results in fluctuating habitat conditions, to which few organisms can adapt.

It is prudent to recognize that the Russian River estuary may provide valuable rearing habitat for juvenile salmonids, similar to what occurs in smaller coastal lagoons, especially since the coastal fog belt moderates high water temperatures in the summer. The larger size and morphology of the Russian River indicate it may function somewhat differently from the smaller estuaries studied elsewhere. Preliminary data from the Mirabel sampling program indicate that naturally spawned juvenile chinook salmon migrate down the Russian River in the spring (SCWA 2000). These fish may rear for a time in some part of the Estuary. The tributaries in the lower Russian River contain high quality steelhead spawning and rearing habitat. Steelhead rear in freshwater throughout the year and may make use of suitable portions of the estuary.

Interim Report 8 evaluated the direct effects of the artificial breaching program. This report addresses the effects of augmented flow on estuarine habitat and the effects due to the need for artificial breaching.

3.7.1 WATER QUALITY

3.7.1.1 Temperature, Dissolved Oxygen and Salinity

Augmented summer flow into the estuary may help maintain DO conditions. The quantity and temperature of the inflowing water likely counterbalance the effect of the cooler coastal atmospheric conditions, and may result in elevated temperatures in the upper part of the estuary. The effects of augmented flows on habitat conditions in the Russian River estuary are also inextricably tied to the need to breach the estuary. While augmented flows may alter water quality parameters in either an open or closed estuarine system, the periodic breaching of the lagoon may cause negative effects compared to those that would occur if the system were more stable and remained either open or closed. These were addressed in *Interim Report 8.*

As noted above, when the sandbar closes across the river's mouth, it traps salt water on the bottom of the lagoon forming a saltwater lens, that traps heat, and through natural processes, anoxic conditions can form. Over time, seepage of the saltwater layer through the sandbar, combined with adequate inflow of fresh water from the river, can result in a "freshening" of the lagoon. With the conversion of the system to fresh water, water temperature decreases, and DO levels increase.

Changes in water temperature, DO and salinity affect primary production and the abundance of aquatic invertebrates. In other lagoons, steelhead growth was poor during periods of warm, stratified water conditions, including long transition periods as lagoons converted to fresh water (Smith 1990). The physical mechanism affecting invertebrates is the amount of the lagoon substrate inundated with the warm, anoxic saltwater. In Central Coast lagoons, a large percentage of the available habitat became unsuitable when thesandbarwas breached because it was inundated with warm, anoxic, saltwater. This greatly reduced invertebrate production, an important food resource for steelhead.

A five-year monitoring study (1996 to 2000) in the Russian River estuary has documented summer water quality conditions in deep pool habitat between Sheephouse Creek and the rivermouth during the summer and fall and in response to the artificial breaching program. The occurrence of low DO in the near-bottom layers of deep pools is often associated with sandbar-closed conditions, but anoxia can develop under tidal conditions during neap tides and/or low river flows (MSC 2000). Water quality was primarily dependent upon how long the sandbar was closed, and sandbar closure was primarily related to ocean and river flow conditions. Once the sandbar is breached, water quality does not immediately improve in the upstream parts of the estuary, and the sandbar may close again before it does improve. Several successive breaching events may be required to improve water quality in upper reaches.

Water quality is affected by the schedule of artificial breaching, but is not completely determined by it. Water quality monitoring in the Russian River estuary found that the renewal of DO in the saline near-bottom layers of deep pools, is mediated by both river flow and tidal action (spring/neap cycle), as well as by post-breaching flushing (MSC 2000).

When the sandbar closes, salinity stratification leads to changes in DO and temperature in the near-bottom layers of deep pools, that contributed to deterioration in water quality in those layers. The freshwater surface layer often provided better DO levels, but surface water temperatures were high during the summer months. When the sandbar was breached, tidal mixing often contributed to a renewal of DO and reduced temperatures. This process occurs most quickly near the mouth of the river, but can take several days to occur at the most upstream monitored site in the estuary (which was only about two thirds of the way up the estuary). The rate of change is influenced by the volume of river flows, the magnitude of tidal range, and the length of time the sandbar remains open. When the sandbar reforms, salinity stratification again leads to a deterioration of water quality in deep pools, reducing the amount of habitat in the water column in which salmonids have adequate water quality conditions. During prebreaching surveys in deep pools, surface temperatures could sometimes become quite high, but bottom layers, with low inadequate DO concentrations, were cooler. Intermediate layers often provided intermediate temperatures and DO levels, and may provide water quality that salmonids can utilize.

