Carmel River Flow Threshold Study

Prepared for:

Monterey Peninsula Water
Management District
5 Harris Court, Building G
P.O. Box 85
Monterey, CA 93942

Prepared by:

Jones & Stokes
2600 V Street
Sacramento, CA 95818-1914
Contact: Mike Rushton
916/737-3000

January 2003

Jones & Stokes. 2003. Carmel river flow threshold study. January. (J&S 99-042.) Sacramento, CA.

Executive Summary

Background and Purpose

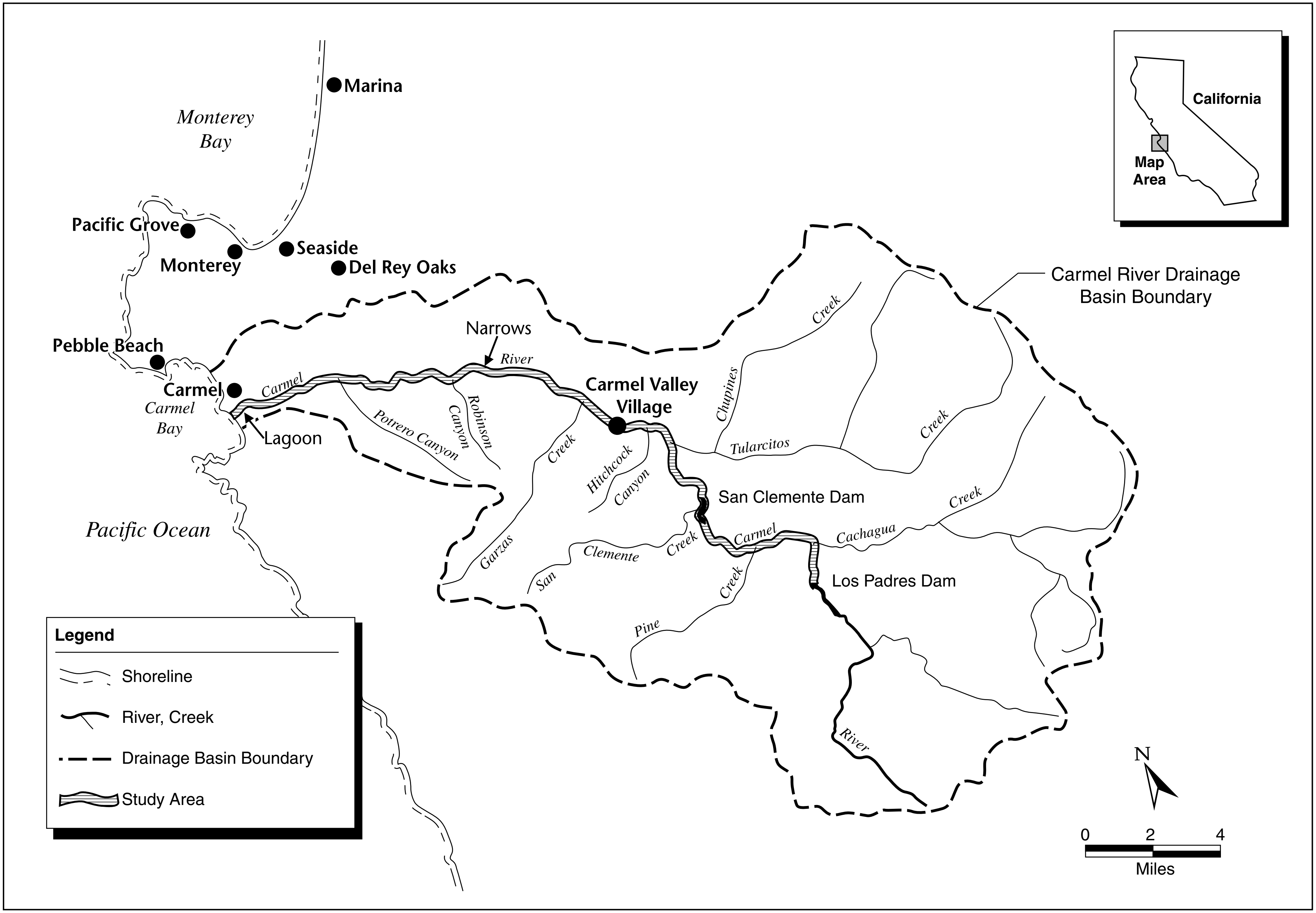
The Monterey Peninsula Water Management District (MPWMD) Board of Directors directed staff to begin preparing an Environmental Impact Report (EIR) on a Water Supply Project (WSP) in first quarter of 2002. Through the process of receiving public and agency scoping comments on the EIR, the MPWMD was reminded that project effects on flows in the Carmel River and the effects of changing flows would be one of the critical factors in the water supply decision making process. Subsequently, the MPWMD decided to review the multiple past technical studies, biological impact analysis, and agency-developed flow requirements for the Carmel River to determine what flows are required to sustain sensitive biological resources.

The primary purpose of the Carmel River flow study is to provide information that will be used to evaluate and determine the significance of biological and water resource impacts on the Carmel River that may occur as a result of operating alternative water supply projects. The study was conducted in support of the Water Supply Project (WSP) Environmental Impact Report (EIR). The results of the study will be used to help evaluate the impacts of some of the water supply alternatives that will be evaluated in the EIR. However, the assessment methods and flow thresholds identified in the study may also be used to assess the effects of future management programs on the Carmel River.

The flow thresholds were developed to assist in the evaluation of environmental impacts pursuant to the California Environmental Quality Act. The flows may not represent the flows or actions necessary to meet flows that may be required for improvement of the biological resources evaluated.

Resources Evaluated

The study focused on evaluating the sensitivity of biological resources to flows in the Carmel River. Three representative biological resources were selected and evaluated in the study. The resources evaluated are steelhead, California red-legged frog (CRLF), and riparian vegetation. The study area encompassed the reach of the Carmel River between Los Padres Dam and the Lagoon (**Figure ES-1**).



09042.99 001

Jones & Stokes

Figure ES-1
Carmel River Flow Threshold Study Area

Steelhead and CRLF were evaluated because both are listed as threatened under the federal Endangered Species Act. Riparian vegetation was evaluated because the California Department of Fish and Game considers it a sensitive plant community. Other biological resources of interest, including birds and benthic invertebrates are not included in the study. However, the condition of birds, benthic invertebrates, and other animals can be associated with the condition of riparian vegetation and steelhead.

Assumptions and Limitations

The study was conducted based on certain assumptions and limitations. The primary study assumptions and limitations are:

- The evaluation of Carmel River flows is based on the past hydrologic record and does not attempt to project future conditions within the watershed. The study did not attempt to estimate the changes in hydrologic conditions that might occur as a result of future projects or natural physical changes in the environment, such as changes in operation of Los Padres or San Clemente Dam. Seven water year types were used in the flow analysis. The water year types were defined by the 12.5 percent exceedence frequency increments of unimparied Carmel River Basin runoff.
- Annual Cal-Am demand was assumed to total 15,285 acre feet with 11,285 acre feet coming from the Carmel River;
- The quality of habitat along the Carmel River was assumed to be stable and the present condition of the river channel and substrate would not change.
- The analysis of steelhead, CRLF, and riparian vegetation assumed a no effect threshold defined as the flows required to ensure that no adverse effects would occur to the species relative to existing conditions.

Conclusions

Steelhead

The proposed flow thresholds for Carmel River steelhead during critically dry, dry and below normal, normal, above normal and wet years are summarized in **Table ES-1.**

Critically Dry Years

In critically dry years, steelhead production is primarily limited by the frequency and magnitude of winter flows needed for attraction and upstream migration of adults, and by the magnitude of flows for rearing and emigration of yearlings during the fall and spring.

Table ES-1. Proposed Flow Thresholds for Carmel River Steelhead

Life Stage	Period	Critically Dry Years	Dry Below Normal Years	Normal And Above-Normal Years	Wet Years	Extremely Wet Years
ADULT MIGRATION						
Attraction	December 15-January 31	Daily flow of 200 cfs to Lagoon whenever inflows to Los Padres Reservoir meet flow criteria in Appendix A in Dettman 1993.	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
	February 1-February 28	Daily flow of 100 cfs to Lagoon whenever inflows to Los Padres Reservoir meet flow criteria in Appendix A in Dettman 1993.	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
	March 1-April 15	Daily flow of 50 cfs to Lagoon whenever inflows to Los Padres Reservoir meet flow criteria in Appendix A in Dettman 1993.	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
Transportation	December 15-January 31	Daily flow of 60 cfs at Narrows and Lagoon for 25-50% of the days following attraction flow (apply to each period)	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
Stranding	December 15-January 31	Daily flow of 40 cfs at Narrows and Lagoon for 50-75% of the days following attraction flow (apply to each period)	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
SPAWNING	February 1-April 15	Average daily flow of 43-81 cfs at Narrows	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years

Table ES-1. Continued

Life Stage	Period	Critically Dry Years	Dry Below Normal Years	Normal And Above-Normal Years	Wet Years	Extremely Wet Years
REARING						
Rearing Capacity	June 1-December 31	Minimum monthly flow of 2-6 cfs at Narrows	Same as critically dry years	Same as critically dry years	Same as critically dry years	Minimum monthly flow of 6-20 cfs at Narrows
Stranding	October 1-March 31	Minimum daily flow of 1-5 cfs at Narrows following first storm event resulting in flows of 20 cfs or more at the Narrows (apply same threshold at Lagoon)	Minimum daily flow >=5 cfs at Narrows following first storm event resulting in flows of 20 cfs or more at the Narrows (apply same threshold at Lagoon)	Same as below normal years	Same as below normal years	Same as below normal years
EMIGRATION/REARING						
	April 1-May 31	Average Apr-May flow of 20-39 cfs at Lagoon	Same as critically dry years	Average Apr-May flow of 40-99 cfs at Lagoon	Average Apr-May flow >=100 cfs at Lagoon	Same as wet years

Based on the flow threshold criteria, significant impacts associated with impaired conditions can be avoided by maintaining suitable attraction flows to the lagoon whenever an opportunity occurs (whenever inflows to Los Padres Reservoir are projected to meet the attraction criteria during the migration season). This requirement, in combination with “fair” passage (transportation) conditions and a “medium” risk of stranding following an attraction event, result in sufficient numbers of spawning adults to achieve “poor” levels of fry seeding in most years (assuming “fair” spawning and rearing capacity). This level of fry seeding, in combination with “fair” rearing and emigration conditions and a “medium” risk of juvenile stranding, was found to maintain adult populations at “poor” levels in all years, which is comparable to levels achieved under unimpaired conditions.

Dry and Below-Normal Years

In dry and below-normal years, flows during the fall and spring rearing and emigration period had the greatest effect on adult production relative to unimpaired flows. Flows associated with “fair” rearing and emigration conditions and a “zero” risk of juvenile stranding were found to maintain adult populations at “poor” to “fair” levels in dry years and at “fair” levels in below-normal years. These levels are comparable to those achieved under unimpaired conditions. Based on the flow threshold criteria, it was also concluded that winter flows should continue to maintain opportunities for attraction and upstream migration of adults whenever they occur. Therefore, the proposed flow thresholds for adult attraction and upstream migration in dry and below-normal years were established at the same levels proposed for critically dry years.

Normal and Wet Years

In normal and wetter years, no major limitations resulting from impaired flows were identified. The proposed flow thresholds are based on the need to maintain conditions that allow the steelhead population to expand in response to good to excellent flow conditions that occur in these water years.

Riparian Vegetation

The growth, survival, and establishment of riparian vegetation along the Carmel River are associated with groundwater levels. The bed of the Carmel River may be dry from the Rancho Canada golf course at River Mile (RM) 2 to 6 miles upstream in critically dry years. The length and duration of the riverbed being dry varies by water year type. With the exception of extremely wet and some wet years, this length and duration is related to upstream flows and amount of groundwater pumping. Under existing conditions, riparian vegetation is maintained by irrigation in the area where the riverbed is periodically dry.

The following conclusions can be drawn about hydrologic effects on riparian vegetation and their implications for flow thresholds:

- Any flow reduction that would lead to a lengthening of the area or time period that the channel is dry may lead to a significant effect on riparian vegetation that would require additional irrigation in excess of the irrigation that is applied under existing conditions.
- Any increase in the time period that groundwater declines exceed 1 foot/day may lead to a significant effect on riparian vegetation.
- Any increase in the time period that groundwater is more than 20 feet deep in riparian areas may cause a significant effect on riparian vegetation.
- During wet or extremely wet years with dispersal flows (e.g., flows in excess of 1,000 cubic-feet/second (cfs) in the March – May period), seed dispersal and seedling establishment are not limited by flows at least until May 31.

California Red-Legged Frog

The evaluation of CRLF indicated no correlation between water temperature and flow during June, the warmest month before tadpoles can potentially complete their development and thus move to cooler environments. Therefore, it may be that low flows would not significantly impact CRLF reproduction during most years, as long as flows were sufficient to maintain water temperatures in July and August below the thermal critical maximum for subadults and adults.

Review of data indicates that the Carmel River and off-channel CRLF reproductive sites are hydrologically connected. However, off-channel sites are buffered from the high Carmel River flows that could result in the scouring and flushing of eggs and tadpoles. Successful reproduction in specific off-channel habitats was documented during the winter and spring of 1999 to 2000, when peak flows of 1,970 cfs at RM 24.8, 3,430 cfs at RM 10.8, and 3,040 cfs at RM 1.1 were recorded. This suggests that flows at or below these levels would not negatively affect CRLF reproduction in off-channel sites.

Bullfrog populations below the two dams are large and a threat to CRLF populations. Bullfrogs were found throughout the reach of the Carmel River below Los Padres Dam, in upper San Clemente Creek and Las Garzas Creek. Flows that change the seasonal nature of in-channel or off-channel habitats and make them perennial could allow for increases in bullfrog populations that could eliminate CRLF. This is particularly true if enough permanent water habitats are created to allow bullfrogs to migrate into areas they do not currently occupy. If bullfrog colonization of newly created permanent water habitats can be prevented, increases in Carmel River summer flows during normal years would benefit CRLF.

Contents

Tables

Figures

Follows Page

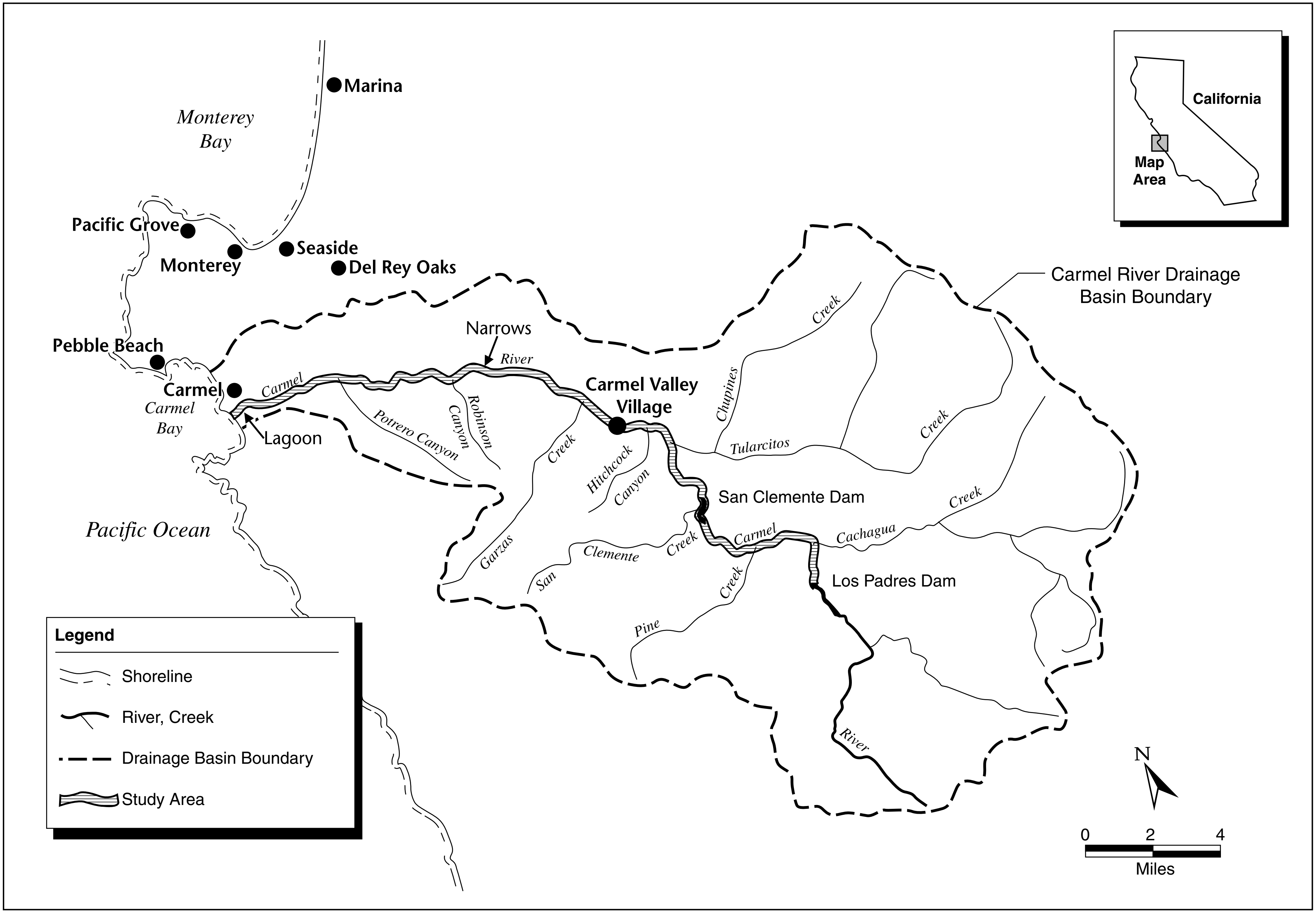
Chapter I
Introduction

This report provides the results of the Carmel River aquatic resources flow threshold study. The primary objective of the study is to provide information that will be used to evaluate and determine the significance of biological and water resource impacts on the Carmel River that may occur as a result of operating alternative water supply projects. In particular, the study supports the Water Supply Project (WSP) Environmental Impact Report (EIR) that is being prepared for the Monterey Peninsula Water Management District (MPWMD).

The study focuses on evaluating the sensitivity of specific biological resources to flows in the Carmel River. The resources evaluated are steelhead, California red-legged frog, and riparian vegetation. The study area encompasses the reach of the Carmel River between Los Padres Dam and the Lagoon (**Figure I-1**).

The report includes the following chapters:

- Chapter II "Report Purpose" provides background information and the purpose of the report;
- Chapter III "Resources Evaluated" describes the resources that are evaluated in the report;
- Chapter IV "Steelhead" describes the assessment methods, life stage requirements, and conclusions of the evaluation relative to steelhead, a salmonid fish listed by the federal government as a threatened species;
- Chapter V "Riparian Vegetation" describes the assessment methods, life stage requirements, and conclusions of the evaluation relative to riparian (stream side) vegetation, a plant community that provides habitat to many animal species;
- Chapter VI "California Red-Legged Frog" describes the assessment methods, life stage requirements, and conclusions of the evaluation relative to the California red-legged frog, listed by the federal government as a threatened species;
- Chapter VII " Flow Thresholds" integrates the conclusions of the steelhead, riparian vegetation, and California red-legged frog evaluation;
- Chapter VIII "References" lists the printed documents and personal communications used as source material for this study;



Jones & Stokes

Figure I-1
Carmel River Flow Threshold Study Area

- Chapter IX "List of Preparers" provides the names and affiliations of the study team;
- Appendix A "Steelhead" provides a discussion of the relationship between flows in the Carmel River and the various life stages of steelhead;
- Appendix B. "Results of Flow Threshold Analysis for Carmel River Steelhead Downstream of San Clemente Dam" provides the results of the flow analysis for steelhead.

Chapter II
Report Purpose

II-1. Background

The MPWMD manages and regulates the use, reuse, reclamation, and conservation of water within its boundaries. The MPWMD conserves and augments water supplies by the integrated management of ground and surface water resources. About 80% of the water collected, stored, and distributed within the MPWMD boundaries is done so by the California-American Water Company (Cal-Am). Cal-Am serves approximately 95% of Peninsula residents and businesses. Approximately 70% of the water delivered by Cal-Am is diverted from the Carmel River Basin.

