Hatchery and Genetic Management Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

December 17, 2010

HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

December 17, 2010

Hatchery Program:	San Joaquin River Salmon Conservation and Research Program
Species or Hatchery Stock:	San Joaquin River Experimental Population of Spring-run Chinook Salmon
Agency/Operator:	California Department of Fish and Game
Watershed and Region:	Middle San Joaquin-Lower Chowchilla Watershed USGS Unit: 18040001. Hatchery location: 36° 59'11.57" N, 119° 43'02.11"W
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Date Submitted:	
Date Last Updated:	

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°F	Degrees Fahrenheit
CDFG	California Department of Fish and Game
cfs	Cubic Feet per Second
Conservation Facility	San Joaquin River Salmon Conservation
CV	Central Valley
CVP	Central Valley Project
CWT	Coded Wire Tag
Delta	Sacramento-San Joaquin Delta
DO	Dissolved Oxygen
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
ESU	Evolutionarily Significant Unit
FESA	Federal Endangered Species Act
FL	Fork Length
FMP	Fisheries Management Plan
FMWG	Fisheries Management Work Group
FR	Federal Register
g	Grams
g/d	Grams per Day
GSG	Genetics Subgroup
HGMP	Hatchery and Genetic Management Plan
HOR	Hatchery Origin
HSRG	Hatchery Scientific Review Group
m^2	Square Meters
mg N/L	Milligrams Nitrogen per Liter
mg/L	Milligrams per Liter
mm	Millimeter
N_b	Breeding Population Size
N_e	Effective Population Size
N_{eh}	Hatchery Broodstock Effective Population Size
N_{eh+w}	Combined Hatchery Broodstock and Wild Population Effective Population Size
N_{ew}	Wild Population Effective Population Size
NMFS	National Marine Fisheries Service
NOR	Natural Origin
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
PBT	Parentage Based Tag
PFMC	Pacific Fishery Management Council
pHOS	Proportion effective Hatchery Origin spawners on spawning grounds
PIT	passive integrated transponder
PNI	Proportionate Natural Influence

pNOB	Proportion Natural Origin spawners in Broodstock
pNOS	Proportion Natural Origin spawners on spawning grounds
ppm	parts per million
Ppt	parts-per-thousand
Program	San Joaquin River Salmon Conservation and Research Program
RA	Returning Adults
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Restoration Area	San Joaquin River from Friant Dam to confluence with Merced River
Settlement	Stipulations of the Settlement Agreement
SJRRP	San Joaquin River Restoration Program
SWP	State Water Project
TAC	Technical Advisory Committee
UC Davis	University of California, Davis
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service

Executive Summary

The San Joaquin River Salmon Conservation and Research Program (Program) will restore a spring-run Chinook salmon population in the San Joaquin River, as mandated by the Stipulation of Settlement (Settlement) in *Natural Resources Defense Council v. Rodgers*, which was approved by the United States District Court for the Eastern District of California in October 2006, and approved by Congress in 2009 through the San Joaquin River Restoration Settlement Act, Pub. L. No. 111-11, 123 Stat. 1349.

The historical San Joaquin River spring-run Chinook salmon populations have become extirpated, and remaining Central Valley (CV) spring-run populations are at varying risk of extinction. This Executive Summary provides a chronological overview of hatchery goals and operational planning.

The Program's Spring-Run Chinook Salmon Hatchery Genetic Management Plan (HGMP), as contained in this document provides guidance on the management and operation of the Program's Conservation Facility. The HGMP and decisions made under this plan are guided by an adaptive management strategy as described in the San Joaquin River Restoration Program (SJRRP) 2010 Draft Fisheries Management Plan (FMP), attached as Appendix 6. While extensive analysis and expertise are used to predict restoration success, these predictions are potentially fallible due to the numerous variables associated with the massive scale of this project. Adaptive management, as described by Williams et al. (2007), recognizes and plans for this uncertainty. All plans for hatchery operations are subject to revision based on this adaptive management approach. Revisions will be guided by a Hatchery and Monitoring Technical Team (Technical Team), meeting twice a year or more, as needed, to review program success and critical actions including: production numbers, newly restored habitat sites, results of previous reintroduction efforts, direction of program into new locations and/or continued planting in current reintroduction areas and other monitoring results. The Technical Team will prepare an Annual Report described in HGMP Section 11. The HGMP will be comprehensively revised and circulated every 5 years.

In Fall 2010, a small-scale Interim Facility (Interim Facility) at the existing State operated San Joaquin Fish Hatchery will begin operation using fall-run Chinook salmon as a surrogate to provide the Program with practical experience captive rearing juvenile Chinook in the Conservation Facility on the same site. The interim facility will also allow the program to implement hatchery operations during the construction of the Conservation Facility, which is planned for completion in 2014. The Program Timeline in Figure ES.1 describes the roll-out of interim and full-scale facilities and their relationship to reintroduction strategies.

The CV spring-run Chinook salmon are listed as threatened under both the Federal Endangered Species Act (FESA) and the California Endangered Species Act (CESA). Spring-run hatchery production cannot commence until the appropriate permits have been issued. Collection of fish from this Evolutionarily Significant Unit (ESU) for broodstock will be governed by a FESA 10(a)1(A) enhancement of population permit. The reintroduced population

will be designated an experimental population under FESA section 10(j), and associated 4(d) rules will be promulgated to allow for hatchery and monitoring operations. Preparation and review of the 10(a)1(A) federal permit and the 10(j) federal designation will be ongoing from 2010 to 2012. In keeping with the settlement agreement, the U.S. Fish and Wildlife Service (FWS) will submit a completed permit application to the National Marine Fisheries Service (NMFS) for the reintroduction of spring-run Chinook salmon as soon as practical, but no later than September 30, 2010. To facilitate reintroduction under the California Endangered Species Act (CESA), new State legislation (SB 1349) has been introduced to allow activities that may grant take of spring-run Chinook salmon to move forward without needing CESA coverage if the activities have obtained or have been provided take authorization by NOAA through an enhancement of survival permit or 4d regulation. This will effectively result in no State action for "take" for any activities that are covered under the federal authorizations.

Once approval to construct a new facility has been secured, construction of the full-scale Conservation Facility is scheduled to begin, ideally in 2011. However, delays in the State budget process and/or delays in allocation of funding may delay construction. In 2011, the permit to work with listed spring-run Chinook salmon will still be under review, and the Interim Facility will continue work with fall-run Chinook salmon.