Table 3-93 provides a summary of sandbar closures and breaching for 1999 as an example of a typical breaching schedule. Similar breaching patterns were observed in other years.

By increasing the number of times the sandbar is breached, augmented flows cause repeated fluctuations in the depth, salinity, and temperature of the estuary. These rapidly changing conditions cause habitat conditions to be unsuitable for the benthic invertebrates. These

Table 3-93 Summary of 1999 Sandbar Closures and Breachings

Date Closed	Days Closed	Date Breached	Gage Height[1]	Days Open
June 12[2]	3	June 15	7.4	6
June 24	6	July 1	6.3	78
September 17	7	September 23	6.6	2
September 25	8	October 4	7.0	3
October 7	14	October 15, 21[3]	6.7, 7.4[3]	9
November 1	3	November 4[4]	5.7	2
November 6	4	November 10	8.9	3

[1]Height on tide gage immediately before breaching.
[2]Sandbar closed completely on June 12, but was partially closed for at least 9 days before that.
[3]Sandbar was breached October 15 but closed again the following day. Sandbar was breached again on October 21.
[4]Sandbar evidently breached itself.

communities may not be able to develop in some areas of the estuary and may impair conditions for good juvenile salmonid rearing in some portions. However, because the Russian River estuary is large and complex, there is likely to be unimpaired invertebrate production that supports juvenile rearing in some portion of the estuary, particularly in upstream freshwater areas.

The smaller systems studied on the Central Coast are nearly completely influenced by breaching events. Rapid changes in salinity and water level in small coastal lagoons can have substantial effects on the invertebrate foodbase. Smith (1990) found that when sandbar formation resulted in anoxic conditions over the majority of the substrate, amphipods were eliminated from those areas, and invertebrate populations crashed as the lagoons went through the transition to fresh water. Continuous breaching, such as occurred at San Gregorio lagoon in summer of 1986, resulted in low overall invertebrate populations as the system fluctuated between anoxic saline conditions and freshwater. The fluctuating habitat conditions resulting from continually having to breach are likely to reduce the availability of food organisms for salmonids in portions of the Russian River estuary.

3.7.2 Shallow Water Habitat

Shallow water habitat provides feeding areas for juvenile salmonids, as well as habitat for aquatic plants and invertebrate production. Augmented flows by themselves would tend to increase the amount of shallow water habitat in the estuary, and therefore provide a benefit for salmonids by increasing the amount of habitat and their foodbase.

The need to breach the estuary periodically results in continually changing habitat conditions for invertebrates, and probably does not allow this community to fully develop. When the estuary is closed, water surface elevation quickly increases and usually has to be breached within two weeks. When the sandbar is breached, however, the volume of the estuary is decreased. This exposes any invertebrates that may have colonized the recently inundated area between the tidally influenced water and the maximum water surface elevation to desiccation. Because the period when the estuary is closed is short (3 to 14 days in 1999), there is insufficient time for a community to establish itself before this habitat becomes unsuitable again. Also, this temporary inundation zone tends to be freshwater; when thesandbarcloses again, this area may be less suitable to estuarine species that can withstand greater levels of environmental variability.

3.7.3 Nutrients and Toxic Runoff

Agricultural and urban runoff and treated sewage discharges from throughout the watershed increase nutrient and chemical levels in the estuary. Augmented summer flows help to dilute these constituents and carry them out of the estuary when it is open.