In 1995, the State Water Resources Control Board (SWRCB) issued Order No. WR 95-10. The order stated that Cal-Am did not have the legal right to divert 70% of the water that was being delivered to Cal-Am users in 1995. This was estimated to be 10,730 acre-feet annually (AFA). However, the SWRCB did recognize the legal right of Cal-Am to divert up to 3,376 AFA from the Carmel River. As part of Order No. WR 95-10, the SWRCB required Cal-Am to obtain a permit to divert the unlawful amount of water or replace that water with another source. In the interim, the SWRCB has set goals to reduce pumping from the Carmel River Basin. The order also directs Cal-Am to reduce the amount of water diverted from the Carmel River Basin to no more than 11,285 AFA in water year 1997.

Since the early 1980s, the MPWMD has studied the effects of construction and operation of a range of water supply alternatives, including a new dam on the Carmel River. In support of a new dam, the MPWMD prepared impact analyses and pursued permits for its New Los Padres Dam and Reservoir Project. Key state and federal permits for the New Los Padres Dam and Reservoir Project were obtained by MPWMD in mid-1995, but voters did not authorize construction of the reservoir in November 1995, partly due to concerns about growth.

After studying various alternatives, in November of 1996 Cal-Am proposed construction of a dam physically identical to MPWMD's New Los Padres Dam. The proposed water yield from the Cal-Am dam project would meet the SWRCB requirements regarding the amount of water that could be legally diverted from the Carmel River. The project was not designed to supplement growth. A Draft

Supplemental EIR on Cal-Am's proposed Carmel River Dam and Reservoir Project was completed in 1998. Completion of final environmental documents for the Cal-Am dam and reservoir project have been delayed due to state legislation effective in 1999 which mandates the California Public Utilities Commission (CPUC) to identify an alternative or set of alternatives to the dam ("Plan B").

The draft and final Plan B reports were completed in Fall 2001 and July 2002, respectively. Plan B is intended to provide 10,730 AFA of legal water supply (CPUC 2002). The goals of the plan are to address SWRCB Order 95-10 while minimizing the risk of institutional challenge, protect the economic well being of the community, and minimize environmental effects (CPUC 2002). The final report recommends a project that combines a seawater desalination plant (9 million gallons per day [mgd]) at Moss Landing with Seaside Basin aquifer storage and recovery (ASR).

Water Rights

The SWRCB administers appropriative water rights in the Carmel Valley alluvial aquifer area. Previous decisions by the SWRCB have identified water rights held (or permits that need to be obtained) by various entities in Carmel Valley. The SWRCB has determined that the Carmel River is over-appropriated in the drier seasons of the year. The MPWMD was issued water rights associated with main stem reservoirs on the Carmel River (Permits 20808 and 7130B). In 2001-2002, MPWMD submitted two Petitions for Change based on the 1995 water rights permits associated with the New Los Padres Dam and Reservoir Project. The first petition requests use of the Seaside Groundwater Basin as a place of storage for some of the Carmel River water, rather than impounding the water behind a dam on the Carmel River. Approval of this petition would enable a water source for a long-term ASR project. The second petition requests diversions from the Carmel River of up to 7,909 AFA, essentially recognizing existing diversions as lawful.

Water Supply Project Environmental Impact Report

In June 2002, MPWMD issued a Notice of Preparation (NOP) indicating its intention to prepare an EIR on a water supply project. The project goals are to provide legal compliance for a water supply that would meet existing levels of water production of 15,285 AFA from the Carmel River and Seaside Groundwater Basin in the short-term and augment the community water supply over the long-term. The NOP indicated that the EIR would include a range of alternatives to meet the water supply goals. These included: an ASR alternative combined with one or more program elements and an alternative based on the Cal-Am Carmel River Dam and Reservoir Project. The ASR would operate by diverting excess flows from the Carmel River and storing this water in the Seaside Groundwater Basin. Other water supply sources to be evaluated include seawater desalination, wastewater reclamation, off-stream storage, and re-use of stormwater. The SWRCB will use the information in the EIR to help determine whether either of the two Petitions for Change should be granted.

II-2. MPWMD Board Direction

As indicated above, the MPWMD directed staff to begin preparing an EIR on the WSP in the first quarter of 2002. Subsequently a NOP was filed in June 2002 and the formal scoping was completed in July, 2002.

Through the process of receiving public and agency scoping comments, the MPWMD was reminded that project effects on Carmel River flows, and the significance of those effects on sensitive biological resources, would be one of the critical factors in its water supply decision-making. MPWMD decided that it would be prudent to review the multiple past technical studies, biological impact analyses and agency-developed flow requirements for the river to determine, based on best available scientific data, what flow thresholds would be needed to sustain the sensitive biological resources.

At its August 29, 2002 workshop, the MPWMD Board directed the General Manager to prepare a scope of work and cost estimate to conduct a Carmel River flow threshold study. At the Board Administrative Committee's September 10, 2002 meeting, it further defined a three-step process for considering Carmel River flows. The first step would be to review historical information about species needs and identify conflicts or unknowns in the various studies. Second, the information would be used by MPWMD staff and consultants to develop the best understanding of species' needs for flow in the river today. A third step, which would not be undertaken immediately, would be to use the results of steps one and two to develop a flow regime that would support the overall recovery of the Carmel River ecological system. Subsequently, after reviewing a scope of work and cost for steps one and two, MPWMD approved a task order for the threshold study at its September 19, 2002 Board meeting. Jones & Stokes, a consultant to MPWMD, was authorized to proceed on the threshold study on September 26, 2002.

II-3. Report Purpose

The primary purpose of the flow threshold study is to provide information that will be used to evaluate and determine the significance of biological and water resource impacts on the Carmel River that may occur as a result of operating alternative water supply projects. In particular, the study will support the impact analyses in the Water Supply Project EIR. Individual water supply alternatives will be reviewed to determine their effect on river flows. If those alterations are sufficient to exceed the thresholds that are established, the alternative would be considered a threat to the long-term sustainability of the biological resources dependent on the flows. A discussion of CEQA significance thresholds is provided below in Section II-4.

The process of determining the flow thresholds also has resulted in the development of an assessment methodology that can be applied to evaluating the environmental effects of the WSP or other projects that may occur in the Carmel River below Los Padres Reservoir. The flow thresholds and assessment methodology may also be used to assess the effects of future management programs on the Carmel River. The results of the flow threshold study will help in determining if additional water rights for diversions from the Carmel River could be permitted by the SWRCB.

II-4. California Environmental Quality Act (CEQA) Thresholds

As indicated in the State CEQA guidelines (Section 15064.7), public agencies are encouraged to develop thresholds of significance that the agency uses in the determination of the significance of environmental effects of a proposed project. The CEQA guidelines also define a threshold as an identifiable quantitative, qualitative, or performance level of a particular environmental effect. A lead agency will normally determine that noncompliance with a threshold would result in a significant impact on the environment.

The flow thresholds and assessment methodology can be used as tools to predict whether constructing and operating an ASR or other water supply project would result in a significant impact on the Carmel River environment.

II-5. Assumptions and Limitations

As indicated above, the primary purpose of this study is to establish flow thresholds for key resources that will be used, in part, to evaluate the significance of potential changes in flows on those and other resources occurring in and along the Carmel River relative to the requirements of CEQA. To conduct the study in a timely manner, certain assumptions were made regarding the hydrology of the Carmel River and the conditions of existing habitat. The following provides a discussion of these assumptions and limitations relative to hydrologic conditions, habitat quality, and the flow thresholds.

Hydrologic Conditions

The hydrology of the Carmel River has been significantly modified by human activity over the past 100 years, including removal of riparian vegetation and construction and operation of San Clemente Dam and Los Pardres Dam. However, over the past 50-80 years, the reservoirs created by the dams have gradually filled with sediment, reducing the ability to store and divert water and in turn, modify Carmel River flows. In more recent years, the diversion of surface water has been replaced by pumping from the alluvial aquifer along the

Carmel River. The most obvious effect of this subsurface flow pumping is experienced in the dry season, when pumping can dewater the lower reach of the Carmel River.

A significant record of historic flow conditions on the river has been developed over the past forty-four years, but this period does not include a natural, uncontrolled condition. It includes primarily the period modified by surface diversions at the two dams and pumping from the alluvium along the river. The Carmel Valley Simulation Model (CVSIM) was developed by MPWMD based on this period of hydrologic record. CVSIM is used to predict flow changes in the future caused by water management in the watershed. CVSIM also allows the simulation of unimpaired Carmel River flows.

The flow analysis in this report is based on the past hydrologic record and does not attempt to project future conditions within the watershed. Because of time and budget constraints, the study did not attempt to estimate the changes in hydrologic conditions that might occur as a result of future projects or natural physical changes in the environment. Seven water year types were used in the flow analysis. The water year types were defined by the 12.5% exceedence frequency increments of unimpaired Carmel River Basin runoff (**Table II-1**).

Certain unknowns exist regarding the operation of Los Padres and San Clemente Reservoirs. The storage capacity of each reservoir will undoubtedly change as a result of continued sedimentation, sediment removal, or state agency requirements regarding dam safety. Any of these unknowns could result in a change in the hydrologic conditions on the reach of the river below the dams. Because these future conditions are not yet known, the study assumed that the existing storage capacity and operation of the reservoirs would not change. Once decisions are made regarding sediment management in the reservoirs and structural and operational changes at the dams, it will be necessary to reevaluate the appropriateness of the flow analysis contained in this document.

The study also assumed that water production to meet demand within the MPWMD boundaries would remain constant. The Cal-Am production was assumed to total 15,285 AFA, with 11,285 AFA coming from the Carmel River basin.

Habitat Quality

Consistent with the assumptions on river flows, the quality of habitat in and along the Carmel River was assumed to remain stable. The condition of the river channel, the movement of sediment in the river channel, and the substrate of the channel would not change. The condition of riparian vegetation would remain as it is and programs instituted by the MPWMD to ensure vegetation survival would continue. When decisions are made to modify the operation of the two dams on the river, these habitat quality assumptions should be revisited.

Table II-1. Water Year Types Used in the Flow Analysis

Water year type	Unimpaired Carmel River Basin runoff (acre-feet)	Exceedence frequency (%)[1]
Extremely wet	above 129,800	12.5
Wet	102,900 – 129,800	12.5 - 25
Above normal	71,500 – 102,900	25 - 37.5
Normal[2]	41,600 – 71,500	37.5 – 62.5
Below normal	29,500 – 41,600	62.5 – 75
Dry	14,700 – 29,500	75-87.5
Critically dry	below 14,700	87.5

Notes:

[1] Classifications are based on selected exceedence frequency values computed from the long-term reconstructed flow record at the San Clemente Dam site (1902-2001).

[2] The 50% exceedence frequency flow is 50,100 AF

Source: Fuerst (pers. comm.)

Flow Thresholds

The analysis of steelhead, riparian vegetation, and red-legged frog assumes a no-effect threshold. This threshold is defined as what river flows are required to ensure that no adverse effect would occur to the species studied relative to the existing condition of these species. Existing condition, for purposes of CEQA analysis, is set at the time the NOP of an EIR is released. The NOP for MPWMD's Water Supply Project was issued in June of 2002. At that time, both the steelhead and red-legged frog populations were considered threatened under the federal Endangered Species Act. Acreage of riparian vegetation was gradually increasing along the river, due primarily to MPWMD restoration programs. The report is not a determination of the significance of a change in conditions, but at what flow(s) these resources would be adversely affected relative to existing conditions. The thresholds were developed to assist in the evaluation of environmental impact pursuant to CEQA and may not represent the flows or actions necessary to meet future desired increases in fish or frog populations, or flows that may be required for "recovery" or improvement of the biological resources evaluated.

Chapter III
Resources Evaluated

III-1. Introduction

Past studies of the Carmel River and the effects of water supply projects on the river have focused on its fish and vegetation resources. These resources are the most obvious indicators of the river's biological health. Riparian (streamside) vegetation often defines a stream's presence to the human eye and provides habitat to a broad array of vertebrate and invertebrate species. The steelhead trout that occupy the river are the largest aquatic species in the system and are sought after by both fishermen and vertebrate predators. The riparian vegetation and the steelhead are also excellent indicators of water quality and flow conditions in the river.

Past water supply project impact analyses on the Carmel River have identified potential significant effects on riparian vegetation and the steelhead trout (MPWMD 1990a, 1994a) and, more recently, the red-legged frog (MPWMD 1998a). The steelhead trout and the red-legged frog are the focus of analyses because the federal Endangered Species Act (ESA) protects them as threatened species. Riparian vegetation is considered a sensitive plant community by the California Department of Fish and Game because of its long-term loss to agriculture and development, and because of the species diversity it supports. Because of these potential effects, MPWMD has developed extensive management, monitoring and mitigation programs for riparian vegetation, steelhead trout and red-legged frog. The protected status of these biological resources and their dependence on river flows has resulted in their inclusion in this threshold study.

Other biological resources of interest, including birds and benthic invertebrates, have not been included in the study. While these animal groups are significant to the overall health of the river system, their health can be assessed with some reliability by considering riparian vegetation and steelhead trout. Riparian vegetation provides habitat for numerous wildlife species including neotropical song birds and raptors. Several special status song birds that may occur in the study area nest and forage in riparian habitat including the least Bell's vireo, yellow warbler, and western bluebird (EIP 1994). Raptors that may utilize riparian vegetation in the Carmel Valley include red-shouldered hawk, sharp-shinned hawk, and Cooper's hawk.

An overview of the life history and conditions in the Carmel River for steelhead, riparian vegetation, and red-legged frog is provided below.

III-2. Steelhead

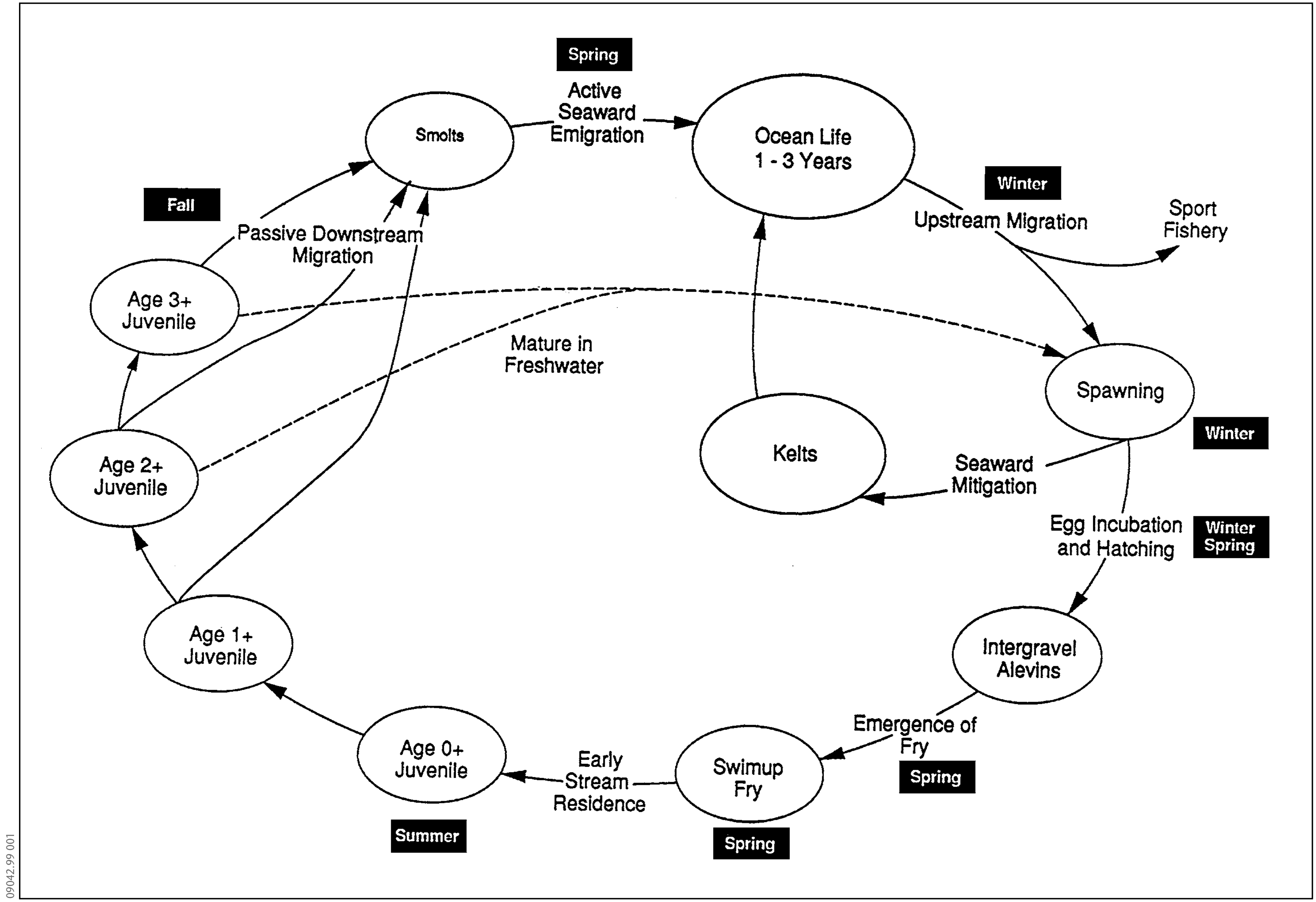
Life History

Steelhead are anadromous (sea-run) rainbow trout that spawn in freshwater, spend the first year (or years) of life in freshwater, and then migrate to the ocean where they continue to grow and mature before returning to spawn. The life cycle of the steelhead is depicted in **Figure III-1.**

In California coastal streams south of San Francisco Bay, adult steelhead begin their upstream migration with the first major storms in late fall and winter. In many streams, the movement of adult steelhead is blocked until flows increase sufficiently to breach the sandbars that form at the mouths of the streams during the dry season. Following upstream migration, the female establishes a territory and digs a redd (gravel nest) with her tail, usually in areas where there is sufficient subsurface flow to sustain eggs and alevins (yolk-sac fry) through the incubation period (usually the lower ends of pools or heads of riffles). She then lays the eggs in the redd where they are fertilized by one or more males.

Eggs buried in redds hatch in 3-4 weeks (at 10-15 Celsius) and fry emerge from the gravel 2-3 weeks later. The fry initially live in quiet waters close to shore and soon establish feeding territories that they defend against other juveniles. As they grow during spring and summer, juvenile steelhead move to faster, deeper water in riffles, runs, and pools. They typically maintain positions near swift currents that carry drifting aquatic and terrestrial insects on which they feed. Some juveniles may move downstream to the lower reaches of streams or lagoons during the summer and fall to complete their freshwater rearing phase. After one year of stream residence, most juveniles become smolts (juveniles adapted to seawater) and migrate downstream to the ocean in late winter and spring. Some juveniles remain in fresh water 1-2 more years before they enter the ocean. Because juvenile steelhead rear for a year or more in freshwater, juveniles of different age groups are usually present year-round in California coastal streams.

Most steelhead spend 1-3 years in the ocean before returning to spawn. Some adults return to the ocean after spawning (kelts) and return to spawn again. Occasionally, juvenile steelhead mature in freshwater and spawn without migrating to the ocean. This occurs most frequently during droughts when juveniles are trapped in the river and cannot migrate to the ocean.



Jones & Stokes

Figure III-1
Life Cycle of Steelhead

Carmel River

Adult Migration

The upstream migration of adults in the lower Carmel River primarily occurs from mid-December through mid-April in response to flows of sufficient magnitude and duration to stimulate movement of adults, permit passage of adults past critical riffles in the lower river, and keep the river mouth open between storms. Although suitable migration conditions may occur earlier, adults typically do not begin arriving at San Clemente Dam until late December or January. Depending on migration opportunities later in the season, the migration of adults may continue into April.