Under the settlement agreement, NMFS will complete the review of the permit applications by April 30, 2012. If the applications are approved, broodstock collection from up to three main source populations (Feather River, Butte Creek, and the Deer/Mill Creek Complex spring-run Chinook salmon) will begin in 2012. Broodstock will be gathered primarily as eggs or juveniles, in order to minimize the impact on source populations while allowing for collection of enough fish to establish a successful broodstock. Broodstock gathered in 2012 will be reared in the Interim Facility and, upon reaching sexual maturity, will be spawned or be released to the river to spawn naturally.

Before completion of the full-scale facility, yearly broodstock collections should gather enough fish or eggs, roughly 300-500 total, across all population, to produce 50-100 total adult pairs. Collections will continue until the full scale facility is constructed, which is planned to be completed in 2014. Additional source population fish may be collected for direct in-river releases, and some fish may be taken from the San Joaquin and its tributaries, depending on their provenance. All broodstock will be genotyped for parentage-based tagging (PBT) and to prepare breeding matrices, per HGMP Section 8 and will be PIT tagged for tracking and identification. Planned Interim Facility operations in 2013 should repeat 2012 actions.

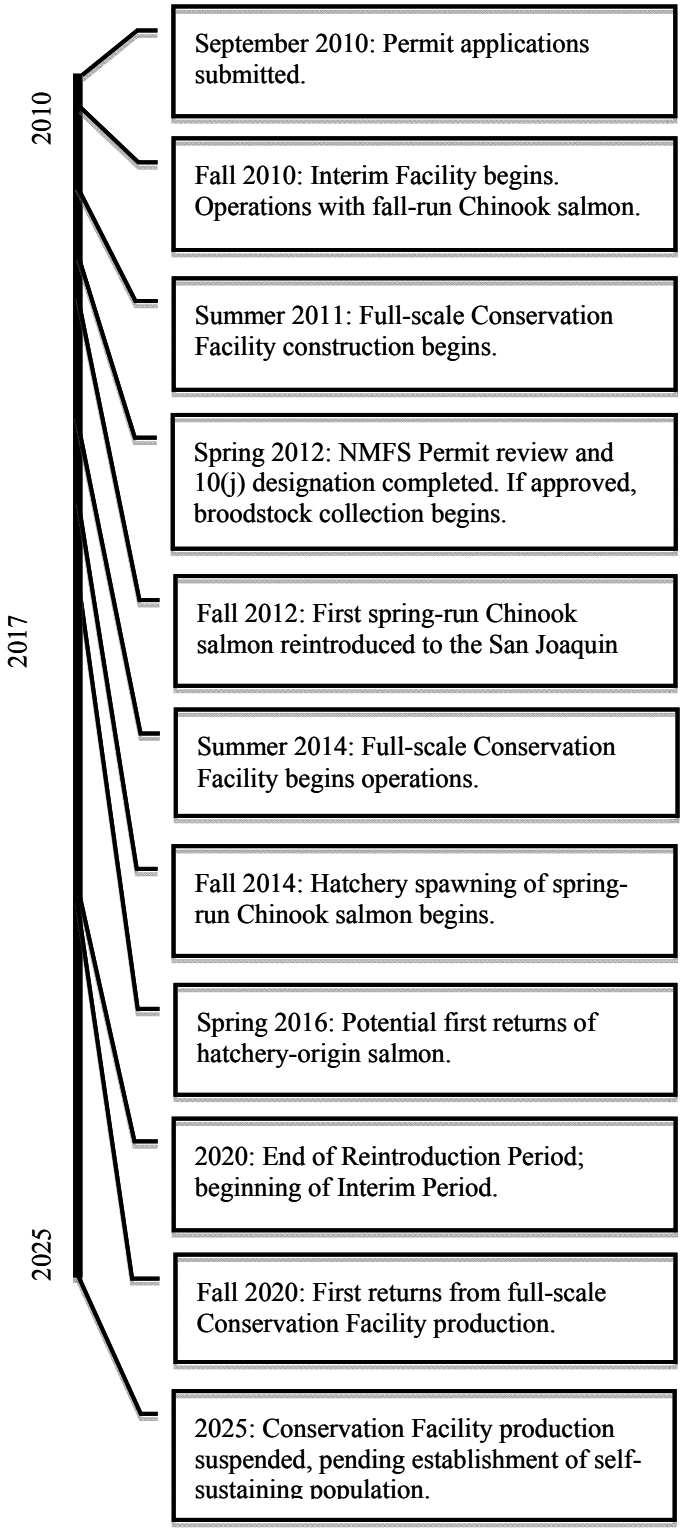

Figure ES.1. Program Timeline, 2010 to 2025.
Projected dates are contingent upon funding availability.

With planned full-scale Conservation Facility construction ending in 2014, hatchery operations should begin the same year, and the Interim Facility will be integrated into the full-scale facility. As the full-scale facility comes on line, broodstock collection can ramp up to the higher levels identified in HGMP Sections 1.11.1 and 6, as permitted. To capture the most genetic diversity while minimizing impacts to the source populations, broodstock collections will continue every year for at least 4 years and potentially up to 8 years, depending upon returns in the San Joaquin and source population Rivers, and on the number of fish taken from the source populations every year. Full-scale operations are anticipated to collect up to approximately 2,700 fish or eggs per year from the source populations to allow for infertility, mortality, and unequal sex ratios, which should produce up to 450 adult pairs. See HGMP Section 1.11.1 for details.

In 2014, yearling broodstock females collected in 2012 should be available for spawning, although this will likely be a small percentage of the anticipated restoration broodstock. These fish will be mated as discussed in HGMP Section 8. Conservation Facility egg production from spawning practices in any year will probably not exceed 750,000 eggs, although more fish may be produced if required to meet the reintroduction goals. See HGMP Section 9 for details. Offspring will be reintroduced to the River as discussed in HGMP Section 10, depending on conditions in the San Joaquin River and escapement for the reintroduced population.

Any adult escapement returns from the direct, in-river releases would begin returning in 2015 and 2016. Depending on escapement numbers, these may be available for use as broodstock. Broodstock collection from returns generally should not exceed 10% of the estimated in-river escapement (as determined to maintain population viability) unless river conditions preclude successful spawning.

Anticipated fish available for production in the hatchery from the small number of broodstock spawned in 2014 could begin returning in 2016. These fish will be genotyped or otherwise identified to determine their parentage. Depending on escapement numbers, these may be available for use as broodstock. Genetic analysis of these returns should provide information on what fish crosses and reintroduction strategies have been most successful, although the Conservation Facility should gather this data for several years before using it to guide reintroduction efforts.