3.7.4 Summary of Effects to the Estuary

The augmented flow in the Russian River estuary has several beneficial effects: it may maintain or improve water temperatures and DO levels; it helps dilute and flush nutrients and potentially toxic chemicals; and it may increase the amount of shallow water habitat available for salmonids and their food. The need to breach the estuary to prevent local flooding probably reduces the value of the estuary for rearing. This frequent breaching may have harmful effects that reduce the somewhat beneficial effects by causing continually changing habitat conditions (depth, salinity, temperature, and DO) in portions of the estuary. While salmonids are highly mobile and can move away from these areas, most of their foodbase is not as mobile and may experience population fluctuations during repeated breachings. The reduction of this foodbase may thereby reduce the suitability of the estuary for juvenile salmonids. The D1610/2020 scenario may decrease the need to breach the estuary as frequently, as it would reduce flows to the estuary by 20 to 30 percent from May through November in normal water supply conditions. This will reduce the benefits associated with improved water temperature and DO levels, and dilution of nutrients. It may also allow water quality to deteriorate more that it does under the current breaching regime, where the estuary is rarely closed for more that 3 to 8 days at a time.

This report provides a preliminary evaluation of the potential effects of flow on protected coho salmon, steelhead, and chinook salmon and their designated critical habitat in the Russian River basin. The report evaluates conditions for different lifestages of coho salmon, steelhead, and chinook salmon based on the flows resulting from all factors influencing flows, whether or not they are related to the project. It evaluates the water temperature and DO conditions that are likely to be present based upon those flows and atmospheric conditions. This analysis was conducted for both the current levels of water demand (year 2000), and for anticipated water demands in the year 2020. In addition, the effect of augmented flows on rearing conditions in estuarine habitat was qualitatively evaluated.

With regard to streamflow, this report, *Interim Report 3*, provides a preliminary qualitative assessment of the suitability of habitat under current operations for the protected species. For water temperature and DO, this report quantitatively evaluates the suitability of water temperature and DO conditions associated with the flow regime present under current D1610 operations. The likely contribution of project operations (water supply and flood control operations and D1610 releases) on the occurrence of unsuitable conditions is assessed. The flow analysis will be revisited in a more quantitative fashion after the habitat-flow relationships are refined with additional site-specific data and analyses. The results of this more quantitative flow analysis will be presented in the Draft BA. The analysis of temperature and DO is complete.

4.1 SUMMARY OF PROJECT OPERATIONS

This report evaluates the effects of typical flow regimes on the three protected species and their habitat based on the flows that generally occur at a given location under a specific water supply condition. Flood control operations provide short-term storage of winter storm flows, reducing the peak flows during the storm and releasing this water over a longer period of time (days or weeks). Water supply operations generally store water in the winter and augment flows in the summer. Minimum releases throughout the year are determined by the requirements of the SWRCB's D1610. This decision sets minimum flow standards at different locations in the Russian River and Dry Creek depending on the water supply conditions within the basin. Water supply condition is determined based on the total inflow and storage in Lake Pillsbury and Lake Mendocino on the first of each month from January through June.

In most years, the net result of these operations causes relatively small changes in flow during the wet winter period when many important activities occur such as upstream passage, spawning, incubation/emergence and downstream passage of salmonids. Flows during the summer period are augmented. During this period, juvenile steelhead and coho are found rearing in freshwater environments. Both species primarily rear in tributary streams, including Dry Creek, although steelhead may rear in the Russian River upstream of Asti. The effects of short-term events, such as storms or maintenance, are addressed in *Interim Reports 1 and 4*, respectively.

The flows present in the various reaches of the Russian River and Dry Creek were described based on the output of the RRSM. The RRSM overlays the operation of the project on the precipitation conditions that existed between 1929 and 1995 to predict flow levels. The water quality characteristics associated with current operations and current releases under D1610 were evaluated using the RRWQM. The RRWQM uses the output of the RRSM as input for flow levels in various locations. Then based on these flow levels and other physical processes, estimates water temperature and DO levels. These values were used to evaluate the suitability of current water quality for important life history stages of the protected species.

4.2 SUMMARY OF FLOW AND WATER QUALITY EFFECTS

4.2.1 UPSTREAM PASSAGE

Conditions for upstream passage were generally good throughout the mainstem and on Dry Creek under normal water supply conditions, which occur 70 to 90 percent of the time.

Under dry water supply conditions (12 percent of the time), passage conditions were good through the lower Russian River and Dry Creek for all species. In the middle and upper Russian River, all species may have encountered some degree of impairment. For coho and chinook, the impairment may have extended through most of the season. For steelhead, the impairment is likely to have occurred near the City of Ukiah in January.