Spawning

The primary spawning season for steelhead in the Carmel River is February through March but spawning may continue through mid-April. Downstream of San Clemente Dam, the highest concentration of redds generally occurs upstream of the Narrows but redds have been observed as far downstream as river mile (RM) 5.5. (River miles represent distances measured upstream of the mouth of the Carmel River.) Of the total spawning habitat upstream of the Narrows, an estimated 41% is between the Narrows and San Clemente Dam, 9% is between San Clemente Reservoir and Los Padres Dam, and 50% is upstream of Los Padres Reservoir. These percentages have probably changed because of a spawning gravel restoration project, which has increased the amount of spawning gravel in the reaches immediately downstream of Los Padres and San Clemente Dams. Habitat-discharge relationships for the reach between the Narrows and San Clemente Dam indicate spawning habitat quality and quantity increases as flows increase from 5 to 135 cfs. (Alley 1992 and 1998).

Juvenile Rearing

In the Carmel River, most steelhead fry emerge from the gravel in April-June and rear for at least one year in the river before migrating to the ocean as smolts. Juveniles may migrate downstream to lower reaches of the Carmel River in late spring or early summer of their first year of life (young-of-the-year or age 0+ juveniles) or in late fall and early winter of their first, second, or third years (as yearling and older juveniles). Juveniles of all age classes may migrate as far downstream as far as the lagoon in years when flows to the lagoon are sustained through the summer and fall. Substantial downstream movement of juveniles in late fall and early winter appears to be associated with the initial storms of the season that result in spill and increased flows downstream of San Clemente Dam.

Based on indices of summer rearing capacity for young-of-the-year steelhead, 28% of the total rearing habitat upstream of the Narrows is between the Narrows and San Clemente Dam, 33% is between San Clemente Reservoir and Los Padres

Dam, and 39% is upstream of Los Padres Reservoir. For yearling steelhead, 23% of the total rearing habitat is between the Narrows and San Clemente Dam, 20% is between San Clemente Reservoir and Los Padres Dam, and 57% is upstream of Los Padres Reservoir. Based on these indices, Dettman and Kelley (1986) estimated that the reach between the Narrows and San Clemente Dam could support young-of-the-year populations ranging from 45,000 to 135,000 fish at summer and fall flows ranging from 5 to 40 cfs. Similar estimates of rearing capacity downstream of the Narrows are not available.

Smolt Emigration

Many juvenile steelhead in the Carmel River become smolts and enter the ocean in late winter and spring after one year in the river. A small number remains for two to three years before emigrating.

III-3. Riparian Vegetation

Vegetation Composition

Vegetation along the portion of the Carmel River included in the study area generally consists of the same species, however the relative species abundance and canopy structure differs between the Upper, Middle, and Lower Carmel Valley. The Upper Camel Valley, upstream of San Clemente Dam (RM 18.6), consists mostly of narrow canyons with a narrow strip of riparian forest generally conforming to Holland's (1986) Central Coast Cottonwood-Sycamore Riparian Forest. Dominant species include western sycamore (*Platanus racemosa*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), white alder (*Alnus rhombifolia*), coast live oak (*Quercus agrifolia*), California bay (*Umbellularia californica*), California buckeye (*Aesculus californicus*), and willows (*Salix* species)[1]. Understory species typically include poison oak (*Toxicodendron diversilobum*), coffeeberry (*Rhamnus californica*), blackberries (*Rubus* species), and others. Marshy vegetation occurs along slower reaches of the river. (EIP 1994).

Riparian vegetation in the Middle Carmel Valley, (San Clemente Dam to The Narrows (RM 9.5)), and in the Lower Carmel Valley, (the Narrows to the river mouth), conforms generally to Holland's (1986) Central Coast Arroyo Willow Riparian Forest, dominated by arroyo willow (*S. lasiolepis*), with red willow (*S. laevigata*), shining willow (*S. lucida* ssp. *lasiandra*), and narrow-leaved willow (*S. exigua*), with black cottonwood as an important component of the overstory and with sycamore, box elder (*Acer negundo*)the other species listed above. In the drier outer floodplains of this region, coast live oak may dominate and the riparian vegetation conforms generally to Central Coast Live Oak Riparian Forest (Holland 1986). The Middle Carmel Valley has a steeper gradient, and a more

[1] Botanical nomenclature follows Hickman (1993).

braided, less stable channel than the Lower Carmel Valley (Curry and Kondolf 1983). The vegetation in the Middle Carmel Valley tends to be more discontinuous than in the Lower Carmel Valley, where a more continuous riparian woodland or forest has developed (McNiesh 1989).

McNiesh's (1989) mapping of the riparian corridor downstream from San Clemente Dam based on 1986 aerial photographs, showed that the riparian zone was on average 271 feet wide, 86 feet being channel and 185 feet being riparian vegetation. The total area of riparian vegetation was 410 acres, 299 acres was made up of riparian woodlands and 111 acres was non-continuous cover.

Carmel River

Riparian vegetation along the Carmel River has been affected by a number of important natural and human-induced events. Knowledge of these events and their effects on riparian vegetation facilitates an understanding of the effects of potential future changes of the system, including flow manipulations. This section describes the riparian vegetation along the Carmel River downstream from San Clemente Dam (RM 18.6), and is based largely on McNiesh's (1989) review of previous studies.

The most important natural events that have affected riparian vegetation include floods and droughts. Major floods occurred in 1862, 1911, 1914, 1995, and 1998 (Kondolf and Curry 1986, Mussetter Engineering Inc. 2002). Major floods cause bank erosion and loss of riparian vegetation, but perhaps more importantly may also affect channel form and depth. The bed of the river incised some 12 feet in response to the 1911 flood until equilibrium was reached in 1965 (Kondolf and Curry 1986).

Recently, two major floods, in March 1995 and February 1998, caused substantial flooding, erosion of riparian vegetation and benefits to riparian regeneration. On March 10, 1995 a flood peak of 16,000 cfs passed Robles del Rio, which has an approximate return interval of 28 years (Mussetter Engineering Inc. 2002). A flood peak of 14,700 cfs followed this flood on February 3, 1998. The 1995 flood caused extensive damage to property and infrastructure. Approximately 8 acres of riparian vegetation was lost as a result of the flood. Restoration projects initiated in the aftermath of the 1995 flood greatly benefited riparian vegetation and reduced impacts of the 1998 flood. To prevent future flood damage, segments of levee east of Highway 1 adjacent to a farm field were removed by various agencies and the Monterey County Department of Public Works notched levees at 5 sites to a level corresponding to a 10-year flood. In addition, riparian and wetland restoration projects were developed west of Highway 1 at the Carmel River Lagoon. The result is that the riparian vegetation along the lower river has been substantially expanded and that the restored vegetation is now exposed to overbank flooding (Jones & Stokes 1998). In spite of these and other improvements, the 1998 flood also caused substantial damage and approximately 17 acres of riparian vegetation in the lower Carmel Valley were lost due to bank failure and channel avulsion. Riparian vegetation has benefited in most areas from the overbank flooding, bank saturation and deposition of fine sediment and organic matter caused by both floods (Jones & Stokes 1998).

Droughts have probably had a substantial effect on riparian vegetation; however, the effect of droughts cannot be separated fully from human activities. For example, the 1975-1977 drought led to extremely heavy groundwater pumping and unprecedented drawdown in the lower Carmel Valley (McNiesh 1989). To what extent the drawdown was the result of pumping or of the natural effects of drought cannot be determined. However, an analysis of simulated unimpaired flows for 1977 using the MPWMD's Carmel Valley Simulation Model (CVSIM) model shows that the river would have been dry at the USGS "Near Carmel" gauge site (RM 3.6) without the presence of dams and pumping wells. McNiesh (1989) points out that droughts by themselves cannot be blamed for vegetation decline in the Carmel Valley, because vegetation decline occurred prior to the 1970's drought and continued after the water table recovery that followed the drought.

The major human-induced changes that have affected the riparian vegetation include encroachment on the riparian vegetation as the result of farming, housing development, and golf course construction, construction of San Clemente (1921) and Los Padres (1948) Dams, and groundwater pumping (McNiesh 1989). In addition, installation of bank protection has reduced lateral movement of the river (Mussetter Engineering Inc. 2002). The dams have relatively small reservoirs that have relatively little effect on flood peaks. Diversions and groundwater pumping have caused the once perennial river to become characteristically dry in late summer. However, reservoir releases also periodically cause increased flows in reaches below the dams that otherwise would have been dry. The dams also trap sediment which was encouraged downstream channel incision (Curry and Kondolf 1983). Groundwater pumping by Cal-Am and others has been identified as a major impact on riparian vegetation (McNiesh 1986, 1989). Although Cal-Am pumped groundwater from 1945 – 1951, which peaked at 1,000 acre-feet annually (AFA), consistent pumping started in 1959 and has increased to a production of 10,750 AFA in 1987, of which 8,440 AF was withdrawn by Cal-Am, and 2,310 AFA by non-Cal-Am pumps (Jones & Stokes 1998-App. C). A portion of the non-Cal-Am pumped water is assumed to return to the aquifer as recharge from irrigation and septic tank return flow. For the simulations used in this study, a maximum system-wide production limit for Cal-Am of 15,285 AF was set, based on the current State Water Resources Control Board limit for Cal-Am diversions from the Carmel River (Fuerst pers. comm.). The 15,285 AFA consists of 11,285 AFA from the Carmel River Basin and 4,000 AFA from the Seaside Basin.

McNiesh (1986, 1989) and others (Zinke 1971, Groeneveld and Griepentrog 1985) have demonstrated that groundwater pumping has led to local riparian vegetation mortality. This mortality has been associated with local bank erosion. McNiesh (1986) has shown that not only total drawdown, but also the rate of drawdown is critical for survival of riparian trees. The precise amount of drawdown that can be tolerated by vegetation cannot be defined, because it is dependent on a large number of interrelated factors (McNiesh 1989). But, a general model was outlined by McNiesh (1986) that can be used to predict thresholds of damage to vegetation. Mild stress of riparian trees occurs if drawdown is between 4 and 8 feet in a season or between 1 and 2 feet per week. Severe stress occurs when seasonal drawdown is greater than 8 feet, or drawdown in a week exceeds 2 feet. These are drawdown rates in excess of the normal seasonal fluctuation in groundwater levels.

Two vegetation restoration measures have been implemented: irrigation and replanting of riparian vegetation. The MPWMD has operated irrigation systems since 1985 to mitigate the effect of groundwater pumping on riparian vegetation under three programs: the Four-Well Irrigation Program, the Interim Relief Program, and the Carmel River Management Program, covering more than 6.4 miles of riverbank (MPWMD 1996). Under the MPWMD Water Allocation Program EIR the Five-year Mitigation Program was implemented in 1991 (MPWMD 1996). This program superseded previous irrigation programs. The mitigation program continues at present. Between 1988 and 1995 annual irrigation volume under this program varied from 4.57 AF in 1995 to 195.53 AF in 1988.

III-4. California Red-Legged Frog

The California red-legged frog (CRLF) is listed as threatened under the Federal Endangered Species Act. It has been extirpated from 70% of its former range and now is found primarily in coastal drainages of central California, from Marin County, California, south to northern Baja California, Mexico. CRLF has been reported from several relatively isolated, although widely distributed locations, along the Carmel River. This Carmel River population has been identified by the U.S. Fish and Wildlife Service as a core population, targeted for development and implementation of a management plan. (U.S. Fish and Wildlife Service 2002).

Life History

Life Stages

CRLF breed from November through April (Storer 1925), although most egg masses are typically laid in March. Males appear at breeding sites approximately 2 to 4 weeks before females (Storer 1925) and begin calling to attract females. A mated pair will then move to the location where eggs are laid, and the eggs will be fertilized while being attached to a brace. Braces include emergent vegetation such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs. Egg masses typically float on the surface of the water (Hayes and Miyamoto 1984), but may occur at depths of up to 1 meter (3.3 feet)(EcoSystems West Consulting Group 2001). Each mass contains approximately 2,000 to 5,000 eggs (Storer 1925). Although egg predation is infrequent, egg masses are susceptible to being washed away by high stream flows. No estimates are reported in the literature, however, regarding the levels of flow necessary to wash away eggs.

Eggs hatch into tadpoles in 6 to 22 days, depending on water temperatures and location (Jennings and Hayes 1994). The tadpoles are highly vulnerable to fish predation, especially immediately after hatching when they are not feeding and relatively sedentary (Schmieder and Nauman 1994, in U.S. Fish and Wildlife Service 2002). Tadpoles typically require 11 to 20 weeks to develop into terrestrial frogs (Storer 1925, Jennings and Hayes 1994). However, several researchers have recently reported observing over wintering tadpoles (i.e., tadpoles that did not metamorphose within their first breeding season) (U.S. Fish and Wildlife Service 2002). Males and females attain sexual maturity at 2 and 3 years of age, respectively (Jennings and Hayes 1985); adults may live 8 to 10 years (U.S. Fish and Wildlife Service 2002). The diet of CRLF is highly variable. The foraging ecology of tadpoles has not been studied, but they are thought to be algal grazers (Jennings et al. in lift. 1992). Hayes and Tennant (1985) found invertebrates to be the most common food items of adult frogs by numbers, although vertebrates such as Pacific tree frogs (*Hyla regilla*) and California mice (*Peromyscus californicus*) represented over half of the prey mass eaten by larger frogs. Feeding typically occurs along the shoreline and on the surface of the water (Hayes and Tennant 1985). Radio-tracking studies suggest that frogs also forage several meters into dense riparian areas (U.S. Fish and Wildlife Service 2002).

Habitat Requirements

CRLF habitat consists of permanent or ephemeral water sources with emergent and or submerged aquatic vegetation. They are known to occupy and breed in marshes, springs, ponds (both natural and artificial), and backwater pools of rivers and streams (Stebbins 1985). CRLF also occur and reproduce in tidally influenced coastal marshes that have low salinity levels during the reproductive season (EcoSystems West Consulting Group 2001).

The types of habitat occupied by CRLF tend to vary with life stage; in general, eggs and tadpoles have narrower habitat tolerances than subadults or adults (EcoSystems West Consulting Group 2001).

Carmel River

Information on CRLF occurrences in the lower Carmel River floodplain, between approximately RM 28 (above Los Padres Dam reservoir) and the Carmel River Lagoon, was taken primarily from information provided in the Draft Interim Biological Assessment for the Carmel River Dam and Reservoir Project (EcoSystems West Consulting Group 2001), although other sources such as Mullen (1996) and the Recovery Plan for the California red-legged frog (U.S. Fish and Wildlife Service 2002) were also reviewed.

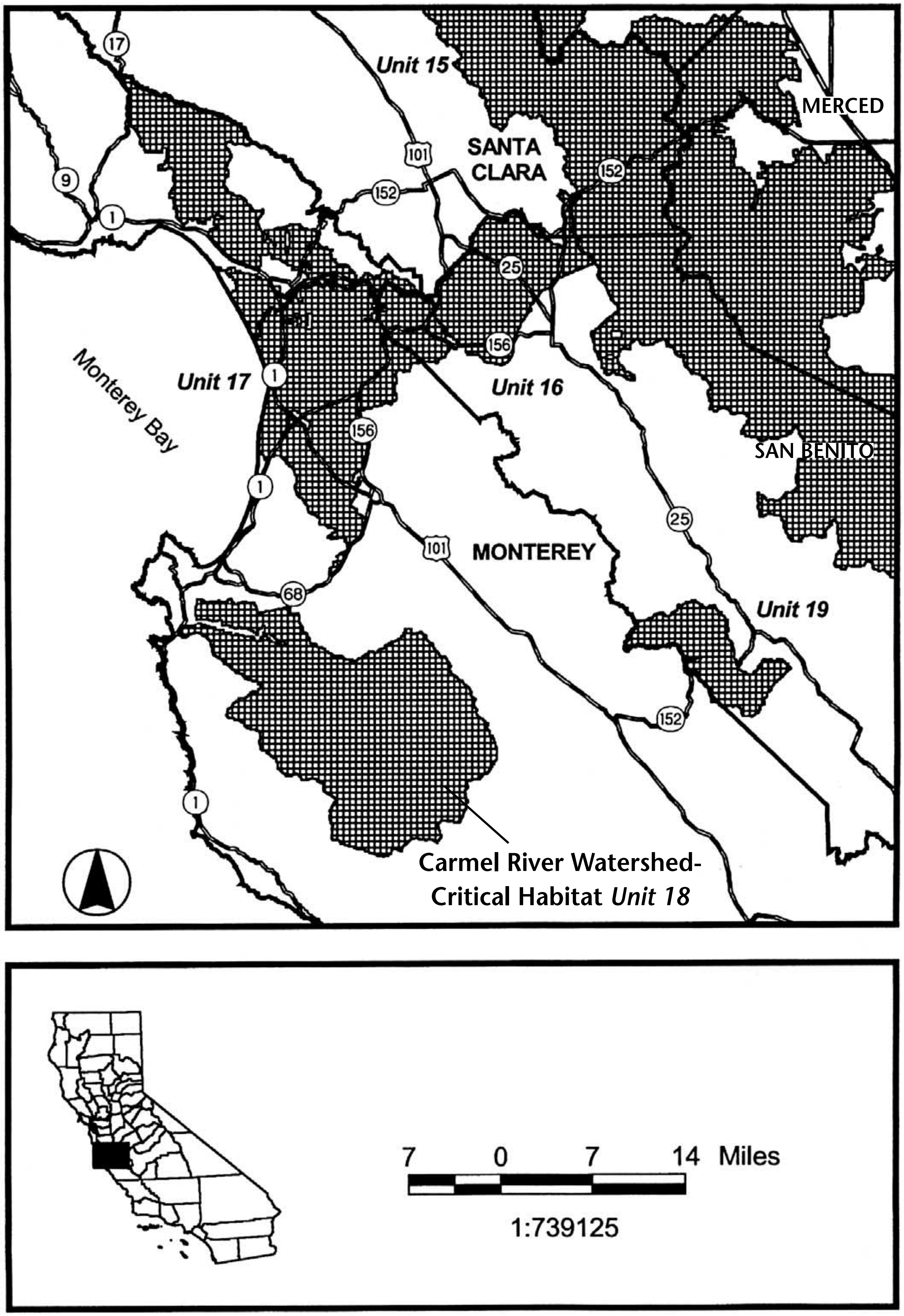
Critical Habitat

The U.S. Fish and Wildlife Service designated critical habitat for the CRLF on March 13, 2001 (FR 69:14626). Critical habitat is defined under the federal Endangered Species Act as "the specific areas within the geographic area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management consideration or protection; and (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon determination that such areas are essential for the conservation of the species." Under the Act, destruction or adverse modification of critical habitat by an activity funded, authorized, or carried out by any federal agency is prohibited. The U.S. Fish and Wildlife Service designated several watersheds as critical habitat units (planning watershed boundaries were used to designate these units). However, to be considered critical habitat, areas within those units must have the three primary constituent elements as defined in the critical habitat designation: essential aquatic habitat, associated uplands, and dispersal habitat connecting essential aquatic habitat (FR 69:14626). Therefore, not all land within the designated habitat unit is actually critical habitat.

Most of the Carmel River watershed was included in critical habitat unit 18 (**Figure III-2**) (FR69:14626). EcoSystems West Consulting Group (2001) mapped critical habitat within habitat unit 18 in the Carmel River watershed for the MPWMD in 2000. However, critical habitat was mapped only from approximately RM 27 southwest to RM 10 due to a mapping resolution error and the resulting confusion concerning the lower boundary of critical habitat unit 18. The firm identified a total of 73 potential reproductive locations for CRLF within critical habitat unit 18 (17 in the main stem and 56 in off-channel areas within the river corridor or within 1.25 miles of the river), in addition to numerous sites that could potentially be used by CRLF during other parts of their life cycle.

