DRAFT Technical Memorandum

Chinook Salmon Temporal Occurrence and Environmental Requirements: Preliminary Tables

December 14, 2007

Table of Contents

Tables

List of Abbreviations and Acronyms

CVP	Central Valley Project
DFG	State of California Department of Fish and Game
DWR	State of California Department of Water Resources
EB	East Side Bypass
FWUA	Friant Water Users Authority
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
PEIS/R	Program Environmental Impact Statement/Report
Reclamation	United Stated Department of the Interior, Bureau of Reclamation
SJRRP	San Joaquin River Restoration Program
TM	Technical Memorandum
USFWS	United States Department of the Interior, Fish and Wildlife Service

This Draft Technical Memorandum (TM) was prepared by the San Joaquin River Restoration Program (SJRRP) Team as a draft document to support preparation of a Program Environmental Impact Statement/Report (PEIS/R). The purpose for circulating this document at this time is to facilitate early coordination regarding initial concepts and approaches currently under consideration by the SJRRP Team with the Settling Parties, Third Parties, other stakeholders, and interested members of the public. Therefore, the content of this document may not necessarily be included in the PEIS/R.

This Draft TM does not present findings, decisions, or policy statements of any of the Implementing Agencies. Additionally, all information presented in this document is intended to be consistent with the Settlement. To the extent inconsistencies exist, the Settlement should be the controlling document and the information in this document will be revised prior to its inclusion in future documents. While the SJRRP Team is not requesting formal comments on this document, all comments received will be considered in refining the concepts and approaches described herein, to the extent possible. Responses to comments will not be provided, and this document will not be finalized; however, refinements will likely be reflected in subsequent SJRRP documents.

1.0 Introduction

This Draft Chinook Salmon Temporal Occurrence and Environmental Requirements TM describes the environmental conditions preferred and targeted for both spring-run and fall-run Chinook salmon. The tables in Chapter 2 outline the months and river reach in which each salmon run is present.

1.1 Background

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and Central Valley Project (CVP) Friant Division contractors. After more than 18 years of litigation of this lawsuit, known as *NRDC et al., v. Kirk Rodgers et al.*, a Settlement was reached. On September 13, 2006, the Settling Parties agreed to terms and conditions of the Settlement, which was subsequently approved by the United States District Court on October 23, 2006. The "Settling Parties" include NRDC, Friant Water Users Authority (FWUA), and the United States Departments of the Interior and Commerce.

The SJRRP will implement the Settlement. The "Implementing Agencies" responsible for managing the SJRRP include the United States Department of the Interior, through the Bureau of Reclamation (Reclamation) and the Fish and Wildlife Service (USFWS), United States Department of Commerce through the National Marine Fisheries Service (NMFS), and the State of California through the Department of Water Resources (DWR) and the Department of Fish and Game (DFG).

The Settlement identified two parallel Goals: the Restoration Goal and the Water Management Goal. Results from the water operations model will (1) depict operation of the Friant Division of the CVP and other water management systems under the Settlement, (2) provide the basis for comparing actions contributing to meeting the Water Management Goal, and (3) produce inputs for other modeling activities for assessing other impacts associated with implementation of the Settlement.

1.2 Purpose of this Technical Memorandum

The Fisheries Management Work Group is providing preliminary tables to be used as planning tools for other workgroups, in particular, the Engineering Workgroup and the Water Management Workgroup. The temporal occurrence and environmental requirement tables included in this TM will be further refined by the Fisheries Management Workgroup and incorporated into a Fish Management Plan.

2.0 Chinook Salmon Temporal Occurrence and Environmental Requirements

This Draft Chinook Salmon Temporal Occurrence and Environmental Requirements TM presents the environmental conditions preferred and targeted for both spring-run and fall-run Chinook salmon. Tables 2-1 through 2-4 contain the temporal occurrence for spring- and fall-run Chinook salmon as well as important environmental criteria (e.g., depth requirements, velocity, temperature criteria, gravel, vegetation cover). Although these environmental criteria and estimated temporal occurrences are based on published scientific literature from San Joaquin and Sacramento river basin tributaries and other Pacific coast rivers, they are estimates and are subject to other variables such as fishery stock characteristics, hydrological conditions, local conditions, and water quality. As mentioned, the temporal occurrence and environmental requirement tables in this section will be further refined by a Fisheries Management Workgroup and incorporated into the Fish Management Plan.