During critical water supply conditions (1.5 to 6 percent of the time), passage is likely blocked by low flows near Guerneville from August through November, which would affect coho and chinook salmon. By December, flows increase to the point where passage is probably unimpaired. These improved flows continue through the steelhead migration period. Therefore, steelhead would be able to move upstream through the lower river with little difficulty throughout their migration season. In the middle and upper Russian River, chinook upstream migration would likely be blocked or at least substantially impaired from August through November. Coho migrating in November would also be blocked. Steelhead migration may also be impaired or blocked, but only in the upper river. Conditions in Dry Creek appear suitable for upstream migration for all species under all water supply conditions for the D1610/2000 scenario.

During dry and critical water supply conditions, the mechanical breaching of the sandbar allows chinook and coho access to the river. Flows during dry and critical water supply conditions are too low for successful passage. Natural runoff in conjunction with flow releases provides sufficient flow for passage under normal water supply conditions (70 to 90 percent of the time). Without this artificial breaching, chinook and coho salmon could not access the Russian River until a storm event breached the bar. This storm event would likely provide sufficient flow to allow passage for some time after thesandbarwas opened.

Conditions for passage are generally good in the Russian River. In dry (9 to 14 percent of the time) and critical (1.5 to 6 percent of the time) water supply conditions, project operations intercept and store storm runoff from upstream areas, which may adversely affect passage. However, the reservoirs capture runoff from only a small fraction of their watersheds. Additionally, review of data from the RRSM indicates that inflow to Lake Mendocino exceeds outflow during 20 percent of days under critical water supply conditions (or about 0.3 percent of all days). For Lake Sonoma, inflow exceeded outflow about 17 percent of the days in this water supply condition (0.3 percent of all days). As this runoff may allow fish to move upstream during storms, intercepting this runoff may increase passage impairment for those days. Therefore, project operations contribute to passage impairment only to a very small degree.

Water temperatures are generally suitable for the upstream migration of adult salmonids from November through March. This period encompasses the peak of the chinook salmon emigration season and all of the coho salmon and steelhead emigration season. Warm water temperatures are often present during the early portion of the upstream migrations for both chinook and sometimes for coho salmon. Water temperatures that are stressful for upstream migrant chinook salmon occur during August through October. These adults are exposed to these temperatures because of the need to breach the sandbar.

In dry and critical water supply conditions, flows under the D1610/2020 scenario would be lower than under the D1610/2000 scenario in the early part of the chinook migration season. These lower flows may further reduce the opportunity of chinook salmon to successfully migrate upstream in the early portion of their migration period. The lower flows would extend into the early part of the coho migration season, and may reduce their migration opportunities as well. Flows are generally higher by December, so chinook and coho would have more success in December and January; and steelhead upstream migration would be largely unchanged under D1610/2020. Temperature and DO scores also remain largely unchanged.

Based on the foregoing observations, the operation of the Russian River project based on the Year 2000 demand does not affect upstream migration during normal water supply conditions, but may adversely affect all three species in dry and critical water supply conditions. The degree to which the project contributes to passage impairment appears to be minor due to the small proportion of the watershed that the dams control and the relative infrequency with which inflow to the dams exceeds outflow during dry and critical water supply conditions. These adverse affects probably apply more to chinook and coho than to steelhead, because chinook and coho have an earlier migration season.

4.2.2 SPAWNING AND INCUBATION

Spawning and egg incubation generally occur between November through May depending on species, with steelhead and chinook spawning in the upper portion of the mainstem and all species spawning in Dry Creek. Spawning and incubation for steelhead and chinook salmon occurs in the mainstem Russian River mainly above Asti, although steelhead rely more heavily on tributaries for these lifestages. Flow in both normal and dry water supply conditions appears to provide suitable habitat for spawning and incubation of steelhead and chinook salmon in both the middle reach above Asti and in the upper reach of the Russian River. With the lower flows present in critical water supply conditions, the amount of available spawning area would be substantially reduced. This would adversely affect these species approximately 1.5 percent of the time. However, as previously noted, critical water supply conditions generally do not persist throughout an entire water year. Therefore, some portion of most seasons when critical water supply conditions occur will likely experience higher flows that may provide chinook and steelhead a better opportunity for these lifestages. Also, as previously noted, during critical water supply conditions, inflows to the project exceed outflows on only about 20 percent of days. Thus, the project may result in reduced spawning habitat for these two species about 0.3 percent of the entire evaluation period.