Distribution of Habitats

As part of their efforts to characterize habitat for CRLF within the entire "action area" of the proposed New Los Padres Dam and Reservoir Project (defined as the area encompassing all of the areas that could potentially be affected by the project), EcoSystems West Consulting Group (2001) identified at total of 100 potential reproductive sites along the Carmel River floodplain. Twenty-two of these occurred in the main stem of the river and 78 occurred in off-channel sites. Numerous additional non-reproductive habitats were also identified. Incidental observations of CRLF in the Carmel River floodplain made during the habitat characterization and critical habitat mapping efforts included observations of adults at 69 sites, sub-adults at 22 sites, young of the year at 15 sites, and tadpoles at 13 sites (EcoSystems West Consulting Group 2001). The majority of potential reproductive sites tend to cluster in two general locations: behind the two existing reservoirs and below RM 1 in the Carmel River lagoon. Surveys conducted by Mullen (1996) indicate that CRLF populations occur in several



Source: 66 Federal Register 49:14706, March 13, 2001

09294.00 001

Jones & Stokes

Figure III-2
Location of California Red-Legged Frog Critical Habitat Unit 18

tributaries of the Carmel River in addition to those identified in the main stem and its floodplain.

Chapter IV

Steelhead

IV-1. Study Area

The study area for the evaluation of effects on steelhead incorporates the segment of the mainstem of the Carmel River from San Clemente Dam downstream to the river's lagoon).(However, the assessment of flow thresholds for attraction of adult steelhead into the Carmel River includes consideration of flows above San Clemente Reservoir.) This reach is critical for upstream migration of adults to spawning areas and downstream migration of juveniles and post-spawning adults to the ocean. Important spawning and rearing habitat exists between the Narrows and San Clemente Dam and upstream of San Clemente Reservoir.

The proposed flow thresholds for attraction and upstream migration of adults, downstream movements and rearing of pre-smolts, and emigration of smolts apply to the entire study reach. However, information for establishing flow thresholds for spawning and first-year rearing (June-December) downstream of the Narrows is not available. Therefore, the proposed flow thresholds for spawning and first-year rearing capacity apply only to the reach between the Narrows and San Clemente Dam. Additional information on habitat continuity, extent, and use in relation to flow and groundwater conditions will be required to evaluate potential project effects on spawning and rearing habitat downstream of the Narrows.

IV-2. Assessment Methods

Biological Criteria

The purpose of this assessment was to establish flow thresholds for assessing the significance of impacts of alternative water supply projects on Carmel River steelhead. Based on CEQA guidelines, significance thresholds for fish and wildlife species should be based on conditions that maintain fish and wildlife populations at self-sustaining levels and cause no reduction in numbers or range of rare, threatened, or endangered species. Given the low population levels of Carmel River steelhead in recent years and uncertainty regarding the stability of the population under existing conditions, appropriate thresholds should address major constraints to steelhead production that threaten long-term viability of the population. As discussed previously, major constraints to annual steelhead production in the Carmel River include insufficient winter flows for upstream migration of adults and reductions in spring flows that reduce habitat for juveniles and impair the downstream migration of smolts. These conditions are particularly severe during droughts when low natural runoff combined with relatively high rates of groundwater pumping can completely eliminate flow in the lower river for much or all of the year. If such conditions occur over two or more consecutive years, the population could be reduced to remnant levels, as occurred during the drought of 1987-1991.

Based on these considerations and a review of general parameters used to measure population viability or performance (McElhany et al. 2000, Lestelle et al. 1996), the following biological criteria were established to guide development of flow thresholds for Carmel River steelhead:

- Maintain access to existing spawning and rearing habitat (i.e., no reduction in present range).
- Maintain life history diversity.
- Meet the needs of the most limiting life stage or stages (which may vary depending on water year type).
- Maintain sufficient levels of abundance to sustain the population through multiyear droughts.
- Maintain the dynamics of the population in response to natural environmental variation.

An important measure of the viability of a population is its ability to utilize the entire range of habitats needed to complete its life cycle. Under existing conditions, most of the steelhead spawning and rearing habitat in the Carmel River and its tributaries occurs upstream of RM 7, with the highest quality habitat occurring upstream of the Narrows and San Clemente Reservoir. Consequently, long-term sustainability of the resource depends on maintaining continued access to these areas. In central California coastal streams, the ability of adults to migrate from the ocean to spawning areas is naturally constrained by the frequency of winter flow events sufficient in magnitude and duration to open the mouth of the stream and provide suitable passage conditions for adults. Similarly, successful completion of the freshwater portion of the steelhead life cycle requires adequate spring flows to permit downstream migration of juveniles to the ocean.

Life history diversity is also considered an important attribute of healthy salmonid populations. For steelhead and other anadromous salmonids, life history diversity includes the variable timing of upstream migration of adults, the variable number of years that juveniles remain in freshwater, and the variable use of different reaches or habitats for rearing. In general, populations exhibiting a wide variety of life history patterns are likely to be more resilient to environmental variability, especially in places where natural variability is high or modified by human activities. Maintaining opportunities for the expression of these patterns is particularly important for central coast steelhead because of high seasonal and annual variability in flow conditions.

Because of this variability, developing flow thresholds requires an understanding of the seasonal flow requirements of individual life stages and how the success of these life stages affects the overall performance of the population. This premise is based on the "limiting factors" concept that generally states that overall production in any given year (e.g., number of smolts or adults) is determined by the resource in least supply. For example, specific life stages may differ in their relative importance to overall production because, under certain conditions, the numbers of individuals produced at one stage may often result in more individuals than can be accommodated by the habitat available to the next life stage. Thus, increasing the habitat available to the second life stage would be expected to have the greatest effect on overall production.

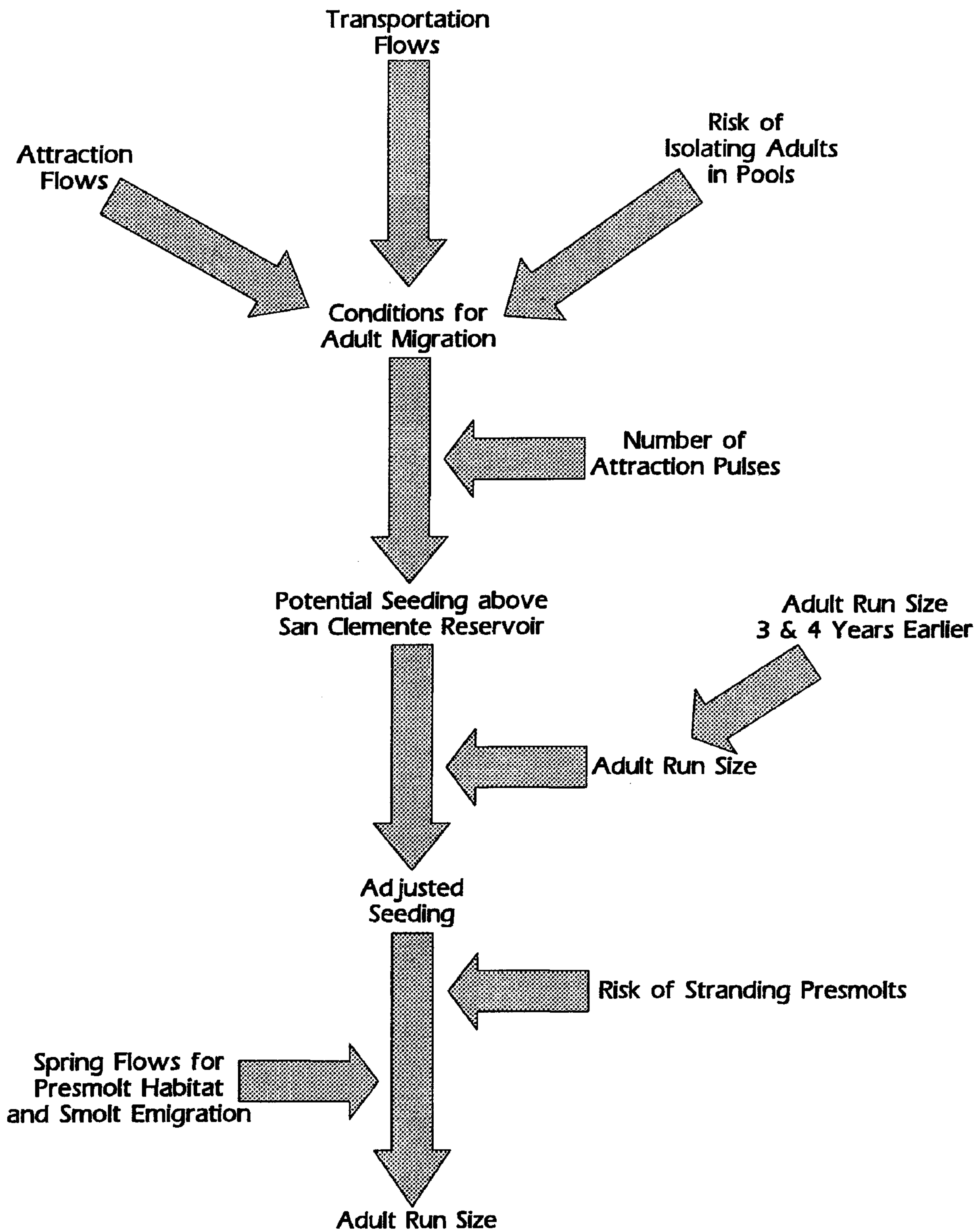
An important measure of the long-term viability of a population is its ability to withstand "worst-case" environmental conditions. A population should be large enough to have a high probability of surviving environmental variation of the extent observed in the past and expected in the future. For the present analysis, the sequence of dry and critically dry years from 1987 to 1991 served to provide a reasonable test for evaluating the effectiveness of the proposed flow thresholds in meeting this requirement.

Another key criterion for ensuring the sustainability of a population is maintaining the natural range of environmental variability to which it is adapted. For steelhead, maintaining natural variation in flows associated with different water year types allows the population to rebound quickly from droughts and take advantage of wetter conditions to increase population size, thus enhancing its ability to withstand future droughts or periods of low ocean productivity.

Adult Return Index

Dettman and Kelley (1987) developed a method for assessing overall trends in abundance of the steelhead population in response to seasonal and annual changes in flow associated with alternative water supply projects. The method, here termed the adult return index (ARI) method, provides a means of evaluating the effect of flows on a given year class by tracking the success of each stage from the time adults enter the river to the time their offspring leave the river one year later. The success each life stage is rated according to one to several criteria that reflect existing relationships between streamflow, habitat quantity and quality, and fish abundance (**Appendix A**). These ratings provide a qualitative index of production at each life stage that are combined in sequence to generate an overall index of the number of adults returning to the river three and four years later (**Figure IV-1**) . The rules for combining individual rating into overall production indicies are described by Dettman and Kelly (1997) and Dettman (1993).

The ARI method has been a valuable tool for analyzing water supply alternatives because it integrates current knowledge on the seasonal flow needs of specific



Source: Dettman (1993)

09042.99 001

Jones & Stokes

Figure IV-1
Illustration of Adult Return Index Method

life stages and provides a means of comparing overall responses or trends in adult populations in response to these alternatives. While this method simplifies the steelhead life cycle and provides only a qualitative measure of potential run strength, it is considered sufficiently robust to evaluate the relative impacts of alternative water supply projects and address the effectiveness of proposed flow thresholds relative to the flow threshold criteria presented above.

Appendix A reviews the flow criteria used in the ARI method to rate flow conditions for each life stage in the Carmel River between the lagoon and San Clemente Dam. These criteria have evolved over time in response to a number of studies designed to further evaluate and refine the flow-habitat relationships for the purpose of impact assessment (citations). These criteria were most recently used in the 1998 Carmel River Dam and Reservoir Project Draft Supplemental EIR to evaluate the potential effects of the project on steelhead abundance relative to no-project and natural (unimpaired) conditions.

Analytical Steps

The flow threshold assessment involved the following sequence of steps:

- Review the results of studies forming the basis for the flow criteria in the ARI method.
- Apply the ARI method to evaluate year class success in different water year types under unimpaired and impaired (existing) conditions.
- Identify flows and life stages that limit year class success in different water year types under unimpaired and impaired conditions.
- Establish flow thresholds for each water year type and adjust impaired flows as warranted to meet the biological criteria stated above (within the limits imposed by unimpaired flows).

Following review of the flow criteria, the ARI method was applied to monthly and daily flows generated by CVSIM for unimpaired and impaired hydrologic conditions during water years 1958-2001. Unimpaired flows represent the predicted response of stream discharge at several locations on the Carmel River to historical hydrologic conditions in the absence of existing facilities. Impaired flows represent predicted stream discharge under the same hydrologic conditions but with existing facilities in place. Three years representing each water year type (critically dry, dry, below normal, normal, above normal, wet, and extremely wet) were selected by starting in 2002 and selecting the first three years that meet the water year criteria while moving back through the record. To evaluate the performance of the population during the 1987-1991 drought, all years in this period were selected for analysis.

For the purposes of this assessment, simulated flows under unimpaired and impaired conditions were used as upper and lower limits for establishing flow thresholds. Because impaired flows generally represent existing conditions, these flows were not considered appropriate significance thresholds because of the general degraded state of the resource under existing conditions. Unimpaired flows were used as an upper limit for flow thresholds because they reflect the flow capacity of the system to in the absence of a project. Accordingly, unimpaired flows provided a benchmark for measuring the degree to which impaired flows could be increased to meet the flow threshold criteria. In addition, the minimum production index among all years within a given water year type under unimpaired conditions was used as a secondary threshold for maintaining opportunities for population growth and recovery following drought periods.

Adult return indices were determined by applying the flow criteria (**Appendix A**) to the impaired and unimpaired flows for each selected water year. Adult returns for a given year class are based on conditions that occur in two consecutive water years (e.g., December 15, 1994 – May 31, 1995). However, flows can vary substantially between years, depending on the sequence of water years. Therefore, to develop flow thresholds consistent with the flow conditions specific to each water year type, spring flows in each selected water year were repeated in the following year before applying the ARI method. For example, conditions for rearing and emigration of yearlings (age 1+) born in the spring of 1994 (a critically dry year) were based on spring flows in 1994 rather than 1995 (an extremely wet year).

For each water year, the results were displayed as a series of ratings for each successive life stage or risk factor (Appendix B). The ratings resulting from impaired flows were then used to identify which life stages had the greatest effect on overall production relative to unimpaired conditions. The ratings for these life stages were then increased incrementally (e.g., "critical" to "poor") until the resulting adult returns exceeded "critical" levels or the level achieved under unimpaired conditions.

The results for water year 1989 (a critically dry year) illustrate the process of identifying limiting life stages and modifying impaired flows to meet the flow threshold criteria. Impaired flows in 1989 resulted in "remnant" levels of adult returns, compared to "poor" levels under unimpaired conditions. Based on performance of individual life stages, remnant adult returns under impaired conditions can be traced primarily to "critical" levels of fry seeding and "critical" conditions for yearlings (rearing and emigration flows). Critical levels of fry seeding can, in turn, be traced to the absence of a suitable attraction flow during the early portion of the migration season (December 15-January 31) (i.e., attraction flow criteria were met under unimpaired conditions but not under impaired conditions).

One of the key criteria for setting flow thresholds is to maintain opportunities for adults to reach critical spawning areas over the entire migration season. Therefore, it was concluded for water year 1989 that impaired flows during the early portion of the migration season should be modified to meet the attraction criteria. The conditions for upstream passage (transportation and stranding risk) during this period were set at the levels achieved under unimpaired conditions, resulting in a "critical" rating for upstream migration. In addition, stranding risk during the latter portion of the migration season (March 1-April 15) was reduced from “critical” to “high” to improve conditions and avoid a “critical” rating for upstream migration during this period. These changes increased the predicted levels of fry seeding from “critical” to “partial”, which, in turn, resulted in a “fair” index for juvenile production (rather than a “critical” index under impaired conditions).

Flows during the spring rearing and emigration period also acted to limit overall production in water year 1989. Because spring flows contributed to the prediction of “remnant” levels in 1989, the conditions for rearing and emigration were improved by increasing impaired flows from “critical” to “fair” levels and reducing the stranding risk from “high” to “medium”. Combined with a “fair” index of juvenile production, these changes resulted in a “poor” index of adult production (rather than a “remnant” index under impaired conditions).

Following the application of this process to all selected years, the results for all years representing each water year type were compared to identify the flows and life stages that most frequently limit adult populations, and develop a common set of flow thresholds applicable to each water year type (Appendix B). The proposed flow thresholds represent the conditions needed to maintain adult populations above “critical” levels and achieve the minimum levels achieved under unimpaired “poor” conditions.

IV.3. Conclusions

The proposed flow thresholds for Carmel River steelhead during critically dry, dry and below normal, normal, above normal and wet years are summarized in **Table IV-1**.

Critically Dry Years

In critically dry years, steelhead production is primarily limited by the frequency and magnitude of winter flows needed for attraction and upstream migration of adults, and by the magnitude of flows for rearing and emigration of yearlings during the fall and spring.

Based on the flow threshold criteria, significant impacts associated with impaired conditions can be avoided by maintaining suitable attraction flows to the lagoon whenever an opportunity occurs (whenever inflows to Los Padres Reservoir are projected to meet the attraction criteria during the migration season). This requirement, in combination with “fair” passage (transportation) conditions and a “medium” risk of stranding following an attraction event, result in sufficient numbers of spawning adults to achieve “poor” levels of fry seeding in most years (assuming “fair” spawning and rearing capacity). This level of fry seeding, in combination with “fair” rearing and emigration conditions and a “medium” risk of juvenile stranding, was found to maintain adult populations at “poor” levels in all years, which is comparable to levels achieved under unimpaired conditions.

Table IV-1. Proposed Flow Thresholds for Carmel River Steelhead

Life Stage	Period	Critically Dry Years	Dry Below Normal Years	Normal And Above-Normal Years	Wet Years	Extremely Wet Years
ADULT MIGRATION						
Attraction	December 15-January 31	Daily flow of 200 cfs to Lagoon whenever inflows to Los Padres Reservoir meet flow criteria in Appendix A in Dettman 1993.	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
	February 1-February 28	Daily flow of 100 cfs to Lagoon whenever inflows to Los Padres Reservoir meet flow criteria in Appendix A in Dettman 1993.	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
	March 1-April 15	Daily flow of 50 cfs to Lagoon whenever inflows to Los Padres Reservoir meet flow criteria in Appendix A in Dettman 1993.	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
Transportation	December 15-January 31 February 1-February 28 March 1-April 15	Daily flow of 60 cfs at Narrows and Lagoon for 25-50% of the days following attraction flow (apply to each period)	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
Stranding	December 15-January 31	Daily flow of 40 cfs at Narrows and Lagoon for 50-75% of the days following attraction flow (apply to each period)	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years

Life Stage	Period	Critically Dry Years	Dry Below Normal Years	Normal And Above-Normal Years	Wet Years	Extremely Wet Years
	February 1- February 28					
	March 1- April 15					
SPAWNING	February 1- April 15	Average daily flow of 43-81 cfs at Narrows	Same as critically dry years	Same as critically dry years	Same as critically dry years	Same as critically dry years
REARING						
Rearing Capacity	June 1- December 31	Minimum monthly flow of 2-6 cfs at Narrows	Same as critically dry years	Same as critically dry years	Same as critically dry years	Minimum monthly flow of 6-20 cfs at Narrows
Stranding	October 1- March 31	Minimum daily flow of 1-5 cfs at Narrows following first storm event resulting in flows of 20 cfs or more at the Narrows (apply same threshold at Lagoon)	Minimum daily flow >=5 cfs at Narrows following first storm event resulting in flows of 20 cfs or more at the Narrows (apply same threshold at Lagoon)	Same as below normal years	Same as below normal years	Same as below normal years
EMIGRATION/REARING						
	April 1- May 31	Average Apr-May flow of 20-39 cfs at Lagoon	Same as critically dry years	Average Apr-May flow of 40-99 cfs at Lagoon	Average Apr-May flow >=100 cfs at Lagoon	Same as wet years

Dry and Below-Normal Years

In dry and below-normal years, flows during the fall and spring rearing and emigration period had the greatest effect on adult production relative to unimpaired flows. Flows associated with "fair" rearing and emigration conditions and a "zero" risk of juvenile stranding were found to maintain adult populations at "poor" to "fair" levels in dry years and at "fair" levels in below-normal years. These levels are comparable to those achieved under unimpaired conditions. Based on the flow threshold criteria, it was also concluded that winter flows should continue to maintain opportunities for attraction and upstream migration of adults whenever they occur. Therefore, the proposed flow thresholds for adult attraction and upstream migration in dry and below-normal years were established at the same levels proposed for critically dry years.