Table 2-1.
Spring-Run Chinook Salmon Temporal Occurrence by Life Stage and Reach (as determined by the San Joaquin Restoration Program), and Month

Life Stage	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration[1]			5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1				
Adult Holding[2, 3]				1A	1A	1A	1A	1A	1A			
Spawning[1, 4]								1A	1A	1A		
Incubation and Emergence[5, 6]	1A	1A	1A					1A	1A	1A	1A	1A
In-River Fry/Juvenile Rearing[1, 7]	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5	1, 2 3, 4, MB, EB, 5
Fry Migration[6, 8, 9]	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5										1, 2, 3, 4, MB, EB, 5
Smolt Migration[6, 8, 9]			1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5						
Yearling Migration[6, 8, 9]	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5						1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5	1, 2, 3, 4, MB, EB, 5

Sources are found in the references section, and are denoted by the superscripted numbers.

Notes:

Periods and/or locations of high relative abundance are shaded in gray.

The numbers in each column represent reach designation.

Key:

EB = East Side Bypass

MB = Mariposa Bypass

Table 2-2.
Optimal and Observed Habitat Conditions Used by Spring-Run Chinook Salmon by Reach and Month

Life Stage	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration		Optimal Depth: ≥0.5 feet [10] Optimal Temperature: ≤ 57ºF,[11] Maximum: 72ºF (constant),[12] **Target:** ≤ 63ºF[13]										
Adult Holding				Optimal Depth: ≥ 8 feet, Minimum Observed: 3 - 10 feet[14] Optimal Velocity: 0.5 - 1.3 fps[14] Optimal Temperature: ≤ 60ºF,[15] Maximum: 80ºF,[15] **Target:** ≤ 70ºF[15]								
Spawning								Observed Depth: > 0.8 - 7 feet[1, 16, 17] Optimal Velocity:1.2-4.0 fps (HSI > 0.7)[1, 17] Optimal Temperature: ≤ 57ºF,[18, 19] Maximum: 65ºF[10], **Target:** ≤ 57ºF Percent Fines: ≤ 10%[10] Median Diameter of Gravel: Optimal: 1-3 and 2-4 inches,[1, 20] Observed: 1-4 [1, 21]				
Incubation and Emergence								Optimal Depth: ≥ 0.8 feet[1] Optimal Velocity: 1.5-2.4 fps[10] Optimal Temperature ≤ 55ºF,[1, 22, 23] Maximum: 61ºF, [24] **Target:** ≤ 55ºF Percent Fines: ≤ 10%[10] Median Diameter of Gravel: Optimal: 1-2 inches,[1] Observed: 1-4 [1, 21]				
In-River Fry/Juvenile	Optimal Depth: 2 - 3 feet[10] Velocity: 0.4 – 0.5 fps for fry,[10] 1 – 1.8 fps for juveniles[1] Optimal Temperature: ≤ 50-68ºF,[12, 25] Maximum: 72ºF,[26] upper incipient lethal level is 79 ºF,[12, 26] **Target:** ≤ 65ºF ≥ 20% instream area cover (e.g., overhanging banks, and vegetation)[10] Floodplain Inundation: Dec – May, ≥ 8 weeks, salmon presence ≥ 14 days[28]											
Fry, Smolt and Yearling Migration	Variable Depth Velocity: 0.4 – 0.5 fps for fry,[10] 1 – 1.8 fps for juveniles[1] Optimum Temperature: ≤ 62ºF,[29] 71ºF may cause avoidance,[26] **Target:** ≤ Floodplain Inundation: Dec – May, ≥ 8 weeks, salmon presence ≥ 14 days[28]											

Sources are found in the references section, and are denoted by the superscripted numbers.

Key: ≤ = equal to or less than ≥ = equal to or greater than ºF = degrees Fahrenheit % = percent fps = feet per second

Table 2-3.
Fall-Run Chinook Salmon Temporal Occurrence by Life Stage and Reach (as determined by the San Joaquin Restoration Program), and Month

Life Stage	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration[30, 31]									5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1	5, 4, MB, EB, 3, 2, 1	
Spawning[32]										1A, B	1A, B	1A, B
Incubation and Emergence[33]	1A, B	1A, B								1A, B	1A, B	1A, B
In-River Fry/ Juvenile Rearing [34]	1A, B, 2, 3, 4, MB, EB, 5	1A, B, 2, 3, 4, MB, EB, 5	1A, B, 2, 3, 4, MB, EB, 5	1A, B, 2, 3, 4, MB, EB, 5	1A, B, 2, 3, 4, MB, EB, 5	1A, B, 2, 3, 4, MB, EB, 5						
Fry/Smolt Migration [34]	Fry 1, 2, 3, 4, MB, EB, 5	Fry 1, 2, 3, 4, MB, EB, 5	Fry Smolt 1, 2, 3, 4, MB, EB, 5	Smolt 1, 2, 3, 4, MB, EB, 5	Smolt 1, 2, 3, 4, MB, EB, 5	Smolt 1, 2, 3, 4, MB, EB, 5						

Sources are found in the references section, and are denoted by the superscripted numbers.

Note:

Periods and/or locations of high relative abundance are shaded in gray.

The Numbers represent Reach designation.