Habitat conditions in Dry Creek for spawning and incubation are similar regardless of the water supply condition. Dry Creek provides spawning and incubation habitat suitable for all three species under the D1610/2000 scenario.

Under the D1610/2020 scenario, flows in Dry Creek are higher than under the D1610/2000 scenario during normal and dry water supply conditions and during August and September in critical water supply conditions. Flows in October and November are very low, but they return to normal levels from December through March. The low November flows would adversely affect chinook salmon spawning and incubation habitat.

Temperatures are generally good for chinook salmon spawning and incubation on the mainstem. Temperatures are also generally good for the spawning and incubation for all three species in Dry Creek, and the upper end of Dry Creek always provides nearly optimal temperature and DO conditions. Results indicate that temperatures in the mainstem may be stressful for steelhead during the latter part of their incubation season (April and May), with temperatures reaching potentially lethal levels in May. Temperatures may also become stressful for steelhead incubation in the lower end of Dry Creek during May.

As discussed in *Section 4.2.1 Upstream Passage*, inflows to the project reservoirs rarely exceed outflows from the reservoirs under critical water supply conditions. Therefore, while the project may adversely affect spawning and egg incubation in critical water supply conditions, this affect would be extremely small, relative to the entire evaluation period.

4.2.3 REARING

Rearing of all three species occurs on Dry Creek, and chinook salmon and steelhead rear in the Russian River above Asti. Coho salmon and steelhead rear in freshwater year-round, while juvenile chinook salmon generally leave the system by the end of June in the year they hatch.

Current flows resulting from water supply, flood control operations, and D1610 releases provide suitable rearing habitat for steelhead and chinook salmon in the upper and middle reaches of the Russian River under both normal and dry water supply conditions. The lower mainstem is not thought to be used as rearing habitat by these species. In critical water supply conditions, there is a reduced amount of habitat for both species in both the middle and upper reaches. The reduced amount of habitat may concentrate juvenile salmonids into pools and increase their exposure to predators who have also taken refuge there. Under the D1610/2020 scenario flows would be very similar to those occurring under D1610/2000 scenario during normal and dry water supply conditions. In critical water supply conditions, flow would be nearly eliminated during the summer and fall months, which would adversely affect rearing steelhead. It would also adversely affect the latter part of the chinook rearing season in May and June.

The current flow regime in Dry Creek under D1610/2000 scenario provides rearing habitat for all three protected salmonid species under normal, dry and critical water supply conditions, since flow in Dry Creek is similar regardless of water supply conditions. However, the flows present in Dry Creek, and to a lesser extent in the mainstem, may result in velocities that are higher than optimal for rearing salmonids. Under the D1610/2020 scenario flows in Dry Creek would be increased over what is present under the D1610/2000 scenario, throughout the summer months in all water supply conditions. This would increase velocities to unsuitable levels during the summer. In October and November, under critical water supply conditions, flows would be reduced to nearly nothing. This would concentrate rearing fish into pools, decrease the area available to them, increase competition, reduce the available food supply, and increase their exposure to predators.

Inflows to the project reservoirs never exceed outflows during critical water supply conditions between April and October, which is the primary rearing season, when habitat compression is most likely to occur. Between November and March, in critical water supply conditions, there are fewer than 2 percent of days between when the project stores water in excess of what it is receiving, and flows in the downstream area are at levels stressful to salmonids. These few days could be attributed to project effects. The somewhat unsuitable water velocities in Dry Creek and, to a lesser extent, the Russian River are attributable to project operations, as the project and D1610 determine flow releases from the dams.