Normal and Wet Years

In normal and wetter years, no major limitations resulting from impaired flows were identified. The proposed flow thresholds are based on the need to maintain conditions that allow the steelhead population to expand in response to good to excellent flow conditions that occur in these water years.

Chapter V

Riparian Vegetation

V-1. Study Area

The study area for riparian vegetation included the riparian zone along the Carmel River between San Clemente Dam (RM 18.6) and the mouth of the river. The riparian zone of the Carmel River is defined as the area that is affected by flows in the river and is vegetated by typical riparian species such as willows, black cottonwood, and western sycamore. This area was estimated to be approximately 410 acres in 1986, including 192 acres of channel (McNiesh 1989). The width of the riparian zone averages 271 feet, including 86 feet of channel. The current riparian vegetation acreage is probably larger due to the extensive planting of riparian vegetation that has occurred since then.

The area can be subdivided into the Middle Carmel Valley, extending from San Clemente Dam to the Narrows (RM 9.5), and the Lower Carmel Valley from the Narrows to the mouth of the River at the Lagoon. The Middle Carmel Valley is underlain by two subunits of the alluvial aquifer. Subunit 1 extends from San Clemente Dam to the USGS gauge at Robles Del Rio (RM 14.4). Subunit 2 extends from Robles del Rio to the Narrows. The Lower Carmel Valley is underlain by aquifer Subunit 3 from the Narrows to the Near Carmel USGS gauge (RM 3.6) and Subunit 4 between the Near Carmel gauge and the Lagoon (McNiesh 1989).

V-2. Assessment Methods

An assessment of minimum flow requirements was developed for three generalized life stages of dominant riparian plants: seed dispersal and germination, seedling establishment, and growth and survival. The analysis focused on arroyo willow and black cottonwood. Arroyo willow and black cottonwood are drought sensitive species and are among the most common species in the Lower Carmel Valley. White alder, is another drought-sensitive species that is more common in higher gradient parts of the watershed, although it does occur in the study area.

Minimum hydrologic requirements for each life stage along the Carmel River below San Clemente Dam were assessed and compared to simulated flows that would occur under unimpaired and existing conditions for seven water year types defined by MPWMD (see the "Assumptions" section in chapter 2).

Flows under unimpaired and existing conditions were simulated using CVSIM under the assumption that maximum total surface and subsurface diversions made by Cal-Am and others in the Carmel River Basin would be 11,285AFA. Flow thresholds that indicate minimum flows under unimpaired and existing conditions below which riparian vegetation would be significantly affected by further flow reductions are developed for those situations where flows are not limiting riparian vegetation. Where groundwater levels were limiting riparian plant survival groundwater level thresholds were developed, because relationships between flow and groundwater levels could not be estimated.

Flow requirements for riparian vegetation were based on relationships between hydrologic parameters and life stage characteristics of key riparian species derived from the literature. McNiesh (1989) reviewed extensive studies of plant-water relationships that were conducted to quantify the effect of groundwater drawdown on plant water potentials in the Carmel Valley. These studies were motivated by the observed mortality of mature riparian trees that was attributed to groundwater pumping. In reviewing the literature, studies that document the direct effect of hydrologic conditions on other life stages, such as the seed dispersal, germination, and seedling establishment phases in the Carmel Valley were not found. Therefore, potential effects of hydrologic conditions on seeds and seedlings were derived from studies on other western United States river systems including studies by Scott et al. (1997), Rood et al. (1998), Shafroth et al. (1998), Stromberg et al. (1991) and others, and discussions with local experts.

V-3. Life Stage Requirements

Seed Dispersal and Germination

Requirements

Flows during the seed dispersal period determine on what geomorphic surface along the river seed can germinate. The seed dispersal period varies by species. Arroyo willow and black cottonwood, the two most abundant woody riparian species in the study area, release their seeds mostly during April and May (Christensen pers. comm.), although dispersal may start in March and extend through June, depending on the weather. Willow and cottonwood seeds are small, short-lived, and disperse by wind and water. The seeds are initially dispersed by wind, but then collect on the water surface and are carried downstream. They usually collect along the waterline, require saturated soil for germination and germinate when flows recede. This leads to typical linear patterns of seedlings along the bank oriented perpendicular to the elevation gradient. Seedlings may also land on saturated soil after wind dispersal and germinate.

Recruitment of riparian vegetation is limited by a lack of available surfaces for seed deposition. Approximately 40% of the banks of the lower 15.5 river miles is armored by various types of bank protection (Mussetter Engineering Inc. 2002). Within much of the remaining area, riparian vegetation has encroached on the channel. The river has also been subject to substantial incision since construction of San Clemente Dam (Kondolf and Curry 1986) and requires, therefore, substantial flow (1,000 – 3,000 cfs, 1- to 3-year return period) to reach bankfull stage in many areas (Hampson pers. comm.)

Downstream from RM 5, in the area of Subunit 4 and the downstream part of Subunit 3 the river has a trapezoidal cross section with a bottom of 50 – 60 feet wide. A low floodplain has developed in some areas in this reach, but most of this reach has banks of 15 – 30 feet high, that do not flood until flows reach approximately 10, 000 cfs, with a return period of approximately 10 years. From RM 5 – 8 the channel is wider and more complex, floodplains are available on either side of the channel, and flows ranging from 2,200 to 3,500 cfs (1.5 to 3-year return period) inundate overbank areas. Much of the area available for seed deposition in this area includes benches created for riparian restoration projects. (Hampson pers. comm.)

In the reach between the Narrows (RM 9.5) and Camp Steffani (RM 15.5), 3 miles downstream from San Clemente Dam, the channel is more complex and the riparian corridor is wider than downstream. Bankfull flows range from 1,000 to 10,000 cfs (1.5- to 10-year return period) depending on the level of constriction of the channel. (Hampson pers. comm.)

Seeds of willows and cottonwoods are short-lived. Once they are wet, viability is lost in a few days, unless seeds are kept under conditions suitable for germination. A moist substrate must be maintained for approximately five days to a week following seed deposition, to allow seeds of willows and cottonwoods to germinate (Scott et al. 2000a). Flow peaks in the Carmel River are often of short duration. This is sometimes referred to as the “flashy” nature of the Carmel River. Flows that inundate a particular surface in the spring, during the seed dispersal period of willows and cottonwoods, may not lead to germination if the surface does not remain saturated for approximately 5 days. It was assumed that flows need to remain at a particular surface for at least 5 days to allow seedlings of willows and cottonwoods to germinate at that surface.

In addition to species that disperse their seeds in the spring, such as arroyo willow and black cottonwood, the riparian zone of the Carmel River supports fall- or winter-dispersing species such as western sycamore, box elder, and others. Germination and establishment of seedlings in these species is not as closely dependent on specific hydrologic events during and immediately following the seed release period as it is for willows and cottonwoods. Seeds of these species may be transported and redeposited by high winter and spring flows. Germination typically occurs earlier in the season than for willows and cottonwoods, when moisture from rainfall is more readily available. In addition, seeds of these species often require burial, and partially shaded environments favor seedling germination and survival.

Hydrologic Conditions

Seedlings establish in suitable overbank areas in years with flood peaks of 1,000 to 10,000 cfs. Flows of this magnitude are not substantially affected by the operations of the existing dams or production wells on the Carmel River. Unimpaired and impaired simulations yield the same results for these events. They typically occur during the dispersal period (March – May) in years that are in the extremely wet and wet year type categories. They may occasionally occur during the dispersal period of above normal years. CVSIM simulations for unimpaired and impaired flows at the Near Carmel gauge show that flood peaks that exceed 1,000 cfs in the seed dispersal period from March – April have occurred 13 times since 1958, which is at an approximately 3 – 3.5 year interval. This is much more frequent than the average interval for recruitment of cottonwoods in most western U.S. rivers (Scott et al. 2000b).

Apparently, hydrologic conditions are not limiting for seed dispersal in the Carmel River system. Because of channel incision, bank armoring, and vegetation encroachment, availability of suitable floodplain surfaces is limiting in most areas. Moreover, flows of the magnitude that lead to dispersal and germination in this system are not substantially affected by groundwater pumping. Therefore, it is not necessary to establish a flow threshold for wet or extremely wet years during the dispersal period (March – May) of the willows and black cottonwood. During above normal and drier years flow thresholds in the March to May period could be necessary to maintain growth and survival, especially in dry and extremely dry years. Those thresholds are discussed in the "Growth and Survival" section below.

Seedling Establishment

Requirements

Establishment of seedlings requires that the growth of the roots of the seedlings keeps up with the rate of decline of the groundwater table in spring and summer. Seedlings can actually draw water from the zone with capillary rise of water that extends above the groundwater table. The height to which this zone extends above the groundwater table depends on soil type. In fine-grained soils, with a relatively high clay or silt content, this zone will be substantially thicker than in sandy soils. Soils of the Carmel River riparian zone are sandy and therefore the capillary zone will be relatively thin and declines in the capillary fringe are assumed to closely track declines in the groundwater table.

In many dammed western U. S. rivers, the hydrograph declines rapidly in the spring, because major dams are operated to capture as much runoff in the spring as possible. This rate of decline often constrains the establishment of cottonwood and willow seedlings (e.g., Braatne et al. 1996, Mahoney and Rood 1998, Shafroth et al. 1998). The maximum drawdown rate that can be tolerated by seedlings depends on several factors, including soil texture, but as a general rule declines that exceed 1.5 – 2 inches per day tend to result in poor survival

(Shafroth et al. 1998, Segelquist et al 1993, Mahoney and Rood 1991). Reservoir storage behind San Clemente and Los Padres Dams is relatively small and it is therefore anticipated that river stage declines in the Carmel River will be more gradual after major storms than in many dammed western U. S. rivers. Although this may lead to survival of seedlings in the spring, summer drawdown rates may be more rapid in some areas of the Carmel River due to groundwater pumping. Drawdown rates may exceed 2 feet per week in some parts of the Carmel River (i.e., exceeding 3.4 inches per day), which is expected to result in severe drought stress in mature trees (McNiesh 1986, 1989). Seedlings are expected to be more susceptible to drought stress because of their more limited root system and less well developed support tissue.

Historical records and tree aging studies have shown that in many unconstrained western U. S. rivers large-scale recruitment events typically occur once every 5-10 years (Mahoney and Rood 1998, Scott et al. 1997, Stromberg et al. 1991). Scott et al. (1997) found that recruitment of mature cottonwood trees in the Upper Missouri River occurred with a recurrence interval of more than 9 years. Hughes (1994) (cited in Scott et al. 1997) wrote that long-term cottonwood establishment was associated with even longer return intervals (30-50 years) along some non-meandering rivers. It was assumed that recruitment conditions for riparian vegetation should occur at approximately a 10-year interval or shorter to maintain a diverse riparian canopy.

Hydrologic Conditions

Hydrograph decline rates from the last day in the dispersal period with flows above 1,000 cfs through May 31 were estimated to range from 0.3 to 0.7 inches/day at the Near Carmel gauge for both impaired and unimpaired flows, well below the fastest allowable rate of 1-1.5 inches per day (**Table V-1**). The rate of spring-time hydrograph decline does not appear to be limiting seedling establishment in the downstream part of the study area. Hydrograph declines at other locations in this time period are expected to be similar or slower. Given the slow rates of decline it was not deemed necessary to establish flow thresholds for the seedling establishment period of March to May for seed dispersal years. In June, impaired flows in seed dispersal years may become less than 3 cfs, at the Near Carmel gauge, and the channel can even become dry. Seedlings are likely to be more susceptible to groundwater declines than mature trees and flow reductions could substantially affect newly established seedlings, even when mature trees are not affected. The CVSIM simulations showed that the channel would dry out during the summer of some seed dispersal years (e.g., 1991) under impaired conditions potentially affecting seedlings, while unimpaired flows would have kept the channel wet year-round, and seedlings would presumably not have been affected.

Flow reductions below the simulated impaired flows in the period of June to October of seed dispersal years are likely to lead to a reduction of recruitment of riparian plants from seed. Currently, irrigation maintains these recruits in the population, but any flow reductions could require additional irrigation.

Table V-1. Simulated River Stage Decline Rates for Years with Flows Exceeding 1,000 cfs in the March - May Dispersal Period Measured at the Near Carmel USGS Gage (RM 3.5, Via Mallorca Bridge) under Unimpaired and Existing Conditions

			Unimpaired flows (cfs)						Impaired flows (cfs)					
Year	Date of peak[1]	days until 5/31	Level of peak	Level at May 31	Level at June 30	Stage at peak (ft)[2]	Stage at May 31 (ft)[2]	Stage drop rate until May 31 (inches/day)	Level of peak	Level at May 31	Level at June 30	Stage at peak (ft)[2]	Stage at May 31 (ft)[2]	Stage drop rate until May 31 (inches/day)
1958	04/11/58	51	1,072	85	37	37.3	35.0	0.5	1,057	66	21	37.3	35.0	0.5
1967	03/17/67	76	1,362	113	20	38.0	35.0	0.5	1,350	94	7	38.0	35.0	0.5
1969	03/06/69	87	1,042	59	47	37.3	35.0	0.3	1,029	40	31	37.3	35.0	0.3
1973	03/01/73	92	1,040	46	17	37.3	35.0	0.3	1,028	26	3	37.3	35.0	0.3
1974	04/02/74	60	1,453	61	26	38.0	35.0	0.6	1,439	42	12	38.0	35.0	0.6
1975	03/22/75	71	1,243	57	24	37.5	35.0	0.4	1,230	38	11	37.5	35.0	0.4
1978	03/09/78	84	1,045	104	37	37.3	35.0	0.3	1,033	84	21	37.3	35.0	0.3
1982	04/15/82	47	1,057	100	75	37.3	35.0	0.6	1,043	81	57	37.3	35.0	0.6
1983	05/02/83	30	1,005	224	110	37.3	35.5	0.7	1,106	205	91	37.3	35.5	0.7
1986	03/19/86	74	1,102	44	22	37.3	35.0	0.4	1,090	32	9	37.3	35.0	0.4
1991	03/25/91	68	1,563	19	9	38.0	35.0	0.5	1,359	3	0	38.0	35.0	0.5
1995	03/25/95	68	1,094	109	69	37.3	35.0	0.4	1,082	90	54	37.3	35.0	0.4
2001	03/06/01	87	1,139	27	11	37.3	35.0	0.3	1,125	14	2	37.3	35.0	0.3

Notes:

[1] Flow declines were calculated from the last day with a peak flow greater than 1,000 cfs
[2] Stage-discharge relationships for the USGS Near Carmel gage were estimated from a graph to the nearest 0.25 foot

Growth and Survival

Requirements

The main physical factor that affects riparian plants after they have become established along the Carmel River is access to groundwater (Woodhouse 1983, McNiesh 1986, 1989). In many western U.S. riparian systems, access to groundwater during the summer and fall has been found to be a limiting factor for maintenance of riparian vegetation (Stromberg et al. 1991, Scott et al. 2000b). Access to groundwater in the Carmel Valley has gained additional importance because groundwater pumping has been implicated in mortality of riparian trees and associated bank erosion, reported extensively in the 1980s (see McNiesh 1989 for a review). Since those observations of tree drought stress and mortality were reported, MPWMD has implemented an extensive irrigation program that mitigates effects of groundwater pumping (MPWMD 1996).

MPWMD monitors groundwater level in approximately 50 wells in the Carmel Valley (MPWMD 1996). Depth to groundwater in wells near the river responds to the level of flow in the river. Monitoring data collected from 1989 to 1996 from the Rubin well (RM 3.5, 60 feet from the channel) showed that groundwater level rises dramatically when river flows increase near the well (MPWMD 1996). Christensen et al. (2001) showed that when the river had dried up in July groundwater levels dropped steadily in response to pumping of the Rancho Canada well, even in a normal water year. The flow threshold analysis assumes that ground water is accessible to riparian plants when there is water in the channel. When the channel is dry, riparian plants may have access to groundwater; however, the depth to groundwater and the rate at which the groundwater declines may both cause riparian plants to exhibit stress and may even cause death.

McNiesh (1986, 1989, 1991) has done extensive studies for the MPWMD on the relationship between drought stress in riparian plants and groundwater drawdown. Based on studies of plant water potential responses to groundwater declines, McNiesh concluded that mild plant water stress usually occurs if the drawdown rate exceeds 1 foot per week, or 4 feet during the dry season. Severe drought stress results when the drawdown rate exceeds 2 feet per week and the seasonal drawdown rate exceed 8 feet (McNiesh 1986, 1989). However, McNiesh (1989) also admits that the question of the rate and magnitude of drawdown that can be tolerated by riparian vegetation before the onset of damage “may never be answered fully, since the answer depends on a host of interrelated factors.”

An important factor in determining the response of willows and cottonwoods to groundwater declines is the groundwater level that the plants have been exposed to prior to the onset of drawdown. When willow roots are exposed to shallow water tables they develop channels of cortical air spaces, or aerenchyma, that provide oxygen to the waterlogged root tips. Groeneveld and Griepentrog (1985) observed such morphological adaptations in willow roots and suggested that these airspaces make the root tips spongy and reduce the penetrating power of the roots and their ability to track rapid water table declines. This phenomenon makes willows and cottonwoods growing near the channel particularly susceptible to rapid *rates* of drawdown.

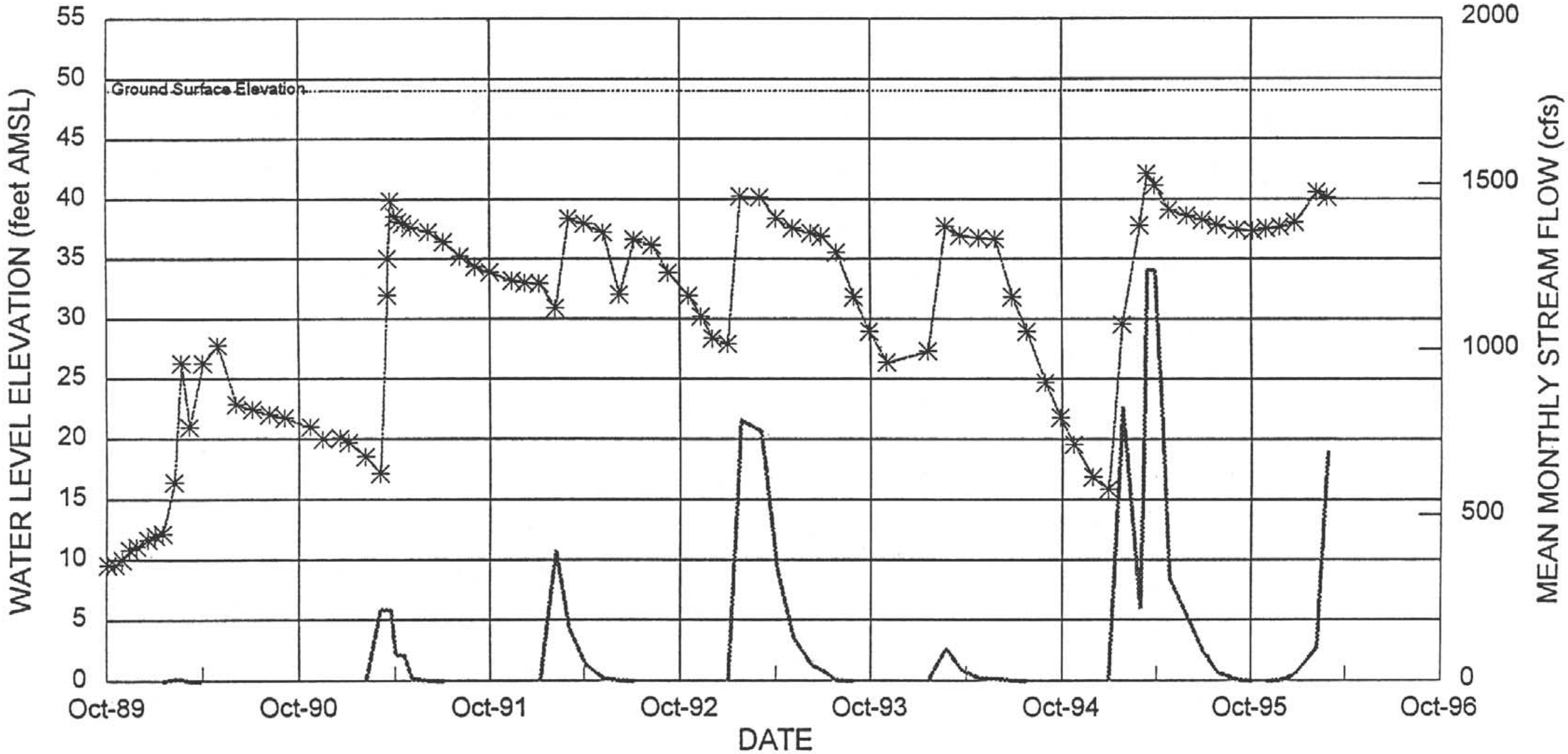
The maximum depth of willow and cottonwood roots can be impressive. McNiesh (1986) observed that riparian trees drew groundwater from below 18 feet along the Carmel River, and he cites sources that report riparian rooting up to 60 feet deep (McNiesh 1989). The rate of groundwater decline would therefore appear more important than the absolute depth of the groundwater.