The first potential large returns of fish, from the full-scale Conservation Facility production, will be in 2020, which should provide information to evaluate restoration success. Dec. 31, 2019, marks the conclusion of the "Reintroduction Period" as identified in the Technical Advisory Committee (TAC) recommendations. Following the TAC recommendations, the return target for 2019 will be 500 "wild" fish. If returns do not meet this target in 2019 or any year thereafter, monitoring data will be reviewed and restoration strategies and efforts will be assessed by the TAC, in consultation with the implementing agencies, to recommend refinements in management actions to improve returns.

January 1, 2020 marks the beginning of the "Interim Period" identified in the TAC Recommendations, which establishes a target minimum population size of 500 wild fish

returning annually throughout the Interim Period, ending December 31, 2024. TAC recommendations establish a 5-year running average target of 2,500 during the interim period.

As per the FMP Population Objectives, "Ten years following reintroduction, less than 15% of the Chinook salmon population should be of hatchery origin." The Settlement further states that a self-sustaining population should be established by 2024. If the population does not meet these targets, monitoring data will be reviewed and restoration strategies and efforts will be assessed by the TAC and the implementing agencies to recommend refinements in management actions to improve returns.

Under the Settlement Agreement, the hatchery should be phased out by 2025, unless required for years with abnormally low flows insufficient to support the salmon population. Hatchery use in the post 2025 period will be assessed annually by the Hatchery and Monitoring Technical Team.

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of hatchery or program.

This HGMP presents information on the San Joaquin River Salmon Conservation and Research Program and its hatchery (the Conservation Facility). The Program consists of two phases, an interim phase during construction of a full-scale facility and then a full-scale operational phase, commencing with the Conservation Facility's full-scale operation in 2014. See Appendix 1 for a year-by-year overview of the spring-run Chinook salmon program at the Conservation Facility.

1.2) Species and population (or stock) under propagation, and ESA status.

The Conservation Facility will propagate spring-run Chinook salmon, *Oncorhynchus tshawytscha*, as part of a reintroduction effort for the extirpated spring-run on the San Joaquin River. The reintroduced salmon, taken from one or more out-of-basin stocks, will be designated as an experimental San Joaquin River spring-run Chinook salmon population under FESA Section 10(j) and will have an associated FESA 4(d) take rule. The source populations are all part of the Central Valley spring-run Chinook salmon ESU, listed as threatened under both FESA and the California Endangered Species Act (CESA), and will be collected under a 10(a)1(A) enhancement of population permit.

1.3) Responsible organization and individuals

The Conservation Program will receive guidance and direction from a Hatchery and Monitoring Technical Team. The Technical Team will be composed of representatives from the Implementing agencies:

- United States Bureau of Reclamation (Reclamation)
- California Department of Fish and Game
- National Marine Fisheries Service
- United States Fish and Wildlife Service
- University of California, Davis (UC Davis)

Representation from each agency may change over time. In addition, the greater SJRRP receives additional assistance from the following agencies:

- California Department of Water Resources (DWR)
- United States Geological Survey (USGS)

Additional organizations will likely be involved in the restoration and reintroduction process. Level of involvement will depend on funding availability and permitting progress.

1.4) Funding source, staffing level, and annual hatchery program operational costs.

Short-term operational and equipment funding for the Interim Facility (Fall 2010 – Fall 2012), and capital funding for Conservation Facility construction (pending approval) will be from Proposition 84 California State Bond Funds (Safe Drinking Water, Water Quality and Supply, Flood Control, and River and Coastal Protection Bond Act of 2006), by CDFG as administered by the California Natural Resources Agency. Initial staffing for the Interim Facility will consist of one Environmental Scientist and one Fish and Wildlife Technician, plus additional assistance from part-time personnel. Short-term operational costs for the Interim Facility will range from $50,000-$150,000 annually with an estimated total cost of $500,000 time. Long-term operational and monitoring costs for the full-scale facility are summarized as follows:

Estimated Hatchery Operational Costs*	**Low Est.**	**High Est.**
Estimated Operation & Maintenance	$200,000	$300,000
Genetics Contract**	$50,000	$100,000
Hatchery Personnel Salaries (Annual)		
Senior Hatchery Supervisor (25%)	$12,478	$15,173
Senior Biologist Supervisor (100%)	$62,388	$75,300
or Fish Hatchery Manager 2 (100%)	$51,744	$62,868
Associate Biologist, Marine Fisheries	$55,596	$67,008
or Biologist, Marine Fisheries (100%)	$33,804	$50,196
Fish and Wildlife Technician (100%)	$34,608	$42,072
Office Technician (50%)	$16,116	$19,584
Total Hatchery Personnel Costs	$148,750	$219,137
Total Hatchery Operational Costs	**$398,750**	**$619,137**

Estimated Monitoring Costs*	**Low Est.**	**High Est.**
Estimated Operation & Maintenance	$50,000	$100,000
Monitoring Personnel Salaries (Annual)		
Senior Biologist Supervisor (25%)	$15,588	$18,813
Environmental Scientist (100%)	$36,924	$68,532
Environmental Scientist (100%)	$36,924	$68,532
Fish and Wildlife Technician (100%)	$34,608	$42,072
Total Monitoring Personnel Costs	$124,044	$197,949
Total Monitoring Costs	**$174,044**	**$297,949**

Total Hatchery and Monitoring Costs	**$572,794**	**$917,086**

*CDFG reimbursable overhead charge (≅ 20-21%) not included.

**Genetics Contract cost may vary depending on the extent and nature of genetic analysis and on the degree to which genetic monitoring costs are covered by ongoing non-program monitoring.

The need for cost sharing of long-term operational and monitoring funding is currently being explored between CDFG and the implementing agencies as operational and monitoring funds currently available to the State will be insufficient.

1.5) Location(s) of hatchery and associated facilities.

The Interim Facility and Conservation Facility will be located along the San Joaquin River (San Joaquin River Basin, river miles 265-266) adjacent to the CDFG's San Joaquin State Fish Hatchery in Friant, California (GPS 36° 59'11.57" N, 119° 43'02.11"W).

1.6) Type of program.

The Conservation Facility is an integrated recovery program.

1.7-1.8) Purpose (Goal) and Justification of program.

The Conservation Facility will produce spring-run Chinook salmon for reintroduction in the San Joaquin River to restore a self-sustaining San Joaquin River spring-run population.