Key:

EB = East Side Bypass

MB = Mariposa Bypass

Table 2-4.
Optimal Depth, Velocity, and Water Temperature Requirements for Fall-Run Chinook Salmon by Reach and Month

Life Stage	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration									Optimal Depth: ≥0.5 feet [10] Optimal Temperature: ≤ 57ºF,[11] Maximum: 72ºF (constant),[12] **Target:** ≤ 63ºF[13]			
Spawning										Observed Depth: > 0.8 - 14 feet[1, 16, 35] Optimal Velocity: 1.2-3.5 fps[1] Optimal Temperature: ≤ 57ºF,[18, 19] Maximum: 65ºF[10], **Target:** ≤ 57ºF Percent Fines: ≤ 10%[10] Median Diameter of Gravel: Optimal: 1-2 inches[1], Observed: 1-4 [1, 21]		
Incubation and Emergence										Optimal Depth: ≥ 0.8 feet[1] Optimal Velocity: 1.5-2.4 fps[10] Optimal Temperature: ≤ 55ºF,[1, 22, 23] Maximum: 61ºF [24], **Target:** ≤ 55ºF Percent Fines: ≤ 10%[10] Median Diameter of Gravel: Optimal: 2-4 inches,[35] Observed: 1-4 [1, 21]		
In-River Fry/Juvenile Rearing	Optimal Depth: 2 - 3 feet[10] Velocity: 0.4 – 0.5 fps for fry,[10] 1 – 1.8 fps for juveniles[1] Optimal Temperature: ≤ 50-68ºF,[12, 25] Maximum: 72ºF,[26] upper incipient lethal level is 79 ºF,[12, 27] **Target:** ≤ 65ºF ≥ 20% instream area cover (e.g., overhanging banks, vegetation)[10] Floodplain Inundation: Dec – May, ≥ 8 weeks, salmon presence ≥ 14 days[28]											
Fry/Smolt Migration	Variable Depth Velocity: 0.4 – 0.5 fps for fry,[10] 1 – 1.8 fps for juveniles[1] Optimum Temperature: ≤ 62ºF ,[29] 71ºF may cause avoidance,[26] **Target:** ≤ 65ºF Floodplain Inundation: Dec – May, ≥ 8 weeks, salmon presence ≥ 14 days[28]											

Sources are found in the References section, and are denoted by the superscripted numbers.

Key: ≤ = equal to or less than ≥ = equal to or greater than ºF = degrees Fahrenheit % = percent fps = feet per second

This page left blank intentionally.

3.0 References

1. California Department of Fish and Game. 1998. Report to the Fish and Game Commission: A Status Review of the Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage. Candidate Species Status Report 98-01. Inland Fisheries Division, Sacramento, California.

2. Vogel, D. A., and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. U.S. Department of the Interior, Bureau of Reclamation, Central Valley Project. CH2M Hill, Redding, California.

3. Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of Chinook salmon in the Central Valley drainage of California, Sierra Nevada Ecosystem Project: final report to congress, Volume III: Assessments, commissioned reports, and background information, University of California, Center for Water and Wildland Resources, Davis, California, pp. 309-362.

4. McReynolds, T. R., C. E. Garman, P. D. Ward, and M. C. Schommer. 2005. Butte and Big Chico creeks spring-run Chinook salmon, *Oncorhynchus tschawytscha* life history investigation 2003-2004. California Department of Fish and Game, Sacramento Valley – Central Sierra Region, Inland Fisheries Administrative Report No. 2005-1.

5. Fisher, F. W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8: 870-873.

6. Ward, P. D., and T. R. McReynolds. 2001. Butte and Big Chico Creeks spring-run Chinook salmon, *Oncorhynchus tshawytscha*, life history investigation, 1998-2000. California Department of Fish and Game, Inland Fisheries Administrative Report.

7. Healey, M. C. 1991. Life history of Chinook salmon. C. Groot and L. Margolis, editors. Pacific salmon life histories. pp. 311-393 UBC Press, Vancouver.

8. Hill, K. A., and J. D. Webber. 1999. Butte Creek spring-run Chinook salmon, *Oncorhynchus tshawytscha*, juvenile outmigration and life history 1995-1998. Inland Fisheries Administrative Report No. 99-5. California Department of Fish and Game, Sacramento Valley and Central Sierra Region, Rancho Cordova.

9. Ward, P.D., T.R. McReynolds, and C.E. Garman. 2002. Butte and Big Chico Creeks spring-run Chinook salmon, *Oncorhynchus tshawytscha*, life history investigation, 2000-2001. California Department of Fish and Game, Inland Fisheries Administrative Report No. 2001-2.

10. Raleigh, R.F., W.J. Miller, and P. C Nelson. 1986. Habitat suitability index models and instream flow suitability curves: Chinook salmon. U.S. Fish and Wildlife Service. Biological Report 82(10.122). 64 pp.