In addition to groundwater depth and the rate of groundwater decline, the duration that the groundwater table remains at a particular depth may determine effects on riparian vegetation. Willows and cottonwoods excavated at the end of the 1988-1992 drought showed poorly developed root systems (Hampson pers. comm.). Long-term depressed groundwater levels that lead to poorly developed root systems of willows and cottonwoods have also resulted in bank erosion along the Carmel River (Hampson pers. comm.).The relationship between surface flow and groundwater recharge has not been quantified. In most years groundwater will relatively quickly recharge when the river flows over its entire length in winter. However, in critically dry years (e.g., water year 1989) groundwater may not be completely recharged (**Figure V-1**). Apart from such rather obvious patterns, flow and groundwater dynamics cannot be quantitatively predicted with currently available modeling tools. Therefore, the effects of depth to groundwater and rate of groundwater decline were assessed for time periods when the river bed was dry.

Hydrologic Conditions

The area with a dry channel bed in summer and fall varies by water year type. In extremely wet years, the river may remain wet over its entire length. However, in all other year types, the riverbed is likely to go dry under existing conditions. The maximum dry area in an above normal water year typically extends from the Rancho Canada golf course (RM 2) to the San Carlos bridge (RM 4), in normal or below normal years typically to the Schulte bridge (RM 6.5), and to approximately the former Scarlett well (RM 9) in critically dry years (Christensen pers. comm.). An assessment of groundwater effects on vegetation should therefore focus on these areas (ranging from 2 to 7 river miles). Any flow reduction below existing conditions in the summer or fall of above normal or drier years may lead to a lengthening of the area or time period that the channel is dry and would likely affect the growth and survival of riparian vegetation. Such a reduction would require additional irrigation in excess of the irrigation that is applied under existing conditions.

In the absence of irrigation drought stress and mortality could occur in areas with a dry river bed under existing conditions in all year types except extremely wet years. These effects would be aggravated by additional pumping in areas where the channel is dry and these effects could extend up to approximately a mile distance from the pumps.



✳ground water elevation - mean monthly flow

well depth: 95 feet

Notes:

MPWMD Rubin Monitoring Well is at RM 3.56 and 60 feet from the Carmel River channel.
The USGS Near Carmel Gage is at RM 3.6.

Source: MPWMD 1996, Figure II-4

09042.99 001

Jones & Stokes

Figure V-1
Groundwater Elevation at the Rubin Monitoring Well and Mean Monthly Stream Flow at the USGS Near Carmet Gage for Water Years 1989-1995

Groundwater table declines in excess of 1 foot/week would result in significant effects on riparian vegetation (McNiesh 1986, 1989). Any flow reduction that would lead to an increase in the time period that groundwater declines exceed 1 foot/week may lead to a significant effect on riparian vegetation.

Based on data presented in Christensen et al. (2001) it appears that along the Carmel River willows and black cottonwood can reach groundwater up to 20 feet deep, even in the most frequently affected area from RM 2 to RM 4. Any change in flow that would cause an increase in the time period that ground water is more than 20 feet deep may cause a significant effect on riparian vegetation.

Chapter VI

California Red-Legged Frog

VI-1. Study Area

California red-legged frog (CRLF) habitat is distributed throughout the Carmel River watershed. However, this analysis considers only the Carmel River and its floodplain from Los Padres Dam to the Carmel River Lagoon (see **Figure I-1**). This area has been surveyed in recent years and critical habitat has been described (EcoSystems West Consulting Group 2001). Water supply project effects on river flows would occur in this area. Mullen (1996) has identified CRLF in the upper tributaries to the Carmel River, but project effects on flow will not extend to the tributaries.

VI-2. Assessment Methods

To develop flow thresholds for the CRLF, life history and occurrence information was collected and reviewed. The major source documents were the Biological Assessment prepared by EcoSystems West Consulting Group (2001) and the federal register package developed to identify critical habitat for the CRLF (FR 69:14626). Flow-related habitat requirements of each life stage of the frog were reviewed and potential flow effects of future water supply projects were predicted. Because there is little information relating specific flow requirements of the CRLF, general flow thresholds were developed.

VI-3. Life Stage Requirements

Egg Masses

Habitats where egg masses are consistently found have been characterized by warm, shallow water and the presence of either free-floating material or emergent vegetation used for egg mass attachment. These sites are selected over cooler or deep-water locations. Both water temperature and depth are useful in characterizing egg mass deposition sites. However, although egg masses are often observed at the surface or within 0.1 m (0.33 feet) of the surface, the ability to locate egg masses in deeper water is hindered by poor water clarity (0.1 m to

0.25 m [0.33 to 0.82 feet] Secchi depth). CRLF egg masses a few days old have been found attached to vegetation at depths ranging from the surface to 1.0 m below the surface (EcoSystems West Consulting Group 2001). CRLF egg masses successfully produced tadpoles at Pescadero Marsh in water depths between 0.1 and 1.0 m (0.33 and 3.3 feet) with a mean depth of 0.3 m (0.98 feet). Approximately 63 % of the sites with tadpoles had water depths less than 0.5 m (1.64 feet), and 23.9% of the sites with tadpoles were found in water depths less than 0.26 m (0.85 feet). Cook (1997) found CRLF egg masses and tadpoles in shallow waters (<0.3 m [<0.98 feet]) in Ledson Marsh at Point Reyes National Seashore. Exploitation of shallow-water habitats (0.075 to 0.152 m [0.25 to 0.50 feet]) for reproduction has also been noted for some populations of the northern subspecies, R. a. aurora (Storer 1925).

Minor changes in water temperature are known to result in significant developmental effects on frog eggs (Licht 1970, Zweifel 1977) and tadpoles (Hayes et al. 1993). Northern red-legged frogs kept at a constant temperature of 15.6° C began hatching in 11 to 12 days while eggs kept at a constant 18.3° C began hatching in 8.5 to 9 days (Storm 1960). By using waters for breeding that are close to, but less than, the thermal maximum, CRLFs may experience an increase in developmental rates. Warmer water sites in ephemeral marshes and ponds may shorten the time required for metamorphosis, providing CRLF the opportunity to complete their life cycle before summer dry down or increases in water salinity in coastal lagoons. However, CRLF tadpoles may have a low critical thermal maximum such that constant high temperatures could cause developmental defects (Cunningham 1955).

Although adult CRLF have been documented to die of heat exposure at 29.0° C (Jennings and Hayes 1990), eggs and tadpoles are likely to be more sensitive because of their greater surface-area-to-volume ratios. Healthy CRLF embryos have been documented in water temperatures up to 21.7° C and healthy tadpoles in water temperatures of 24.9° C, suggesting that the thermal maximum increases as development progresses. Therefore, critical thermal maximums for eggs and tadpoles are assumed to be lower than 29.0° C and above 21.7° C for eggs and above 25.0° C for tadpoles (EcoSystems West Consulting Group 2001).

CRLF can successfully reproduce in lagoon environments that contain fresh water from February through July, if maximum salinity remains below 4.5 parts per thousand (ppt) through April for egg mass development, and below 7.5 ppt through the end of June and beginning of July for tadpoles to complete their development (EcoSystems West Consulting Group 2001). Egg masses exhibited 100% mortality when exposed experimentally to salinity levels of 4.5 ppt for a prolonged period of time (Jennings and Hays 1990). Brackish-water habitats in Pescadero Marsh were suitable for CRLF reproduction from February though July. However, they became too saline during the late summer months to permit successful reproduction by bullfrogs, a non-native competitor of CRLF (EcoSystems West Consulting Group 2001).

Tadpoles

For successful reproduction to occur, water needs to be available long enough for tadpoles to complete metamorphoses. In successful breeding sites, water needs to be present at a minimum from March to late June (EcoSystems West Consulting Group 2001). Reproductive habitats must also contain lentic waters (still or slow moving waters) between the months of March and late June to prevent eggs and tadpoles from being flushed away. Aquatic environments with high stream flows between March and June, in addition to providing unstable environments for egg masses, often contain fish populations that predate on CRLF. Tadpoles have been observed to use both aquatic vegetation and mud for cover (Jennings and Hayes 1988, Jennings and Hayes 1994). Reis (1999b, in EcoSystems West Consulting Group 2001) found that cattails (*Typha* sp.) and pondweed (*Potamogeton* sp.) were commonly associated with the presence of tadpoles and that pondweed abundance was often a strong predictor of the presence of CRLF. In coastal marshes, tadpoles are unlikely to survive if waters become too saline. Tadpoles apparently do not survive in water salinity concentrations greater than 7.5 ppt (Jennings and Hayes 1990).

Sub-Adults

Sub-adult CRLF appear to utilize slightly different habitats than adults. Sub-adults are often found in sites with shallow water, limited shoreline and emergent vegetation (Jennings and Hayes 1988). It may also be important for sub-adults to have small (1 meter [3.3 feet]) breaks or clearings in vegetation or dense riparian cover to permit sunning and foraging, while still having nearby escape cover from predators (Jennings and Hayes 1988). In areas with limited reproductive habitat, sub-adults have been observed to remain further upstream in creek environments than adults during the reproductive season. Where reproductive habitats are larger, sub-adult frogs are often found using both reproductive and non-reproductive habitats throughout the year (EcoSystems West Consulting Group 2001).

Adults

Adult CRLF utilize a wider variety of habitat types than any of the other life stages. Adult frogs at Pescadero Marsh were more likely to utilize deeper water areas (mean water depth, 0.64 m [2.10 feet]) than other life stages (EcoSystems West Consulting Group 2001). Additionally, although vegetation cover is important, there was no correlation between presence of adults and minimum vegetation cover requirements. Adults showed no association with specific plant species. In coastal marshes and lagoons, adult mortality is thought to occur at salinity levels greater than 9.0 ppt, and at temperatures in excess of 29.0° C (Jennings and Hayes 1990).

Both adult and sub-adult CRLF utilize adjacent upland habitats and vegetation. CRLF have been documented to move up to 2 miles overland without regard for topography, vegetation type, or riparian corridors (U.S. Fish and Wildlife Service 2002).

Summary of Requirements by Life Stage

For proper egg mass and tadpole development, reproductive habitats must have warm, shallow, lentic waters free from high stream flows with water depths from 0.75 to 1 meter (2.46 to 3.3 feet) from March through late June and early July. Water temperatures must not exceed 22 to 29° C while egg masses develop and not exceed 25 to 29° C during tadpole development; salinity levels must be less than 4.5 ppt from February to April, and less than 7.5 ppt from April through June. Emergent and submerged vegetation or free floating material for egg mass attachment and escape cover, mud for escape cover, and shallow waters for escape from predatory fish are also typically required for successful development.

Subadults utilize shallow water areas with limited shoreline and emergent vegetation. Small (1 m [3.3 feet]) breaks or clearings in vegetation or dense riparian cover are required for sunning and foraging while also providing escape cover from predators.

Adults utilize deeper water (mean depth of 0.64 m [2.10 feet]) than other life stages, will often occupy areas without extensive cover, and utilize adjacent uplands to a greater degree than other life stages. Adults require salinity levels less than 9 ppt and temperatures less than 29° C.

VI-4. Conclusions

Data on water temperature and streamflow collected by MPWMD staff were analyzed by EcoSystems West Consulting Group (2001) to assess potential effects of a proposed dam and reservoir on CRLF populations. These data indicated no correlation between water temperature and streamflow during June, the warmest month before tadpoles can potentially complete their development and thus move to cooler environments. Therefore, it may be that low flows would not significantly impact CRLF reproduction during most years, as long as flows were sufficient to maintain water temperatures in July and August below the thermal critical maximum for subadults and adults (29 C). In fact, monthly maximum water temperatures at six sites along the river measured during 1997 and 1999 never exceeded the thermal critical maximum for adult CRLF (EcoSystems West Consulting Group 2001).

Several off-channel reproductive sites occupied by CRLF and adjacent main stem channels were monitored by EcoSystems West Consulting Group (2001) under winter flows of 210 and 388 cfs. These data indicate that the main stem and the off-channel reproductive sites are hydrologically connected, and that off-channel sites are buffered from the high flows occurring in the main stem that could result in the scouring and flushing of eggs and tadpoles. Successful reproduction in specific off-channel habitats was documented during the winter and spring of 1999 to 2000, when peak flows of 1,970 cfs at RM 24.8, 3,430 cfs at River Mile 10.8, and 3,040 cfs at RM 1.1 were recorded (EcoSystems West Consulting Group 2001). It would appear that flows at or below these levels would not negatively affect CRLF reproduction in off-channel sites. Monitoring data at off-channel and adjacent main stem sites also indicated that off-channel pools with channel bottom elevations lower than the surface water elevation in the adjacent main stem contained perennial water, as long as there was flow in the river. Off-channel sites with channel bottom elevations equal to or higher than surface water in the main stem contain seasonal water dependent on stream flow.

Bullfrog populations below the two dams are large and a threat to CRLF populations. Mullen (1996) indicated that bullfrogs were found throughout the Carmel River below Los Padres Dam and in upper San Clemente and Las Garzas Creeks. They were the dominant frog within the main channel of the Carmel River below San Clemente Dam. Bullfrogs are predators of CRLF and compete for space in perennial water environments. Flows that change the seasonal nature of in-channel or off-channel habitats and make them perennial could allow for increases in bullfrog populations that could eliminate CRLFs. This is particularly true if enough permanent water habitats are created to allow bullfrogs to migrate into areas they do not currently occupy. However, if bullfrog colonization of newly created permanent water habitats can be prevented, increases in summer water flows during normal years would be beneficial to CRLF.

Chapter VII
Thresholds

This chapter describes the flow thresholds developed for the three resources evaluated in the study. Section VII-4 discusses the interrelationship of the separate thresholds, to the extent that interrelationships have been determined..

VII-1. Steelhead

The sustainability of the steelhead population in the Carmel River is critically dependent on flows in the lower river, especially in years with low levels of rainfall. In dry and critically dry years, annual steelhead production can be severely limited by inadequate winter flows for upstream migration of adults and inadequate spring flows for rearing and downstream migration of juveniles. These conditions can result in zero to remnant levels of production, and may lead to severe reductions or collapse of the population if such conditions persist for two or more consecutive years. Consequently, a key objective of this analysis is to define flow thresholds that maintain annual steelhead production at levels that would sustain the resource through such periods. This has been achieved by applying the adult return index (ARI) method to evaluate the relative performance of the population under existing and unimpaired hydrologic conditions, as simulated by CVSIM. The ARI method was developed by Dave Dettman (1993), senior fisheries biologist for MPWMD.

Based on an analysis of adult returns (see **Appendix A**), the proposed flow thresholds for dry and critically dry years are designed to:

- maximize opportunities for upstream migration of adults to critical spawning areas upstream of the Narrows,
- maintain sufficient rearing flows during the summer and fall to support the resulting levels of fry seeding, and
- provide adequate juvenile rearing and emigration flows to sustain the population through an event equivalent to the 1987-1991 drought.

The flow thresholds for dry and critically dry water years are designed to avoid significant impacts on the steelhead resource resulting from multi-year droughts, and also serve as minimum thresholds for other year types. However, to provide additional protection and resilience of the population in view of uncertainties regarding future conditions, these flow thresholds have been increased in below normal to wet years to ensure that potential increases in production associated with these year types continue to be realized. The proposed flow thresholds for Carmel River steelhead are summarized in **Table IV-1** and in **Figures VII-1**, **VII-2** and **VII-3**.

VII-2. Riparian Vegetation

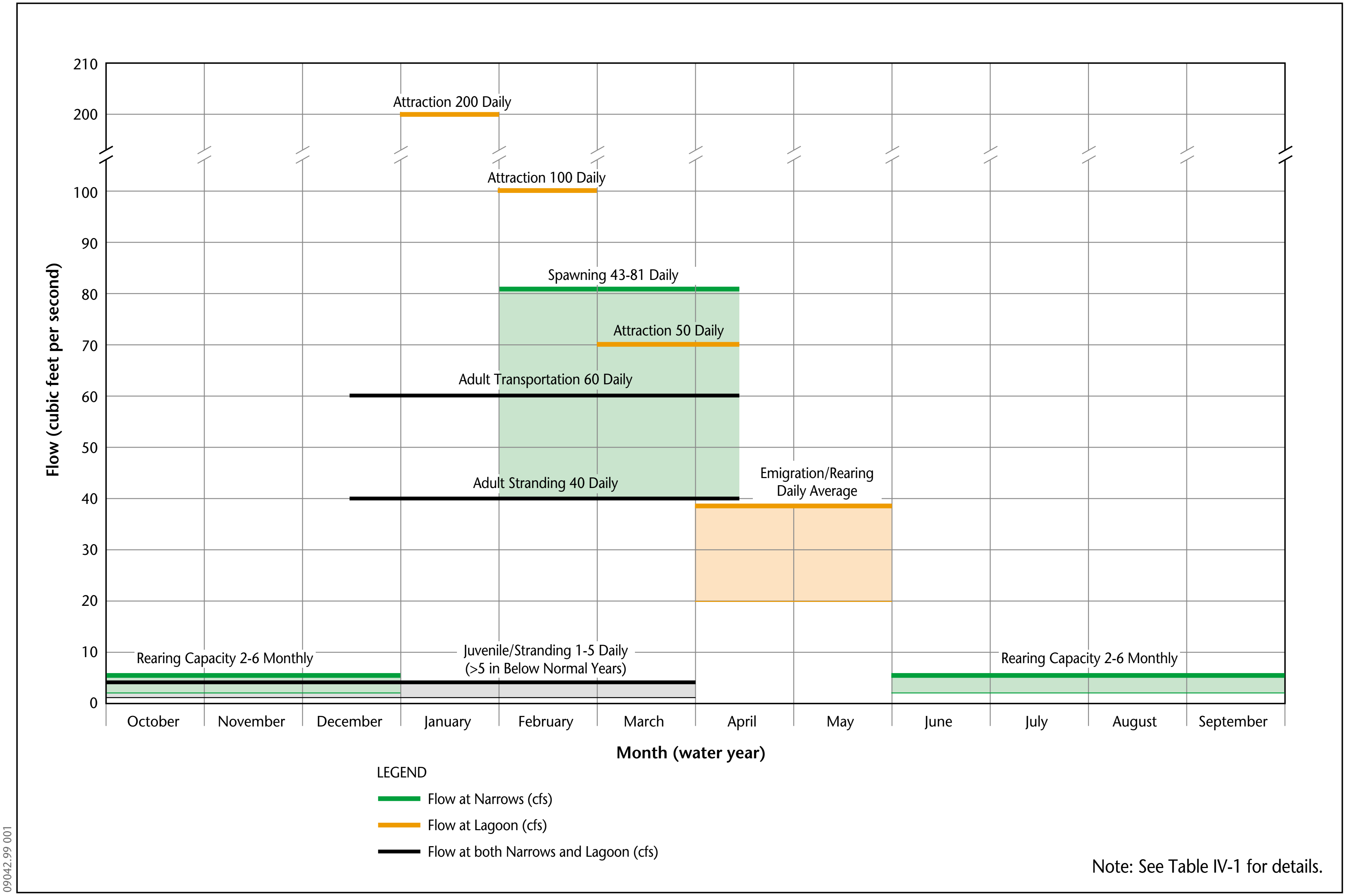
Establishment, growth, and survival, of riparian vegetation along the Carmel River are strongly affected by the absolute depth and change in depth of groundwater. Groundwater levels adjacent to the river are dependent primarily on river flow and level of groundwater pumping. The effects of groundwater level change are most apparent in dry years. In extreme conditions (critically dry years), the riverbed may be dry from the Rancho Canada golf course (RM 2) to 6 miles upstream due to decreased surface flow and high levels of pumping to meet domestic water supply needs. This situation places stress on existing riparian vegetation. The length and duration of these dry riverbed conditions vary by water year type. However, with the exception of extremely wet and some wet years, the riverbed dries out annually over some distance and for some duration . Under existing conditions, riparian vegetation is maintained by irrigation in the area where the riverbed is periodically dry.