The Settlement requires the reintroduction of spring-run Chinook salmon into the San Joaquin River. The Conservation Facility may only expect limited transfers from any Central Valley (CV) spring-run Chinook salmon population and will depend on artificial propagation using broodstock to attain sufficient fish numbers for reintroduction.

The goals established by the Settlement drive the development of measurable objectives designed to assure achievement of those goals. The settlement reads:

> [T]he Restoration Goal of this Settlement shall include the reintroduction of spring-run and fall-run Chinook salmon to the San Joaquin River between Friant Dam and the confluence with the Merced River by December 31, 2012, consistent with all applicable law.

Based on the settlement goals, the Restoration Administrator developed three population goals (Meade 2007), and the Fisheries Management Working Group (FMWG) developed two more. These five population goals are presented in the FMP, with the first four goals being relevant to management of the hatchery:

1. Establish natural populations of spring-run and/or fall-run Chinook salmon that are specifically adapted to conditions in the upper San Joaquin River. Allow natural selection to operate on the population to produce a strain that has its timing of upstream migration, spawning, outmigration, and physiological and behavioral characteristics

adapted to conditions in the San Joaquin River. In the case of spring-run Chinook salmon, the initial population would likely be established from Sacramento River Basin stock.

2. Establish populations of spring-run and/or fall-run Chinook salmon that are genetically diverse so they are not subject to the genetic problems of small populations, such as founder's effects, inbreeding, and the high risk of extinction from catastrophic events. The minimum population threshold established in the Settlement was set with this goal in mind and suggests genetic and population monitoring will be required.

3. Establish populations of spring-run and fall-run Chinook salmon that are demographically diverse in any given year, so returning adults represent more than two age classes. Given the vagaries of ocean conditions, the likelihood of extreme droughts, and other factors that can stochastically affect Chinook salmon numbers in any given year, resiliency of the populations requires that multiple cohorts be present. Chinook salmon populations in the Central Valley are dominated by 3-year-old fish, plus 2-year-old jacks, partly as the result of the effect of fisheries harvest [and hatchery mating practices]. Both population resiliency and genetic diversity require that 4-, 5-, and even 6-year-old Chinook salmon be part of the population each year.

4. Each population (spring-run, fall-run) should show no substantial signs of hybridizing with the other. In addition, each population (spring-run, fall-run) should show no substantial signs of genetic mixing with nontarget hatchery stocks.

The FMWG also developed the genetic management goals for the San Joaquin River Restoration Program (SJRRP) which are to:

> [P]romote and protect genetic diversity within the reestablishing populations while safeguarding against negative genetic effects to out-of-basin source and nontarget populations.
>
> Reestablish self-sustaining San Joaquin River spring- and fall-run salmon populations.

From these goals, the FMWG developed the FMP Population Objectives. Not all of the nine population objectives listed below are directly relevant to hatchery operations, but all are presented here to provide context. As noted in the FMP, the population goals should be treated as preliminary recommendations, subject to revision as the system and its capacity to support spring-run Chinook salmon is better understood. The hatchery program is a necessary component of achieving these goals, but river and ocean conditions will affect whether they can be achieved. The FMP Sections 3.2.1 - 3.2.2 provide a detailed justification for these objectives:

1. A 3-year target of a minimum of 2,500 naturally produced adult spring-run Chinook salmon and 2,500 naturally produced adult fall-run Chinook salmon (Table 1).

2. Each year, a minimum of 500 naturally produced adult spring-run and [500 naturally produced] adult fall-run Chinook salmon each should be in adequate health to spawn successfully. Thus, the minimum annual effective population target would be 500 adult Chinook salmon of each run. Note, the expectation is that there will be a 50:50 sex ratio.

3. Ten years following reintroduction, less than 15% of the Chinook salmon population should be of hatchery origin.

4. A Growth Population Target of 30,000 naturally produced adult spring-run Chinook salmon and 10,000 naturally produced fall-run Chinook salmon (Table 1.1).

5. Prespawn adult Chinook salmon mortality related to any disease should not exceed 15%.

6. Mean egg production per spring-run Chinook salmon female should be 4,200, and egg survival should be greater than or equal to 50%.

7. A minimum annual production target of 44,000 spring-run Chinook salmon juveniles and 63,000 fall-run Chinook salmon juveniles and maximum production target of 1,575,000 spring-run Chinook salmon juveniles and 750,000 fall-run juveniles migrating from the Restoration Area. Juvenile production includes fry, subyearling smolts, and age 1+ yearling smolts. Estimated survival rate from fry emergence until they migrate from the Restoration Area should be greater than or equal to 5%. Ten percent of juvenile production for spring-run Chinook salmon should consist of age 1+ yearling smolts.

Performance Period	Annual Average Target	Period of Average	Annual Max./Min.*	Source
N/A	833	3 years	none/500	Lindley et al. 2007
By Dec. 31, 2019	N/A	N/A	none/500	Meade 2007
Jan. 1, 2020 - Dec. 31, 2024	2,500	5 years	5000/500*	Meade 2007
Jan. 1, 2025 - Dec. 31, 2040	30,000	5 years	none*/500	Meade 2007
		Juveniles		
N/A	N/A	N/A	1,575,000/44,000**	Various

*Acknowledges annual fluctuations up to 50%.
**Derived from the annual average adult target of 833 (Lindley et al. 2007) and based on estimates of fecundity and life stage-specific survival.
Table 1.1. Potential Adult and Juvenile Restoration Targets for Chinook Salmon Populations in the San Joaquin River Restoration Area. Originally Table 3-1 in the FMP.

8. The incidence of highly virulent diseases should not exceed 10% in juvenile Chinook salmon.

9. A minimum growth rate of 0.4 grams per day (g/d) during spring and 0.07 g/d during summer should occur in juvenile Chinook salmon in the Restoration Area.

The Conservation Facility will generally embrace these goals and objectives, with a few exceptions. First, the fourth population goal presented in the FMP, that the spring-run and fall-run fish in the river should show no substantial signs of hybridizing with each other, will be effected by the likelihood of using Feather River spring-run Chinook salmon as a source population. The Feather River population is addressed in more detail in HGMP Sections 2 and 6, below. The Conservation Facility will instead seek to minimize the introgression between spring-run and fall-run fish through the use of a segregation weir and genetic analysis of all broodstock.