Water temperature is the primary factor limiting rearing habitat, particularly for steelhead. Temperatures are suitable for a large portion of the year, but almost always become stressful during July, August, and September, particularly in the mainstem Russian River. The upper portion of Dry Creek appears to have suitable rearing temperatures year-round. Temperatures can become quite warm (average daily temperatures exceed 23°C) in the Russian River above Asti and somewhat stressful in the lower portion of Dry Creek. Coho salmon avoid exposure to these temperatures to a large extent, because they do not utilize the mainstem Russian River for rearing. However, they may experience stressful temperatures in the lower portion of Dry Creek. Chinook salmon avoid exposure to these stressful temperatures by emigrating to the ocean within a few months after emergence (although they would experience stressful temperatures during emigration). Steelhead rearing in the mainstem or in the lower portion of Dry Creek would experience the full effect of these temperatures. Steelhead, however, are thought to rear primarily in tributaries to the Russian River. Temperature scores would be very similar under the D1610/2020 scenario to those described above. Model results indicate that DO conditions are excellent for rearing salmonids throughout the Russian River and Dry Creek year-round under both scenarios.

The water temperatures that occur in both the Russian River and in Dry Creek probably are moderated by the operation of the project. The two dams release water from the hypolimnion of the reservoirs; therefore, it is the coolest available waters. There is only one outlet port in Coyote Valley Dam, so it is not possible to adjust release levels to modify temperatures. Additionally, the water that flows into Lake Mendocino from the PVP is already relatively warm. Warm Springs Dam releases are made specifically to meet the requirements of the Don Clausen Fish Hatchery and therefore are near optimal for salmonids. Because of these operational considerations, the warm water temperatures in the Russian River system are unlikely to be caused by the project, but rather reflect the warm atmospheric temperatures that occur naturally from late spring through early fall. Consequently, the project is unlikely to adversely affect water temperature.

Based on the foregoing, project operations may adversely affect rearing juvenile chinook, coho and steelhead by increasing water velocities to less suitable levels. Under critical water supply conditions, the project may reduce the amount of habitat available for rearing for a few days.

Under D1610/2020 scenario increased flows during some months and the near elimination of flow in other months would further reduce habitat quality.

4.2.4 EMIGRATION

Emigration for all three species occurs from February to mid-May, and extends through June for steelhead and chinook salmon. Flows are generally highest during the early portion of this season and decline toward the end of the season. Higher flows are generally better for emigrating salmonids, as they can take advantage of the current to help carry them downstream. However, smolts migrate actively, and swim downstream in the absence of high flows, although they need a velocity cue to help them orient in a downstream direction. Normal water supply conditions provide adequate flows for emigration. Generally, flows are several hundred cubic feet per second until the latter part of the emigration season. Flows of these magnitudes provide high velocities in the river, which will adequately carry smolts downstream. Under dry water supply conditions, flows are substantially lower, and therefore emigration would be slower. There would still be substantial velocity to assist smolts in their emigration, although flows decline in April and May, and would reduce the speed of emigration during those months. In critical water supply conditions flows drop even further, to the point where velocities may be quite slow. Under these conditions, emigration may be prolonged even further. The duration of the emigration for an individual smolt is important, particularly late in the season; the longer the trip takes, the longer that individual is exposed to stressful water temperatures and to predators.

Water temperatures for downstream migrants also vary from good, early in the downstream migration periods, to stressful, in the later portion of the period. Juvenile coho salmon, steelhead, and chinook salmon may migrate downstream before stressful levels occur, but stressful temperatures occur during the latter part of the season, particularly for chinook and steelhead, which continue to emigrate through June. In May, conditions for emigrating steelhead are somewhat stressful in the lower Russian River, and in June very stressful temperatures have been encountered about one third of the time.

As discussed previously, the project reservoirs generally release as much or more water than they receive during critical water supply conditions. During a small portion of the time under these water supply conditions, the project reservoirs store more water than they receive. This would have an adverse effect on emigration related to project operations, based on reduced flows prior to April (the project never stores water in excess of what it receives in critical water supply conditions from April through June). As previously described, water temperatures may be improved by project operations, and therefore, unsuitable temperatures are not the result of project operations.

Under D1610/2020 scenario, flow levels are not substantially different from the D1610/2000 scenario in normal and dry water supply conditions. In critical water supply conditions, flow levels in the upper and middle Russian River are generally similar or slightly higher from February through April, but substantially lower in May and June. This would reduce the suitability of conditions for steelhead and chinook salmon smolts. In the lower Russian River, flows in June are slightly higher above Wohler inflatable dam and flows in May are somewhat lower below Wohler inflatable dam. The higher flows in June increase the suitability for emigration in this reach, but conditions below Wohler inflatable dam would be less suitable than under the D1610/2000 scenario.