The following conclusions can be drawn about hydrologic effects on riparian vegetation and their implications for flow thresholds:

- Any flow reduction that would lead to a lengthening of the area or time period that the channel is dry may lead to a significant effect on riparian vegetation that would require additional irrigation in excess of the irrigation that is applied under existing conditions.
- Any increase in the time period that groundwater declines exceed 1 foot/day may lead to a significant effect on riparian vegetation.
- Any increase in the time period that groundwater is more than 20 feet deep in riparian areas may cause a significant effect on riparian vegetation.
- During wet or extremely wet years with dispersal flows (e.g., flows in excess of 1,000 cfs in the March – May period), seed dispersal and seedling establishment are not limited by flows at least until May 31.

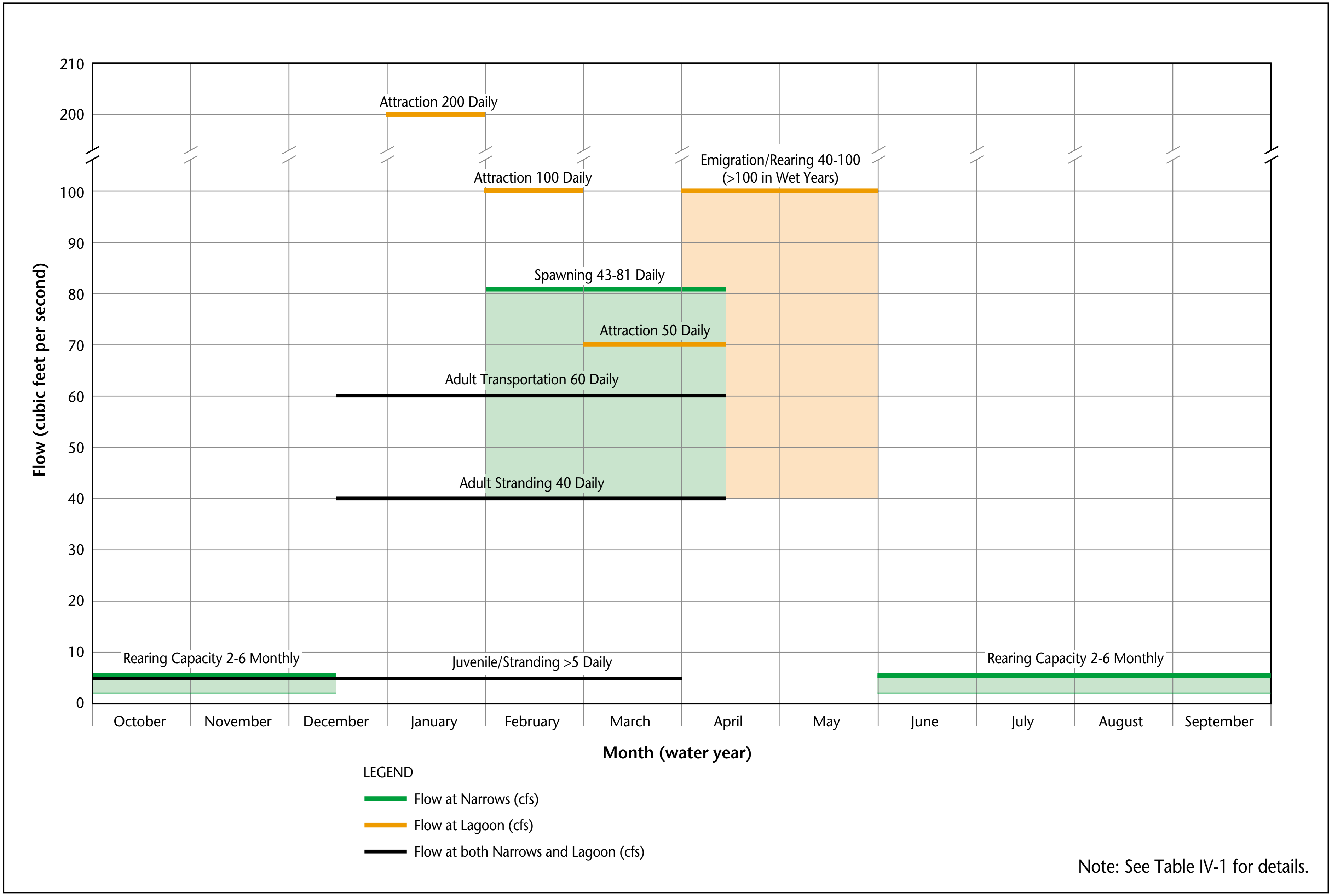
VII-3. California Red-legged Frog

The historical conditions of the CRLF population in the Carmel River watershed are poorly documented prior to construction of the two dams in the system (Los Padres and San Clemente), alteration of stream flows, and the advent of groundwater pumping. In addition, there is no information on trends in CRLF populations in this area, or on the structure of the population. However, based on CEQA's treatment of significant effects with respect to "threatened and



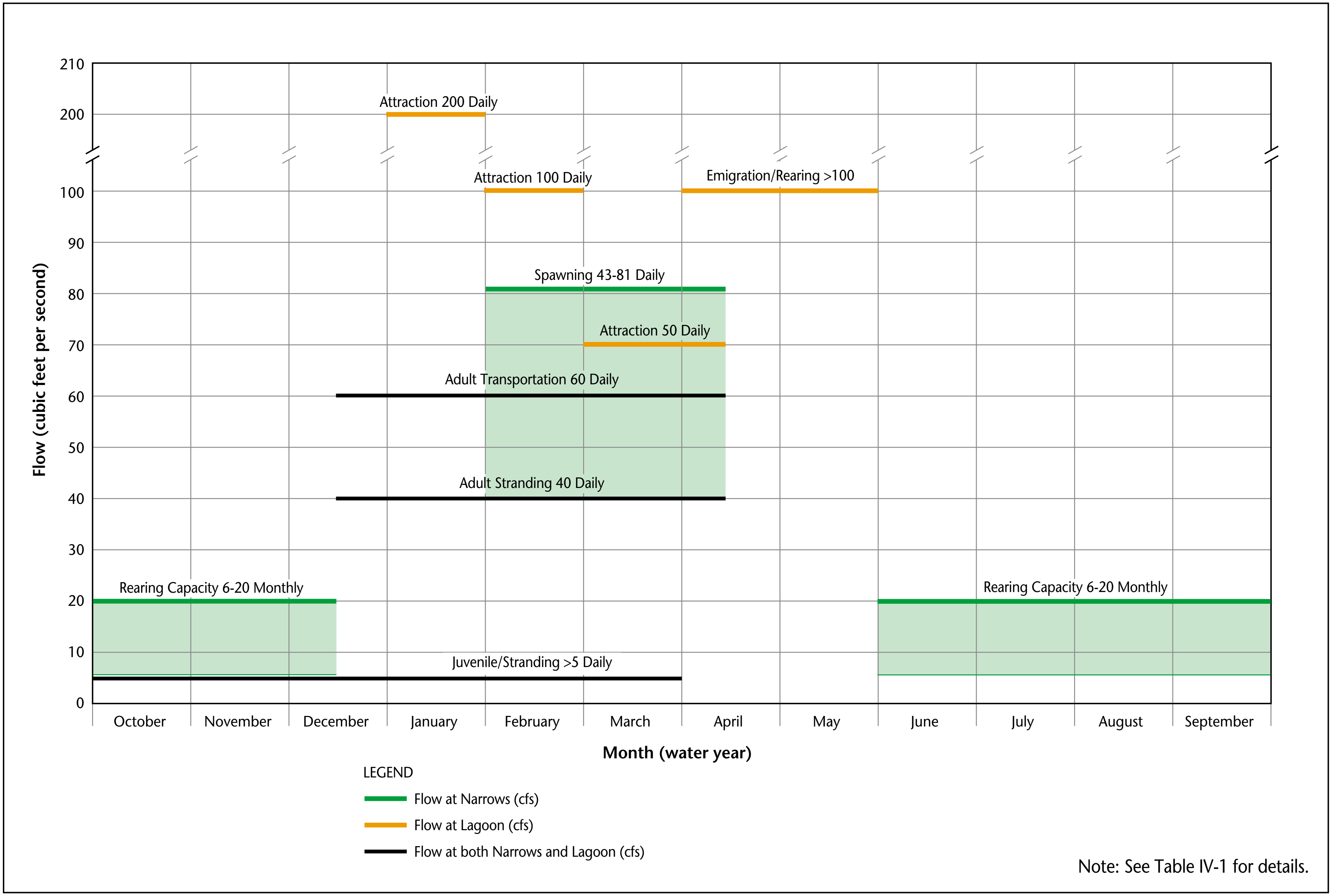
Jones & Stokes

Figure VII-1
Summary of Flow Thresholds for Carmel River Steelhead in Critically Dry, Below Normal, and Dry Years



Jones & Stokes

Figure VII-2
Summary of Flow Thresholds for Carmel River Steelhead in Normal, Above Normal, and Wet Years



09042.99 001

Jones & Stokes

Figure VII-3
Summary of Flow Thresholds for Carmel River Steelhead in Extremely Wet Years

endangered" species, it is assumed that any overall negative effect on the current CRLF population could be considered a significant effect. .

Given the limited information on population dynamics and distribution of CRLF along and adjacent to the Carmel River, river flow thresholds for determining adverse effects must be general in nature and based on flow trends rather than specific flow levels. Proposed flow thresholds are as follows:

- Any project-induced increase in flows that results in currently ephemeral in-channel or off-channel habitats becoming permanently inundated in most years would allow bullfrogs and non-native fish to colonize new habitat. If the new habitat was occupied by CRLF, it would likely adversely affect the sustainability of the CRLF population in the Carmel River watershed.
- Any project-induced decrease in Carmel River flows such that a substantial amount of ephemeral off -channel habitats become dry in normal water years, too soon (prior to June) to allow for metamorphosis of the current year's production of tadpoles, would likely adversely affect the sustainability of the CRLF population in the Carmel River watershed.

VII-4. Thresholds Comparison

Existing information and the results of the analyses contained in Chapters IV and V suggest that the flow thresholds developed for the steelhead would also be protective of riparian vegetation. While the relationship between river flow and groundwater in Carmel Valley is not precisely understood because the lower Carmel River frequently runs dry during the summer months requiring artificial irrigation of riparian vegetation, any increase in river flow is expected to benefit vegetation. In addition, the peak flow required for seed dispersal of riparian species would be maintained by the flows that are protective of steelhead.

The exact relationship between Carmel River flows and the quality of habitat for CRLF is not well known. The majority of the critical habitat for CRLF is outside of the main river channel below San Clemente Dam, where most of the critical flows must be maintained for steelhead. The flow thresholds developed for steelhead would not have a major effect on the side channels or tributary streams of the Carmel River, which is the important habitat for CRLF. Flow increases to support steelhead populations that would create new perennial water could affect the distribution of predators, primarily bull frogs. Increases in bullfrog populations could have negative effects on CRLF, but the magnitude of this effect is not known. Any action that decreases flow below existing conditions could adversely affect CRLF by decreasing off-channel habitat. None of the flow thresholds for steelhead or riparian vegetation are expected to result in lower flows in the Carmel River.

Chapter VIII

References

VIII-1. Printed References

Alley, D, R. 1992. Instream flow analysis of steelhead spawning habitat between the Scarlett Narrows and San Clemente Dam, Carmel River, Monterey County, California, 1991. Prepared for the Monterey Peninsula Water Management District. Monterey, CA. June 1992.

Alley, D, R. 1998. Determination of weighted usable spawning area for steelhead in two stream segments - the Scarlett Narrows to San Clemente Dam and between San Clemente and Los Padres Dams, Carmel River, Monterey County, California, 1998. Prepared for the Monterey Peninsula Water Management District. Monterey, CA. March 1998.

Braatne, J. H., S. B. Rood, and P. E. Heilman. 1996. Life history, ecology, and conservation of riparian cottonwoods in North America. Pages 57–85 in R. F. Stettler, H. D. Bradshaw, P. E. Heilman, and T. M. Hinckley (eds.). Biology of *Populus*. National Research Council Press. Ottowa, Canada.

Christensen, T., C. Chabre, and J. Wheeler. 2001. Riparian corridor monitoring report Carmel River. Draft. Monterey Peninsula Water Management District. Monterey CA.

Cook, D. 1997. Microhabitat use and reproductive success of the California red-legged frog (*Rana aurora draytonii*) and bullfrog (*Rana catesbeiana*) in an ephemeral marsh. Master's thesis submitted to Sonoma State University, Sonoma California.

Cunningham, J.E. 1955. Notes on abnormal *Rana aurora draytonii*. Herpetologica: 11:149.

Curry, R. R. and G. M. Kondolf. 1983. Sediment transport and channel stability, Carmel River, California. Unpublished report to MPWMD.

Dettman, D.H. and D.W. Kelley. 1986. Assessment of the Carmel River steelhead resource. Volume I. Biological Investigations. Prepared for the Monterey Peninsula Water Management District. Monterey, CA. September 1986.

Dettman, D.H. and D.W. Kelley. 1987. Assessment of the Carmel River steelhead resource. Volume II. Evaluation of the effects of alternative water supply projects on the Carmel River steelhead resource. Prepared for the Monterey Peninsula Water Management District. Monterey, CA. October 1987.

Dettman, D.H. 1989. Evaluation of instream flow recommendations for adult steelhead upstream migration in the lower Carmel River. Monterey Peninsula Water Management District Technical Memorandum 89-05. Monterey, CA. October 1989.

Ecosystems West Consulting Group. 2001. Biological Assessment of California Red-legged Frog for the Carmel River Dam and Reservoir Project, Monterey County, California. December 2001 Interim Draft. Monterey Peninsula Water Management District, U.S. Army Corps of Engineers, and California-American Water Company.

EIP Associates. 1994. Final environmental impact report/statement. Monterey Peninsula Water Supply Project. Volume I. March. Prepared for Monterey Peninsula Water Management District, Monterey, CA.

Fishery Working Group. 1994. Completion report: Recommended instream flow requirements for the Carmel River steelhead resource. Prepared for Interagency Group by Fishery Working Group (Monterey Peninsula Water Management District, California Department of Fish and Game, National Marine Fisheries Service). March 1994.

Groeneveld, D. P. and T. E. Griepentrog. 1985. Interdependence of groundwater, riparian vegetation, and streambank stability: a cast study. USDA Forest Service general technical report RM-120, pp. 44–48.

Hayes, M.P. and M.M. Miyamoto. 1984. Biochemical, behavioral and body size difference between *Rana aurora aurora* and *R.a. draytonii*. Copeia (4): 1018-1022.

Hayes, M.P. and M.R. Tennant. 1985. Diet and feeding behavior of the California red-legged frog *Rana aurora draytonii* (Ranidae). The Southwestern Naturalist 30(4): 601-605.

Holland, R. F. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game. Sacramento, CA.

Hickman, J. C. (editor). 1993. The Jepson manual: higher plants of California. University of California Press. Berkeley, CA.

Hughes, F. M. R. 1994. Environmental change, disturbance, and regeneration in semi-arid floodplain forests. Pages 321–345 in A. C. Millington and K. Pye (eds.), Environmental change in drylands: biogeographical and geomorphological perspectives. John Wiley. New York, NY.

Jennings, M. 1988. Natural history and decline of native ranids in California. Pages 61-72. *In* Proceedings of the conference on California herpetology. H.F. DeLisle, P.R. Brown, B.

Kaufman, and B.M. McGurty, (eds). Southwestern Herpetologists Society Special Publication (4): 1-143.

Jennings, M.R. and M.P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): The inducement for bullfrog (*Rana catesbeiana*) introduction. Herpetological Review 31 (1): 94-103.

Jennings, M. R., and Marc P. Hayes. 1988. Habitat correlates of distribution oft the California red-legged frog (*Rana aurora draytonii*) and the foothill yel1ow-legged frog (*Rana boylii*): implications for management. Proceedings from Management of Amphibians, Reptiles and Small Mammals in North America Symposium, 1988.

Jennings, M.R., and M.P. Hayes. 1990. Final report of the status of the California red-legged frog (*Rana aurora draytonii*) in the Pescadero Marsh Natural Preserve. Prepared for the California Department of Parks and Recreation under contract No. 4-823-9018 with the California Academy of Sciences. 30 pp.

Jones & Stokes Associates, Inc. 1998. Supplemental environmental impact report for the Carmel River Dam and Reservoir Project. Draft. Volume II: Appendices. November 13, 1998. (JSA 97-236.) Sacramento, CA. Prepared for Monterey Peninsula Water Management District, Monterey, CA.

Kondolf, G. M., and R. R. Curry. 1986. Channel erosion along the Carmel River, Monterey County, California. Earth surface processes and landforms, 11:307–319.

Licht, L.E. 1970. Breeding habits and embryonic thermal requirements of the frogs, *Rana aurora aurora* and *Rana pretiosa pretiosa* in the Pacific Northwest. Ecology. 52(1):116-124.

Mahoney, J. M., and S. B. Rood. 1991. A device for studying the influence of declining water table on poplar growth and survival. Tree physiology 8:305–314.

Mahoney, J. M., and S. B. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment – an integrative model. Wetland 18:634–645.

McNiesh, C. M. 1986. Effects of production well pumping on plant water stress in the riparian corridor of the Lower Carmel Valley. Unpublished report to MPWMD.

McNiesh, C. M. 1989. An inventory of the riparian vegetation resource of the Carmel Valley. Prepared for Monterey Peninsula Water Management District, Monterey, CA.

McNiesh, C. M. 1991. Projected riparian vegetation impacts along the Carmel River under eleven Water Supply Project alternatives. Prepared for Monterey Peninsula Water Management District, Monterey, CA.

Monterey Peninsula Water Management District. 1996. Evaluation of MPWMD Five-year Mitigation Program 1991–1996. Final. A component of the MPWMD Water Allocation EIR. October. Monterey, CA.

______________. 1990a. Final environmental impact report on the water allocation program. Volume I. [State Clearinghouse No. 87030309.] Monterey, CA. April. Prepared by J. Laurence Mintier & Associates, Jones & Stokes Associates, D.W. Kelley & Associates, and Water Resources Associates, Sacramento, CA.

______________. 1994a. Monterey Peninsula water supply project final environmental impact report and statement. Volume I-Summary and Chapters 1 through 24. (State Clearinghouse No. 03033025.) Monterey, CA. March. Prepared by EIP Associates, San Francisco, CA.

______________. 1998a. Carmel River Dam and Reservoir Project draft supplemental environmental impact report. Volume 1- Chapters 1 through 14. Monterey, CA. November. Prepared by Jones & Stokes Associates, Sacramento, CA.

Mussetter Engineering Inc. 2002. Carmel River dam removal study, Monterey County, CA. Prepared for California Department of Water Resources, Fresno, CA.

National Marine Fisheries Service. 2002. Instream flow needs for steelhead in the Carmel River. Bypass flow recommendations for water supply projects using Carmel River waters. Santa Rosa, CA. June 2002.

Rood, S. B., A. R. Kalischuk, and J. M. Mahoney. 1998. Initial cottonwood seedling recruitment following the flood of the century of the Oldman River, Alberta, Canada. Wetlands 18:557–570.

Scott, M. L., G. T. Auble, and J. M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological applications 7:677–690.