11. Marine, K. R. 1992. A background investigation and review of the effects of elevated water temperature on reproductive performance of adult Chinook salmon (*Oncorhynchus tshawytscha*) with suggestions for approaches to assessment of temperature induced reproductive impairment of Chinook salmon stocks in the American River, California. Department of Wildlife and Fisheries Biology, University of California.

12. U. S. Environmental Protection Agency. 2003. EPA Region 10 guidance for Pacific northwest state and tribal temperature water quality standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, Washington.

13. Berman, C. H. 1990. The effect of holding temperatures on adult spring Chinook salmon reproductive success. Master's Thesis, University of Washington.

14. Marcotte, B.D. 1984. Life history, status and habitat requirements of spring-run Chinook salmon in California. Lassen National Forest, Chester Ranger District, Chester, California. 34 pp.

15. Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish Species of Special Concern in California. Second edition. California Department of Fish and Game. Sacramento, California.

16. Sommer, T., D. McEwan, and R. Brown. 2001. Factors affecting Chinook salmon spawning in the Lower Feather River. In Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(1): 269-297.

17. U.S. Fish and Wildlife Service. 2003. Flow-habitat relationships for spring-run Chinook salmon spawning in Butte Creek, Sacramento, California.

18. Bell, M. C. 1990. Fisheries Handbook of Engineering Requirements and Biological Criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon.

19. Reiser, D. W., and T. C. Bjornn. 1979. Habitat Requirements of Anadromous Salmonids. In W. R. Meehan (tech. ed.)., Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. U.S. Forest Service GTR PNW-96.

20. U.S. Fish and Wildlife Service. 2007. Flow-habitat relationships for spring-run Chinook salmon and steelhead between Whiskeytown Dam and Clear Creek Road. Sacramento, California.

21. Mesick, C. 2001. Studies of spawning habitat for fall-run Chinook salmon in the Stanislaus River between Goodwin Dam and Riverbank from 1994 to 1997. In

Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2): 217-252.

22. Combs, B. D., and R. E. Burrows. 1957. Threshold temperatures for the normal development of Chinook salmon eggs. The Progressive Fish-Culturist 19:3-6.

23. McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Report No. EPA 910—D-01-005. Prepared for the USEPA.

24. Alderdice, D. F., and F. P. J. Velsen. 1978. Relation between temperature and incubation time for eggs of Chinook salmon (*Oncorhynchus tshawytscha*). Journal of the Fisheries Research Board of Canada 35: 69-75.

25. Marine, K.R., and J.J. Cech, Jr. 2004. Effects of high water temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management 24: 198-210.

26. Burck, W. A., R. B. Lindsay, B. J. Smith, and E. A. Olsen. 1980. Spring Chinook studies in the John Day River, Federal Aid Progress Reports – Fisheries. Oregon Department of Fish and Wildlife – Fish Division, Portland, Oregon.

27. Hanson, C. H. 1991. Acute temperature tolerance of juvenile Chinook salmon from the Mokelumne River. Prepared by Hanson Environmental, Inc. Walnut Creek, California.

28. Philip Williams & Associates, Ltd. 2004. San Joaquin River National Wildlife Refuge Phase 2: habitat implications of levee breaching alternatives. Final Report.

29. Zedonis, P. A., and T. J. Newcomb. 1997. An evaluation of flow and water temperatures during the spring for protection of salmon and steelhead smolts in the Trinity River, California. U.S. Fish and Wildlife Service, Coastal California Fish and Wildlife Office. Arcata, California.

30. Cramer Fish Sciences. 2007. Upstream fish passage at a resistance board weir using infrared and digital technology in the lower Stanislaus River, California, 2006-2007 Annual Data Report. Prepared for the Anadromous Fish Restoration Program.

31. Ford, T., and L. R. Brown. 2001. Distribution and abundance of Chinook salmon and resident fishes of the lower Tuolumne River, California. In Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2): 253-303.

32. CDFG. 1991–2005. Annual reports, fiscal years 1987-2004, San Joaquin River Chinook Salmon Enhancement Project. Sport Fish Restoration Act. Region 4, Fresno.

33. MID and TID (Modesto Irrigation District and Turlock Irrigation District). 1992. Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project (Project No. 2299), Appendix 22 of the

Fisheries Studies Report, Lower Tuolumne River Predation Study Report. Prepared by EA Engineering, Science, and Technology for the Federal Energy Regulatory Commission. Lafayette, California. February 5.

34. Fishbio Environmental, LLC. Unpublished data.

35. U.S. Fish and Wildlife Service. 2003. Flow-habitat relationships for steelhead and fall, late-fall and winter-run Chinook salmon spawning in the Sacramento River between Keswick Dam and Battle Creek, Sacramento, California.