Flows in Dry Creek would be the very similar or slightly higher under both scenarios from February through April, but would be substantially increased in May and June. This would improve the suitability of conditions for emigrating coho, steelhead, and chinook.

4.2.5 Dissolved Oxygen

In general, modeled DO levels were rated good to excellent in all reaches of the Russian River and Dry Creek for coho salmon and steelhead. They were generally rated excellent to optimal in all reaches. Lower DO values for chinook egg incubation in the upper reach of the Russian River were generally associated with dry years. However, even during these times, overall modeled DO levels were rated as good. Thus, current water supply and flood control operations and D1610 releases do not appear to negatively affect this parameter.

4.2.6 Estuary

The augmented flow in the Russian River estuary under the D1610/2000 scenario has several beneficial effects: it may maintain or improve water temperatures and DO levels; it helps dilute and flush nutrients and potentially toxic chemicals; and it may increase the amount of shallow water habitat available for salmonids and their food. The need to breach the sandbar at the mouth of the estuary during the late summer and fall to prevent local flooding may reduce the value of the estuary for rearing. This breaching causes continually changing habitat conditions (depth, salinity, temperature, and DO) in portions of the estuary. However, because the sandbar is open most of the summer, and because it does not generally remain closed for more than three to ten days at a time in the fall, the estuary tends to be open more than closed. The short duration of sandbar closures may limit the development of the poor water quality conditions that can be observed during the transition phase that occurs after the sandbar closes. The food organisms inhabiting the estuary can tolerate a wide range of salinity, temperature and DO concentrations and can likely tolerate the conditions following sandbar closure for a few days, although some stress would be expected. Nonetheless, the cyclic closure of the sandbar may reduce the suitability of the estuary for some food organisms and thus may also reduce its suitability for juvenile salmonids. However, salmonids are highly mobile and can move away from areas of poor water quality. They also may be able to shift to other food resources to offset this lost production. The extent to which they may successfully do this has not been documented.

The D1610/2020 scenario would reduce flows to the estuary by 20 to 30 percent from May through November. This would likely increase the period of closure of the sandbar. This may decrease the need to breach the sandbar as frequently; however, artificial breaching would still likely be necessary. The reduced flows under the D1610/2020 scenario will reduce the benefits associated with improved water temperature and DO levels, and dilution of nutrients as the estuary would not be flushed of these pollutants as frequently. This would tend to make water quality less suitable for salmonids and other estuarine organisms. The flow is unlikely to be reduced enough to allow a freshwater regime to become established in the estuary, however. Additionally, the increased duration of time that the sandbar-open photic zone community is at depths greater than light can penetrate the water column may reduce the productivity of this shallow water habitat. There would be insufficient time for areas at higher elevations to successfully establish themselves, and therefore there would likely be no additional shallow water communities in this area. The D1610/2020 scenario would therefore decrease the suitability of the estuary for salmonids relative to the D1610/2000 scenario.

4.3 SYNTHESIS OF EFFECTS

The analyses presented in this report show that the flow levels resulting from the operation of Coyote Valley Dam and Warm Springs Dam for flood control, water supply, and D1610 minimum flow releases provide a substantial amount of suitable habitat for all lifestages of protected salmonids. Many miles of habitat exist below each of these facilities where flow-related habitat, including spatial habitat, temperature and DO meet the needs for the completion of upstream passage, spawning and incubation, rearing, and emigration during normal water supply conditions, which exist 70 to 90 percent of the time, depending on month. In some areas of Dry Creek and the Russian River, summer flows under normal water supply conditions may exceed the preferred velocities for rearing coho and steelhead.

Under dry water supply conditions, which occur 9 to 13 percent of the time, habitat continues to support the spawning and incubation, rearing, and emigration lifestages. The upstream passage of all species remains good through the lower reach of the Russian River and Dry Creek. The upstream passage of adult coho and chinook salmon through the middle and upper reaches of the Russian River may be somewhat impaired. Steelhead also may experience some impairment in the upper reach. Adult salmonids may need to wait for pulses of flow associated with storm events to move upstream during some portions of the upstream migration period.