Scott, M. L., G. T. Auble, and P. B. Shafroth. 2000a. Evaluating effectiveness of flow releases for restoration of riparian vegetation on the San Joaquin River. February. Unpublished Report. Prepared for the U. S. Bureau of Reclamation, Fresno, CA. Prepared by the U. S. Geological Survey. Midcontinent Ecology Science Center, Ft. Collins, CO.

Scott, M. L., G. C. Lines, and G. T. Auble. 2000b. Channel incision and patterns of cottonwood stress and mortality along the Mojave River, California. Journal of Arid Environments 44:399–414

Segelquist, C. A., M. L. Scott, and G. T. Auble. 1993. Establishment of Populus deltoides under simulated alluvial groundwater declines. American Midland Naturalist 130:274–285.

Shafroth, P. B., G. T. Auble, J. C Stromberg, and D. T. Patten. 1998. Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona. Wetlands 18:577–590.

Stebbins, R.C. 1985. Peterson Field Guides: Western Reptiles and Amphibians. Second edition. Houghton Mifflin Company, Boston, MA p336.

Storer, T. 1925. A Synopsis of the amphibia of California. University of California Publications in Zoology 27:1-342.

Storm, R.M. 1960. Notes on the breeding biology of the red-legged frog (*Rana aurora aurora*). Herpetologica 16(3): 251-259.

Stromberg, J. C., D. T. Patten, and B. D. Richter. 1991. Flood flows and dynamics of Sonoran riparian forests. Rivers 2:221–235.

U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California Red-legged Frog (Rana aurora draytonii). U.S. Fish and Wildlife Service, Portland, Oregon. viii + 173 pp.

Woodhouse, R. M. 1983. Baseline analysis of the riparian vegetation in the Lower Carmel Valley. Unpublished report to MPWMD.

Zinke, P. J. 1971. The effect of water well operation on riparian and phreatophyte vegetation in the middle Carmel Valley. Unpublished report to the Carmel Valley Property Owners Association (CVPOA).

Zweifel, R.G. 1977. Upper thermal tolerances of anuran embryos in relation to stage of development and breeding habits. American Museum Novitates. 2617: 1-21.

VIII-2. Personal Communications

Christensen, Thomas. Riparian Projects Coordinator. Monterey Peninsula Water Management District, Monterey, CA. November and December 2002. Telephone conversations, electronic mail messages to Gerrit Platenkamp (Jones & Stokes).

Fuerst, Darby W. Senior Hydrologist. Monterey Peninsula Water Management District, Monterey, CA. November 2002. Electronic mail message to Bill Mitchell (Jones & Stokes).

Hampson, Larry. Water Resources Engineer. Monterey Peninsula Water Management District, Monterey, CA. December 3 and 9, 2002. Electronic mail messages to Gerrit Platenkamp (Jones & Stokes). January 15, 2003. Electronic mail message to Mike Rushton and Gregg Roy (Jones & Stokes)

Chapter IX
List of Preparers

This report has been prepared by Jones & Stokes staff, with technical assistance from staff of the MPWMD. The preparers and their roles in the study are listed below.

Jones & Stokes

Gregg Roy. BS, Political Economy of Natural Resources, U.C. Berkeley. Project manager

Bill Mitchell. MSc, Fisheries Biology, Humboldt State University. Steelhead threshold analysis

Gerrit Platenkamp. PhD, Ecology, U.C. Davis. Riparian vegetation threshold analysis

Doug Leslie. MSc, Wildlife Biology, Colorado State University. Red-legged frog threshold analysis

Mike Rushton. MA, Physical Geography, U.C. Davis. Project principal

Monterey Peninsula Water Management District

Henrietta Stern. District project manager. Document review

Dave Dettman. District senior fisheries biologist. Technical assistance with fisheries issues and document review

Darby Fuerst. District senior hydrologist. Hydrologic modeling support and document review

Larry Hampson. District water resources engineer. Document review

Thomas Christensen. District riparian projects coordinator. Technical assistance with riparian vegetation issues and document review

Appendix A

Steelhead

Appendix A

Steelhead

Adult Migration

Successful attraction and migration of adult steelhead requires pulses of high winter flows to the lagoon to stimulate movement of adults, flows of sufficient magnitude and duration to permit passage of adults past critical riffles in the lower river, and adequate outflows to keep the river mouth open between storms.

Attraction flows are defined based on the sequence of daily flows that historically attracted adult steelhead into the lower Carmel River. Peak numbers of adult steelhead arriving at San Clemente Dam typically coincide with storm events that increase flows to 200 cfs or more for several days, although adults respond to lower flows of shorter duration later in the season (Dettman and Kelley 1986). Dettman and Kelley (1986) also recognized the importance of maintaining these flow pulses throughout the season (associated with the natural sequence of storms) to maximize migration opportunities for adults. Thus, the ratings for potential migration opportunities in any given year are based on the number of attraction flows during the migration season (Dec 15 – Apr 15).

Adult Attraction
Flows Measured at Los Padres Dam[1]

Number of Pulses during Migration Season	Rating
0	Zero
1	Poor
2	Fair
3-5	Good
>=6	Excellent

[1]Use inflow to Los Padres Reservoir for identifying attraction flows under "unimpaired" conditions and outflow from Los Padres Dam for rating attraction flows under "impaired" conditions (see Appendix A in Dettman 1993).

Following an attraction event, the ability of adults to reach spawning areas below San Clemente Dam can be influenced by passage conditions (water depths) at critical riffles and suitable resting habitat in the lower river. Based on a review of previous assessments and additional field measurements in 1991, Dettman (1993) concluded that a minimum flow of 60 cfs into the lagoon is needed to provide adequate conditions for adult passage in the lower river. In addition, a minimum flow of 40 cfs was considered necessary for maintaining suitable resting habitat for adults during their migration (Dettman 1989). Thus, the suitability of flows for adult migration is rated based on the percentage of days in each month that flows are 60 cfs or more following an attraction event. This rating is downgraded if flows are less than 40 cfs for more than 7 days per month.

Adult Transportation
Flows Measured at Narrows and Lagoon

Percent of days each month with flow <=60 cfs following attraction flow	Rating[1]
>75	Poor
51-75	Fair
25-50	Good
<25	Excellent

[1]Downgrade rating if flow is less than 40 cfs for more than 7 days per month.

Stranding of adults in pools in the lower river is associated with flows less than or equal to 40 cfs. Such flows can delay migration and increase the susceptibility of adults to angling mortality (or poaching) and predation. The level of risk associated with these flows is defined by the following criteria.

Stranding Risk
Flows Measured at Narrows and Lagoon

Percent of days each month with flow <=40 cfs following attraction flow	Rating[1]
Zero flow	Lethal
>75	Critical
51-75	High
25-50	Medium
<25	Low

[1]Increase risk rating if flow is less than 25 cfs for more than 7 days per month.

These ratings are combined to assess overall conditions for upstream (i.e., potential for adults to reach spawning areas).

Spawning

Streamflow in combination with channel and substrate conditions determines the availability of suitable nest sites for spawning adults and, hence, the potential number of fry produced in a given reach. The flow criteria for rating spawning habitat in the Narrows to San Clemente Dam reach were based on:

- relationships between flow and spawning habitat quantity and quality (measured in terms of weighted usable area) (Alley 1992, 1998);
- an estimate of the average area of habitat needed to accommodate each nest (and appropriate factors for converting weighted usable area to actual habitat area) (Dettman and Kelley 1986); and
- an estimate of the number of nests needed to fully seed the rearing habitat (i.e., produce enough fry to fully utilize available habitat) (Dettman and Kelley 1986).

Thus, the rating for each flow range defines the capacity or potential for fry production based on available spawning habitat. The following criteria are based on WUA-versus-flow curves developed by Alley (1992). These curves were later revised to reflect new assumptions regarding the depth preferences of spawning adults (Alley 1998). However, because the revised curves only affect whether a flow is rated “good” or “excellent”, revisions to the following criteria were considered unnecessary for the present analysis.

Spawning Habitat
Flow Measured at Narrows

Average Feb-Mar flow (cfs)	Rating
<5	Zero
5-27	Poor
28-42	Fair
43-81 or >214	Good
81-213	Excellent

Juvenile Rearing

The potential for fry production in a given year is based on overall ratings for adult migration and spawning. These ratings are adjusted downward in years when returns of age 3 and age 4 adults (predicted 3 and 4 years earlier) were both rated as poor or remnant. The following criteria are then applied to determine the capacity of the Narrows to San Clemente Dam reach to rear juveniles through the summer and fall months (Jun-Dec). The flow criteria for rating rearing habitat capacity in the Narrows to San Clemente Dam reach were based on:

- relationships between flow and rearing habitat quantity and quality (rearing habitat index) in the Narrows to San Clemente Dam reach (Dettman and Kelley 1986), and
- relationships between the rearing habitat index and steelhead population density from studies conducted on other central coast streams where rearing habitat was assumed to be fully seeded with juveniles (Dettman and Kelley 1986).

Rearing Capacity for Age 0+ Steelhead
Measured at Narrows

Minimum monthly Jun-Dec flow (cfs)	Rating
<0.5	Critical
0.5-1.7	Poor
1.8-6.0	Fair
6.1-20.0	Good
>20.0	Excellent

The rating for rearing capacity is then adjusted downward if flows at the Narrows and Lagoon increase to at least 20 cfs in response to fall and winter storms (Oct-Mar) and then drop to levels associated with stranding of juveniles downstream of the Narrows.

Stranding Risk
Measured at Narrows and Lagoon

Daily Oct-Mar flow (cfs)	Rating
>=5	Zero
1-5	Medium
<1	High

Smolt Migration

Smolt survival from upstream rearing areas to the lagoon during the spring emigration period is rated based on the average Apr-May flow at the lagoon. Previous studies indicate that the quality and quantity of habitat for yearling steelhead and the survival of emigrating smolts is related to the magnitude of spring flows (Snider 1983, Dettman and Kelley 1986). The following criteria are based on a correlation between adult counts at San Clemente Dam and spring flows, the relationship between flow and rearing habitat for yearlings, and observations of the flows needed to keep the river mouth open during the spring.

Smolt Survival
Measured at Lagoon

Average Apr-May flow (cfs)	Rating
<10	Critical
10-19	Poor
20-39	Fair
40-99	Good
>=100	Excellent

Appendix B

Results of Flow Threshold Analysis for Carmel River Steelhead Downstream of San Clemente Dam

Appendix B

Results of Flow Threshold Analysis for Carmel River Steelhead Downstream of San Clemente Dam

The following tables summarize the results of the flow threshold analysis for Carmel River steelhead. Letters correspond to the flow criteria ratings for each life stage or risk factor, as described in Appendix A. Highlighted cells denote changes made to "impaired" ratings to meet flow threshold criteria. The proposed ratings are consistent with the flow thresholds presented in **Table IV-1** and **Figure VII-1**.

Table B-1. Critically Dry Conditions

		ADULT MIGRATION				SPAWNING	FRY	REARING	JUVENILE REARING/EMIGRATION			ADULT
		ATTRACTION	TRANSPORT	STRANDING	RATING	CAPACITY	SEEDING	CAPACITY	POP. SIZE	STRANDING	EMIGRATION	POP. SIZE
1988	Unimpaired	G	P, Z, Z	L, Z, Z	F, Z, Z	P	C	F	C	Z	P	P
	Impaired	F	P, Z, Z	C, Z, Z	C, Z, Z	P	C	F	C	H	C	Z
	Modified	G	P, Z, Z	M, Z, Z	F, Z, Z	P	C	F	C	M	P	P
1989	Unimpaired	G	P, P, P	C, C, M	C, C, F	G	P	P	P	M	F	P
	Impaired	F	Z, P, P	Z, C, C	Z, C, C	F	C	F	C	H	C	R
	Modified	G	P, P, P	C, C, M	C, C, F	G	P	F	F	M	F	P
1990	Unimpaired	F	P, G, Z	C, L, Z	C, G, Z	G	P	F	F	Z	C	P
	Impaired	P	Z, P, Z	Z, C, Z	Z, C, Z	F	C	C	C	H	Z	R
	Modified	F	P, F, Z	C, M, Z	C, G, Z	G	P	F	F	Z	C	P
1994	Unimpaired	G	Z, E, Z	Z, L, Z	Z, E, Z	G	F	C	P	Z	F	F
	Impaired	G	Z, P, Z	Z, H, Z	Z, P, Z	G	P	P	P	Z	C	P
	Modified	G	Z, P, Z	Z, H, Z	Z, P, Z	G	F	P	P	Z	P	P
	Proposed	F	Z, Z, F	Z, Z, M	Z, Z, G	G	P	F	F	M	F	P

Table B-2. Dry Conditions

		ADULT MIGRATION				SPAWNING	FRY	REARING	JUVENILE REARING/EMIGRATION			ADULT
		ATTRACTION	TRANSPORT	STRANDING	RATING	CAPACITY	SEEDING	CAPACITY	POP. SIZE	STRANDING	EMIGRATION	POP. SIZE
1985	Unimpaired	G	Z, F, E	Z, L, L	Z, G, E	E	F	F	F	Z	G	F
	Impaired	G	Z, P, G	Z, M, L	Z, F, E	E	F	F	F	H	F	P
	Modified	G	Z, P, G	Z, M, L	Z, F, E	E	F	F	F	Z	F	F
1987	Unimpaired	G	Z, P, G	Z, L, L	Z, F, G	E	F	F	F	Z	F	F
	Impaired	G	Z, P, F	Z, C, H	Z, C, F	G	P	F	F	H	C	P
	Modified	G	Z, P, F	Z, C, H	Z, C, F	G	P	F	F	Z	F	P
1991	Unimpaired	E	Z, E, E	Z, L, L	Z, E, E	E	F	F	F	Z	G	F
	Impaired	G	Z, Z, F	Z, Z, H	Z, Z, F	E	P	F	F	H	P	P
	Modified	G	Z, Z, F	Z, Z, H	Z, Z, F	E	P	F	F	Z	F	F
	Proposed	G	Z, Z, F	Z, Z, M	Z, Z, G	G	F	F	F	Z	F	F

Table B-3. Below Normal Conditions

	ADULT MIGRATION				SPAWNING	FRY	REARING	JUVENILE REARING/EMIGRATION			ADULT
	ATTRACTION	TRANSPORT	STRANDING	RATING	CAPACITY	SEEDING	CAPACITY	POP. SIZE	STRANDING	EMIGRATION	POP. SIZE
1959 Unimpaired	G	P, E, P	M, L, H	F, E, P	E	F	C	P	Z	F	F
Impaired	G	P, E, P	C, L, C	C, E, C	E	P	P	P	Z	P	P
Modified	G	P, E, P	C, L, C	P, E, P	E	F	P	P	Z	F	F
1971 Unimpaired	P	E, Z, Z	L, Z, Z	E, Z, Z	G	C	C	C	Z	G	F
Impaired	P	E, Z, Z	L, Z, Z	E, Z, Z	G	C	P	C	M	F	P
Modified	P	E, Z, Z	L, Z, Z	E, Z, Z	G	C	P	C	Z	G	F
1981 Unimpaired	E	G, E, E	L, L, L	G, E, E	E	F	F	F	Z	G	F
Impaired	E	F, Z, E	M, Z, L	G, Z, E	E	F	F	F	Z	G	F
Proposed	G	F, Z, Z	M, Z, Z	G, Z, Z	G	F	F	F	Z	F	F

Table B-4. Normal Conditions

	ADULT MIGRATION				SPAWNING	FRY	REARING	JUVENILE REARING/EMIGRATION			ADULT
	ATTRACTION	TRANSPORT	STRANDING	RATING	CAPACITY	SEEDING	CAPACITY	POP. SIZE	STRANDING	EMIGRATION	POP. SIZE
1999 Unimpaired	E	E, E, E	L, L, L	E, E, E	G	F	F	F	Z	E	G
Impaired	E	E, E, E	L, L, L	E, E, E	G	F	F	F	Z	E	G
2000 Unimpaired	E	E, E, E	L, L, L	E, E, E	G	F	F	F	Z	G	F
Impaired	E	G, E, E	M, L, L	G, E, E	G	F	F	F	Z	G	F
2001 Unimpaired	G	E, Z, E	L, Z, L	E, Z, E	G	F	P	P	Z	G	F
Impaired	G	P, Z, E	M, Z, L	F, Z, E	G	F	F	F	Z	G	F
Proposed	G	G, Z, E	M, Z, L	G, Z, E	G	F	F	F	Z	G	F

Table B-5. Above Normal Conditions

	ADULT MIGRATION ATTRACTION	TRANSPORT	STRANDING	RATING	SPAWNING CAPACITY	FRY SEEDING	REARING CAPACITY	JUVENILE REARING/EMIGRATION POP. SIZE	STRANDING	EMIGRATION	ADULT POP. SIZE
1975 Unimpaired	E	P, E, E	H, L, L	P, E, E	G	F	F	F	Z	E	G
Impaired	E	P, E, E	C, L, L	C, E, E	G	F	F	F	H	E	F
Modified	E	P, E, E	C, L, L	P, E, E	G	F	F	F	Z	E	G
1996 Unimpaired	E	E, E, E	L, L, L	E, E, E	G	F	F	F	Z	E	G
Impaired	E	G, E, E	L, L, L	E, E, E	G	F	F	F	H	G	F
Modified	E	G, E, E	L, L, L	E, E, E	G	F	F	F	Z	G	F
1997 Unimpaired	F	E, Z, Z	L, Z, Z	E, Z, Z	E	P	P	P	Z	G	F
Impaired	F	E, Z, Z	L, Z, Z	E, Z, Z	E	P	F	F	Z	F	F
Proposed	G	G, Z, Z	M, Z, Z	G, Z, Z	G	F	F	F	Z	G	F

Table B-6. Wet Conditions

	ADULT MIGRATION ATTRACTION	TRANSPORT	STRANDING	RATING	SPAWNING CAPACITY	FRY SEEDING	REARING CAPACITY	JUVENILE REARING/EMIGRATION POP. SIZE	STRANDING	EMIGRATION	ADULT POP. SIZE
1973 Unimpaired	E	E, E, E	L, L, L	E, E, E	G	F	P	P	Z	E	G
Impaired	E	E, E, E	L, L, L	E, E, E	G	F	F	F	Z	E	G
1986 Unimpaired	E	P, E, E	H, L, L	P, E, E	G	F	G	G	Z	E	E
Impaired	E	P, E, E	C, L, L	C, E, E	G	F	G	G	Z	E	E
1993 Unimpaired	G	E, E, E	L, L, L	E, E, E	G	F	F	F	Z	E	G
Impaired	G	G, E, E	L, L, L	G, E, E	G	F	F	F	Z	G	F
Modified	G	G, E, E	L, L, L	G, E, E	G	F	F	F	Z	E	G
Proposed	E	G, E, E	M, L, L	G, E, E	G	F	F	F	Z	E	G

Table B-7. Extremely Wet Conditions

		ADULT MIGRATION				SPAWNING	FRY	REARING	JUVENILE REARING/EMIGRATION			ADULT
		ATTRACTION	TRANSPORT	STRANDING	RATING	CAPACITY	SEEDING	CAPACITY	POP. SIZE	STRANDING	EMIGRATION	POP. SIZE
1983	Unimpaired	E	E, E, E	L, L, L	E, E, E	G	F	E	E	Z	E	E
	Impaired	E	E, E, E	L, L, L	E, E, E	G	F	G	G	Z	E	E
1995	Unimpaired	G	E, Z, E	L, Z, L	E, Z, E	G	F	G	G	Z	E	E
	Impaired	G	E, Z, E	L, Z, L	E, Z, E	G	F	F	F	Z	E	G
	Modified	G	E, Z, E	L, Z, L	E, Z, E	G	F	G	G	Z	E	E
1998	Unimpaired	E	E, E, E	L, L, L	E, E, E	G	F	E	E	Z	E	E
	Impaired	E	E, E, E	L, L, L	E, E, E	G	F	G	G	Z	E	E
	Proposed	E	E, Z, E	L, Z, L	E, Z, E	G	F	G	G	Z	E	E

Z = zero
C = critical
P = partial (fry seeding only) or poor (all other categories)
F = full (fry seeding only) or fair (all other categorires)
G = good
E = excellent
L = low
M = medium
H = high
R = remnant