Second, the third FMP Population Objective, that less than 15% of the Chinook salmon population should be of Conservation Facility origin 10 years following reintroduction, should be measured from the beginning of releases from the full scale Conservation Facility in 2017; the Interim Facility will not be able to produce enough salmon to support the escapement necessary to meet this goal within 10 years of the beginning of the Interim Facility operation. Collections will be permitted beginning in 2012, and full-scale collections will begin with the completion of the full-scale facility in 2014. Those fish will be spawned beginning in 2017, with full-scale releases beginning that year. Those fish will not return in significant numbers until 2020, and thus wild production will probably not be very significant until then. By 2027, the fish from the first full-scale release will have spawned in the wild three times, and the population should be able to meet the 3rd FMP Population Objective.

Finally, FMP Population Objective 7 states that "Ten percent of juvenile production for spring-run Chinook salmon should consist of age 1+ yearling smolts," but the actual percent will depend on river conditions. This may not be possible to accomplish, if river conditions in a given year preclude release of fry or other ages of fish, or if the Conservation Facility has not yet reached full capacity. Releases will also be evaluated based on success, as established through the studies outlined in HGMP Section 12.

With the above exceptions, these goals and objectives drive the HGMP Objectives, Performance Standards, and Performance Indicators in HGMP Section 1.9, below.

1.9) List of program "Performance Standards" and program "Performance Indicators".

The objectives are the Conservation Facility goals, based on the FMP objectives and the NMFS recommendations for HGMP objectives (NMFS 2000, NPPC 2001). "Performance Standards" are designed to achieve the Program goal/purpose, and are measurable, realistic, and time specific. "Performance Indicators" determine the degree that program standards have been achieved and indicate the specific parameters to be monitored and evaluated. Some of these indicators are already measured and will continue to be measured as part of other ongoing programs; these indicators are marked as "*Ongoing Non-Program Monitoring*" in the list below. Data from the ongoing monitoring efforts will be gathered by the Hatchery and Monitoring

Technical Team and will be included in the Annual Reports, but the funding for these ongoing efforts is not included in the HGMP budget and will be met with resources provided by the Program.

In support of the FMP objectives and as funding becomes available, the Program will:

HGMP Objective 1. Select and collect broodstock from existing Central Valley spring-run Chinook source stock(s) for reintroduction that captures phenotypic and genotypic diversity of the source population. Collections in this manner are intended to produce an experimental population with the capability of producing a self-sustaining naturally reproducing population in the San Joaquin River restoration area, while minimizing impacts to wild source stocks. The populations or individuals (potentially including strayed fish as available) providing fish for artificial propagation in the Conservation Facility are termed the "source populations," and the fish collected and reared in the Conservation Facility for the purpose of hatchery spawning are termed "broodstock." This objective addresses protection of the source population; while some fish returning to the San Joaquin River may be integrated into the hatchery population, protection of this experimental population is covered in HGMP Objectives 2 and 3.

Standard 1.A. Source population(s) selected for use as broodstock are genetically diverse and either at low risk of extinction or have risk factors that would not be substantially increased by removal of fish for broodstock.

Indicator 1.A.i. Periodic viability and extinction risk analyses of extant Central Valley spring-run populations and evaluation of the indicators outlined by Allendorf et al. (1997), including effective population size, census size, and hatchery influence. *Ongoing Non-Program Monitoring*.

Indicator 1.A.ii. Periodic assessment of life history characteristics, genetic diversity, disease prevalence, hatchery influence, and transplantation history into and out of source river system. *Ongoing Non-Program Monitoring*.

Standard 1.B. Fish collected for broodstock provide a representative sample of the range of genetic diversity found in the source population(s).

Indicator 1.B.i. Comparison of broodstock genetic diversity with the diversity of the source population.

Indicator 1.B.ii. Broodstock contains representation of the genetic diversity found throughout the temporal and spatial distribution of the source populations. *Program and Ongoing Non-Program Monitoring.*

Indicator 1.B.iii. Temporal and spatial distribution of broodstock collection relative to the temporal and spatial distribution of the source population. *Ongoing Non-Program Monitoring.*

Standard 1.C. Stock selection decisions are adaptively managed through ongoing evaluation of the hatchery program.

Indicator 1.C.i. The success of progeny from each source population in the upper San Joaquin River, measured as a percentage of the escapement gene pool that each source is contributing.

Indicator 1.C.ii. The impact of broodstock collection on source populations (based on Standards 1.E-1.G). *Program and Ongoing Non-Program Monitoring.*

Indicator 1.C.iii. Program is guided by the Technical Team, meeting regularly, to review annual production numbers, newly restored habitat sites, results of previous reintroduction efforts, determination of direction of program into new sites and/or continued planting in current reintroduction areas, success of efforts, or other monitoring results. Technical Team incorporates requirements/mandates from NOAA Fisheries, and recommendations from the TAC, the FMWG, and the Hatchery Scientific Review Group (HSRG), as needed.

Standard 1.D. Broodstock collection does not significantly reduce the source populations' potential juvenile production in natural rearing areas.

Indicator 1.D.i. Number of individuals, by life history stage, of natural origin removed from source populations for broodstock, both in total and as a percentage of source population life history stage in question.

Indicator 1.D.ii. Number and origin of spawners migrating to natural spawning areas. *Ongoing Non-Program Monitoring*.

Indicator 1.D.iii. Broodstock collection is ended when Program broodstock goals are achieved.

Standard 1.E. Collection of broodstock does not adversely impact the genetic diversity of the naturally spawning source population.

Indicator 1.E.i. Based on estimated survival ratios of source population fish from the life history stage collected to adult escapement, reduction in effective population size attributable to broodstock collection.

Indicator 1.E.ii. Periodic (at least once every 4 years) genetic evaluations of the source populations' adult escapement from the time collections commence until three years after they cease.

Standard 1.F. Broodstock collection operation does not significantly alter spatial and temporal distribution of any naturally produced population.

Indicator 1.F.i. Total estimated escapement, obtained through existing monitoring programs, until four years after collections cease. *Ongoing Non-Program Monitoring.*

Indicator 1.F.ii. Spatial and temporal spawning distribution of natural population, currently and compared to historic distribution. *Ongoing Non-Program Monitoring.*

Standard 1.G. Mortality rates in weir/trap/collection operations do not exceed allowable limits.

Indicator 1.G.i. Mortality rates in traps.

Indicator 1.G.ii. Prespawn mortality rates of trapped fish in hatchery or after release.

Indicator 1.G.iii. Best management practices employed in collecting/handling fish/maintain equipment.