Under critical water supply conditions, which occur 1.5 to 6 percent of the time, habitat suitability for all lifestages of all species is reduced from those during dry and normal water supply conditions. Upstream passage is substantially impaired for all three species in all of the mainstem reaches, although passage up Dry Creek would remain available. The impairment in upstream passage in the mainstem, however, is not principally due to project operations. In critical water supply conditions during the migration season, Coyote Valley Dam releases more water than it receives from upstream sources except in 20 percent of the days. Therefore, only a small portion of the impaired passage condition can be attributed to the project. The lower flows in critical water supply conditions may also result in reduced area available for spawning and rearing, and may prolong emigration substantially.

Under the D1610/2020 scenario, conditions in normal and dry water supply conditions would be similar to those under the D1610/2000 scenario. Under future demands habitat conditions during dry water supply conditions would be less favorable for salmonids than they are currently. Upstream passage would become further impaired, including passage on Dry Creek. Additionally, rearing habitat in May and June would become limited to isolated pools under future demands and summer flows and water velocities on Dry Creek would increase substantially relative to the current demand during critical water supply condition.

Temperatures are generally suitable for all salmonid lifestages between November and April, but may begin to warm to stressful levels in May and very stressful levels in June. These very stressful temperatures persist in the mainstem and stressful temperatures persist in lower Dry Creek through the summer. These warm summer water temperatures are caused by the warm air temperatures of the interior valley and lack of riparian shading. Releases from both dams are made from their cool hypolimnetic water, the coolest water available for release. Thus, the warm water temperatures are not a project effect. These cool areas provide substantial amounts of suitable habitat for salmonids and are considered a beneficial effect of the project.

DO concentrations are suitable for all lifestages in all reaches. The only exception to this would be upper Dry Creek, where DO levels are sometimes stressful for chinook egg incubation during November. Temperature and DO conditions are similar to those that currently exist under the D1610/2020 scenario.

There are numerous factors that contribute to poor habitat conditions in the Russian River basin including high summer water temperatures, lack of channel structure and habitat complexity, agricultural and urban encroachment on the flood plains and riparian corridors, and the introduction of non-native species. These factors are not directly related to project operations. The following effects are directly related to flows from project operations, and are summarized in Table ES-1.

The habitat conditions that result from the flow releases from Coyote Valley and Warm Springs dams were evaluated. These evaluations found some impairment of upstream migration for all three species in the middle and upper Russian River during dry and critical water supply conditions under both demand scenarios. Under the D1610/2020 scenario critical water supply condition, the passage impairment becomes more severe and extends into the lower portion of Dry Creek, where it would affect chinook and coho salmon.

A second area of effect was the reduction of suitable spawning and incubation habitat under critical water supply conditions for both demand scenarios. This reduction was found in the upper and middle Russian River for chinook salmon and steelhead. Under the D1610/2020 scenario, spawning and incubation habitat for coho and chinook salmon in Dry Creek would also be reduced under critical water supply conditions.

Summer flows levels for both demand scenarios result in velocities that are higher than optimal for juvenile salmonids. High velocities may affect steelhead in some portions of both Dry Creek and the Russian River and coho salmon in some portions of Dry Creek.

4.4 CONCLUSION

The results of this analysis are considered preliminary until the results of the flow-habitat relationship study can be incorporated. The results of the water temperature and DO analysis are complete, but need to be integrated with the final flow effects before a final statement of project effects can be made.

The flows resulting from the operation of Coyote Valley and Warm Springs dams are likely to adversely affect coho salmon, steelhead and chinook salmon. Although the operations of the project under the current demand scenario have may have adverse effects on critical habitat, these changes in habitat seem unlikely to diminish the capability of the habitat to the extent that they fail to satisfy the essential requirements of the three species. Thus, it is concluded that current project operations do not adversely modify the critical habitat of coho salmon, steelhead, or chinook salmon. Under the D1610/2020 scenario, the increased flows in Dry Creek in dry and critical water supply conditions would result in conditions that would likely substantially decrease summer habitat for steelhead and coho. This may make the good habitat that currently exists in Dry Creek unusable. The loss of this important rearing habitat would likely have a pronounced effect on the population levels of all three species within the basin. Therefore it is concluded that the D1610/2020 scenario would adversely modify the critical habitat of all three species.

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