Indicator 1.G.iv. Traps are checked at least 2 times per day.

Indicator 1.G.v. Collection of eggs from redds occurs during the less sensitive eyed egg stage.

HGMP Objective 2. Conduct Conservation Facility operations to minimize domestication selection and to maximize effective population size in the broodstock (N_{eh}), experimental population (N_{ew}), and the combined population (N_{eh+w}) (Meade 2007, Meade 2008).

Standard 2.A. Breeding protocols for Conservation Facility operations maximize N_{eh} and, once the wild population is established, N_{ew} and N_{eh+w}.

Indicator 2.A.i. Effective population size and genetic diversity for the broodstock.

Indicator 2.A.ii. Use of genetically-defined breeding matrices to avoid matings between related individuals. Selected cut-off for relatedness coefficient will depend on the genetic characteristics of the collected broodstock and will be included in the Annual Report.

Indicator 2.A.iii. Once established, effective population size and genetic diversity of the combined hatchery and natural origin experimental population.

Standard 2.B. Reintroduction protocols should emphasize returns of adult spawners during the reintroduction and interim population phases (Meade 2007, 2008).

Indicator 2.B.i. Genetic pedigree analyses (PBT, per Anderson and Garza (2006), and other marking and tagging methods, as appropriate) and well-designed propagation experiments evaluating which reintroduction methods achieve the greatest success in returning adult spawners and in overall fitness.

Standard 2.C. Conservation hatchery approaches, as established in this HGMP, are used as appropriate throughout all stages of Conservation Facility operations.

Indicator 2.C.i. Compliance with this HGMP detailed in Annual Reports.

HGMP Objective 3. Establish a self-sustaining natural-born population of spring-run Chinook salmon.

Standard 3.A. The artificial propagation program contributes to an increasing number of spawners returning to natural spawning areas in the upper San Joaquin River.

Indicator 3.A.i. Annual number and percentage (pNOH) of hatchery-(HO) and natural-origin (NO) spawners on spawning grounds (actual count and moving geometric mean, including calculated age at return).

Indicator 3.A.ii. Spawner-recruit ratios.

Indicator 3.A.iii. Annual number of redds in selected natural production index areas (actual count and moving geometric mean).

Indicator 3.A.iv. Trends in percent natural-origin composition of spawning adults.

Indicator 3.A.v. Annual number of outmigrants, by origin (hatchery or wild).

Standard 3.B. Releases are 100% marked, allowing for statistically significant evaluation of program contribution to natural production and of effects of the program on the natural populations in the San Joaquin basin. Marks may include coded wire tags (CWT), PBT, passive integrated transponders (PIT), or other agency approved tag or mark.

Indicator 3.B.i. Marking rates and type of mark.

Indicator 3.B.ii. Number of marks and estimated total proportion of this population in juvenile dispersal areas, if possible (obtained through Delta monitoring efforts), and in adults on San Joaquin River spawning grounds.

Standard 3.C. Annual release numbers do not exceed estimated basin-wide and local habitat capacity, including spawning, freshwater rearing, migration corridor, and estuarine and near shore rearing.

Indicator 3.C.i. Carrying capacity criteria for available habitat in the project area, based on current and future monitoring programs.

Indicator 3.C.ii. Annual release numbers from all hatcheries in basin, including size and life-stage at release, and length of acclimation, by hatchery.

Indicator 3.C.iii. Correlation between releases (pulse flows, turbidity) and release location's influence on the survival, behavior and stray rates of hatchery salmon.

Indicator 3.C.iv. Migration behavior of hatchery origin salmon, compared to source populations and compared to the San Joaquin natural origin salmon, once established.

Indicator 3.C.v. Annual estimates of naturally produced juveniles present.

Indicator 3.C.vi. Level of development/smoltification of juveniles at release.

Indicator 3.C.vii. Number of eggs or juveniles placed in river.

Standard 3.D. Juveniles are released on-station, as river conditions permit, or, for offsite releases or releases of any direct-transfer fish, after sufficient acclimation to maximize homing ability to intended return locations.

Indicator 3.D.i. Annual release numbers from all programs in basin and subbasin, including size and life-stage at release,

release type, whether forced, volitional, or direct stream release, and length of acclimation, by program.

Indicator 3.D.ii. Location of releases and natural rearing areas.

Indicator 3.D.iii. For off-site releases, reason for off-site release.

Indicator 3.D.iv. Experimental program to evaluate effectiveness of various in-river release strategies. Specifically, experimental program should evaluate parameters such as type of release method (boat ramps, volitional, release chutes), release times (day vs. night), flow, and habitat type.

Indicator 3.D.v. Proportion of adult returns to program's intended return location, compared to returns to unintended areas.

HGMP Objective 4. Once the experimental population is established, minimize the influence of hatchery origin fish on wild fish in the experimental population, which includes progeny of repatriated, recolonizing, or returning spring-run Chinook salmon spawners, by maintaining a four-year mean Proportionate Natural Influence (PNI) above 0.67, in keeping with HSRG recommendations (HSRG 2007). PNI is the proportion natural origin spawners in broodstock (pNOB) divided by the sum of the proportion effective hatchery origin spawners on spawning grounds (pHOS) and pNOB (HSRG 2007).

Note on the use of HSRG recommendations in a reintroduction.

The HSRG has produced guidelines for integrated hatcheries, with the goal of ensuring that natural selection outweighs domestication selection while a population is augmented by hatchery production. The HSRG has not explicitly considered the unique problems presented in a reintroduction effort and does not have explicit goals for such programs. While the HSRG recommendations would apply to a reintroduction after a wild population has been established, the recommendations are not appropriate for the early years of a reintroduction and should not be the goals for the initial stages of such efforts. The Program's goals, during the Reintroduction Period (2012-2020) and Interim Period (2020-2025), are different for two primary reasons. First, the HSRG work is predicated on the existence of natural population, and there is no natural population in the Restoration Area. A natural population must be established by the hatchery before the HSRG recommendations can be used to evaluate hatchery practices, because. Second, in a reintroduction, it is desirable that the genetics of the broodstock dominate for the first 4 to 8 years, to avoid founder effects and to ensure that as much diversity as possible is captured from the source populations (Fraser et al. 2008), before natural selection becomes the primary selective force. This contrasts with a typical hatchery situation, where the HSRG recommendations seek to minimize the hatchery influence on the natural population. After a natural origin population is established and begins adapting to the new river system, the HSRG recommendations will become applicable to the Program. The timing of the applicability of the HSRG recommendations will depend on the success of the reintroduction effort, but will almost certainly be applicable after the Interim Period and may be applicable at the middle or end of the

Reintroduction Period. The Hatchery and Monitoring Technical Team will evaluate the appropriateness of the HSRG recommendations annually, reporting their findings in the Annual Report. Moreover, the Technical Team will consider any recommendations from the upcoming California HSRG recommendations for implementation, as appropriate.

Standard 4.A. Release groups are sufficiently marked in a manner consistent with information needs and protocols to enable determination of impacts to natural- and hatchery-origin fish in fisheries.

Indicator 4.A.i. Marking rate by mark type for each release group.

Indicator 4.A.ii. Number of marks of this program observed in any fishery samples, including available information from river and ocean catches. *Ongoing Non-Program Monitoring.*

Indicator 4.A.iii. Evaluation of hatchery contribution to the census size of returning upper San Joaquin River Chinook salmon populations based on physical marks, genetic assignment tests, or otolith analysis, as appropriate.

Standard 4.B. After the interim population phase, life history characteristics of the natural population are not controlled by hatchery production but are allowed to adapt to the conditions in the restored San Joaquin. Four-year mean PNI is above 0.67 after Interim Period.

Indicator 4.B.i. Assessment of adaptation of successive generations of naturally spawning fish to conditions in the San Joaquin River to determine performance of the experimental population. This will be done via development of a monitoring program that will collect biological data and samples. Biological data will be collected from monitoring of multiple life history stages and characteristics. Data to be collected in the experimental population may include:

- Juvenile dispersal/outmigration timing
- Juvenile size at outmigration, and outmigration age composition
- Adult return timing
- Adult return age and sex composition
- Adult size at return
- Spawn timing and distribution
- Fry emergence timing
- Juvenile rearing densities, distribution, and behaviors

- Juvenile growth rate, condition factors, and survival at several growth stages prior to final release
- Diet composition and availability
- Adult physical characteristics (length, weight, condition factors)
- Fecundity and egg size
- Spawning behavior and success

Indicator 4.B.ii. Annual genetic analyses indicate natural- and hatchery-origin fish are genetically similar.

Indicator 4.B.iii. Periodic and four-year mean PNI, pNOS, and pNOB.

Standard 4.C. Hatchery produced adults in natural production areas do not exceed appropriate proportion of the total natural spawning population. The appropriate portion will vary based on the phase of reintroduction and the performance of the program, with interim targets established by the Technical Team, but the four-year average pHOS should be trending down, beginning in 2020. Per TAC recommendations, in 2027 four-year man pHOS is less than 15%. Origin of adults will be based on physical marks, genetic analysis, otolith analysis and/or mark status of a representative sample of the population.

Indicator 4.C.i. Extent of distribution of known hatchery fish spawning on selected (Reach 1A) natural spawning grounds.

Indicator 4.C.ii. Observed and estimated total numbers of naturally produced and known artificially produced adults passing a counting station (if present) close to natural spawning areas, if available.

Indicator 4.C.iii. Proportion of hatchery origin adults in natural spawning areas.

HGMP Objective 5. Conservation Facility is operated in compliance with CDFG fish health policies and guidelines, and releases do not introduce pathogens not already existing in the local populations and do not significantly increase the levels of existing pathogens. Survival rates of 85-90% from egg to fry stages, 75% or better from egg to smolt, and 50% or better survival from smolt to adult are achieved (Pollard and Flagg 2004).

Indicator 5.A.i. Number of broodstock sampled for pathogens. Types and frequencies of observed infections.

Indicator 5.A.ii. Rearing survival rates: 1) egg to fry; and, 2) fry to juvenile fish released, both by family group and in population as a whole.

Indicator 5.A.iii. Results of fish health examinations.

Indicator 5.A.iv. Number of juveniles sampled and pathogens observed immediately prior to release.

Indicator 5.A.v. Evaluation of juvenile fish health immediately prior to release, including pathogens present and their virulence.

Indicator 5.A.vi. Juvenile densities during artificial rearing.

Indicator 5.A.vii. Samples of natural populations for disease occurrence before and after artificial production releases.

Standard 5.B. Any distribution of carcasses or other products for nutrient enhancement is accomplished in compliance with appropriate disease control regulations and guidelines, including state, tribal, and federal carcass distribution guidelines.

Indicator 5.B.i. Number and location(s) of carcasses or other products distributed for nutrient enrichment.

Indicator 5.B.ii. Statement of compliance with applicable regulations and guidelines.

HGMP Objective 6. Maintain or further isolate the genetic and phenotypic characteristics of the experimental population spring-run Chinook salmon.

Standard 6.A. River and Conservation Facility management emphasize segregation of fall- and spring-run spawning.

Indicator 6.A.i. Report describing evaluation of carrying capacity of the San Joaquin River to support self-sustaining in-river spawning spring- and fall-run Chinook populations. This should address placement of a segregation weir, egg-taking stations, and future changes to production that may be necessary to improve broodstock management practices.

Indicator 6.A.ii. Presents of barriers or adaptation of river flow management or other methods to provide a mosaic of habitats for survival of fish from both ESUs and segregation of natural spawning grounds.

Indicator 6.A.iii. Employment of marking and/or tagging techniques for Conservation Facility produced salmon that allow distinction between fall- and spring-run fish, and distinction from other CV hatchery fish.

Indicator 6.A.iv. Management release strategies that would encourage homing to the upper watershed and discourage straying into lower watershed tributaries.

Standard 6.B. Genetic analyses of experimental San Joaquin River spring-run Chinook salmon do not show increasing levels of introgression with fall-run Chinook.

Indicator 6.B.i. Genetic analysis of San Joaquin River Chinook salmon population status conducted periodically, to evaluate the degree of hybridization between spring- and fall-run salmon on multiple spatial and temporal scales.

Standard 6.C. San Joaquin River spring-run Chinook salmon show an array of life history strategies similar to those found in the source populations, as appropriate to the transplant environment.

Indicator 6.C.i. Documentation that source population phenotypes and life histories are represented in broodstock used for reestablishment, unless those life histories are incompatible with the restored San Joaquin River conditions.

Indicator 6.C.ii. Multiple strategies used during spawner and early life history stages to favor reestablishing diverse spring-run Chinook salmon populations.

Indicator 6.C.iii. Temporal and spatial distribution of broodstock collection compared to source populations. *Ongoing Non-Program Monitoring*.

Indicator 6.C.iv. Lifestage composition of broodstock collected.

HGMP Objective 7. Phase out Conservation Facility operations based on an adaptive management approach and achievement of restoration objectives.

Standard 7.A. Beginning in 2020, hatchery proportion of the total natural spawning population is declining measured by a four-year moving average, expressed as pHOS. pHOS is less than 15% in 2027.

Indicator 7.A.i. Observed and estimated total numbers, and the ratio, of naturally produced and artificially produced adults, estimated per HGMP Standard 4.C.

Indicator 7.A.ii. Proportion of hatchery origin fish carcasses on natural spawning areas.

Standard 7.B. Quantitative natural population targets (e.g. N_e, census size, genetic diversity) and other community and ecosystem indicators of reintroduction success are derived and periodically evaluated to determine the schedule for phase out of Conservation Facility production.

Indicator 7.B.i. Natural portion of San Joaquin River spring-run Chinook salmon population evaluated annually against restoration targets in HGMP Table 1.1.

Indicator 7.B.ii. Reductions in hatchery production are made based on achievement of goals in HGMP Table 1.1, allowing for annual variation of up to 50% from the goals to accommodate natural fluctuation, per the FMP.

Indicator 7.B.iii. Hatchery production needs are evaluated annually against estimated natural production.

Indicator 7.B.iv. Natural population's long-term viability is assessed annually.

HGMP Objective 8. Meet all applicable legal requirements.

Standard 8.A. Program addresses FESA and CESA responsibilities.

Indicator 8.A.i. FESA consultation(s) under Section 7 and 10 of the ESA have been completed and NMFS has approved this associated HGMP by April 30, 2012.

Indicator 8.A.ii. CESA consultations and permitting completed by April 30, 2012 as necessary.

Standard 8.B. The artificial propagation program is monitored and evaluated on an appropriate schedule and scale to address progress toward achieving the restoration goals and effects on natural populations.

Indicator 8.B.i. Monitoring and evaluation framework including detailed time line.

Indicator 8.B.ii. Annual and final reports reporting on all indicators.

Standard 8.C. Effluent from artificial production facility will not detrimentally affect natural populations.

Indicator 8.C.i. Reported dates, locations and number of water samples collected.

Indicator 8.C.ii. Samples analyzed and results reported.

Indicator 8.C.iii. Effluent water quality compared to the hatcheries current National Pollutant Discharge Elimination System (NPDES) permit.

Standard 8.D. Water withdrawals and water diversion structures for artificial production facility operation will not prevent access to natural spawning areas, affect spawning behavior of natural populations, or impact juvenile rearing environment. If water is taken directly from Friant Dam, as planned, Indicators 7.D.ii. – iii will not apply.

Indicator 8.D.i. Water withdrawals and impacts on instream flow.

Indicator 8.D.ii. Number of adult fish aggregating and/or spawning immediately below water intake point.

Indicator 8.D.iii. Number of adult fish passing water intake point.

Indicator 8.D.iv. Proportion of diversion of total stream flow between intake and outfall.

Standard 8.E. Data on Conservation Facility operations will be collected, reviewed and reported in a consistent and scientifically rigorous manner, and in a manner consistent with reporting requirements specified in this HGMP.

Indicator 8.E.i. Annual reports are produced, reviewed, and finalized by August each year. For example, annual report for 2011-2012 season is due by August 2012.

Indicator 8.E.ii. Reports are available for public review on the SJRRP website.

Indicator 8.E.iii. Reports and, if requested, all raw data are distributed in electronic or hard copy to all participating state and federal agencies.

HGMP Objective 9. Conduct effective public outreach on the San Joaquin restoration generally and on Conservation Facility's role in the reintroduction of the spring-run Chinook salmon.

Standard 9.A. Conservation Facility personnel are available to lead public tours during appropriate, specified days/hours, with limited fish/human contact.

Indicator 9.A.i. Hours and dates for public tours.

Indicator 9.A.ii. Public outreach is managed to avoid conflict with the Conservation Facilities primary duties.

Standard 9.B. The Program provides educational materials on San Joaquin River restoration generally and on the Conservation Facility's role in the reintroduction of the spring-run Chinook salmon.

Indicator 9.B.i. Examples of educational materials are appended to the Annual Report.

Indicator 9.B.ii. Amount of material distributed and to whom.

1.10) Expected size of program.

1.10.1) Proposed annual broodstock collection level (maximum number of adult fish).

Broodstock will be collected from up to three spring-run Chinook salmon stocks (Feather River, Butte Creek, and Deer/Mill Creek Complex), primarily as eggs or juveniles, and reared to maturity. It is unlikely that adult fish will be used due to their limited availability and the difficulty in capturing, transporting and holding adult spring-run Chinook salmon, although salvaged fish and some adults from the Feather River Hatchery (FRH) may be used. If the opportunity arises, the program may use adult fish for the collection of gametes, broodstock spawning, or collection and transfer (if wild) and release into the river for natural spawning.

The quantity of donor broodstock removed from each population/complex will be based on several factors related to population viability and extinction risk, including the number of returning adults, the genetic diversity of each population, the ability to collect sufficient numbers of unrelated fish and the anticipated loss of fish reared to adulthood. In the short term, the goal of the program will be to collect sufficient numbers of broodstock fish to provide a minimum of 50 relatively unrelated gravid adult females and an equal number of fertile males, from all stocks combined. These 100 fish, collected from the wild, will be the first broodstock reared in the interim facility, and their offspring will be released to the San Joaquin River. See Table 1.2. The long-term goal of the full-scale Conservation Facility will be to propagate sufficient numbers of broodstock to provide a minimum of 50 and a maximum of 150 relatively unrelated gravid adult females and an equal number of fertile males from each source population, per year, for a minimum of four to eight years. Based solely on genetic considerations for the experimental population, 150 unrelated gravid adult females and an equal number of fertile males from each population per year for four years would provide a better representation of the genetic diversity in the source populations. The rational for these figures is explained in HGMP Section 6. The actual number of fish collected each year will depend on permitting. If the larger numbers of fish cannot be obtained, the program will require a longer duration to ensure capture of significant diversity from each population. Ultimately, however, the maximum allowable yearly collection from each of the source populations will be based on each stock's viability and the NMFS permitting decisions.

See Appendix 3 for conservation facility mid-range annual inventory projections.

Table 1.2 Anticipated assemblage to meet genetic and Conservation Program goals

Collection Source	Targeted Life Stage	Activity	Total Collection	Years
Butte, Deer and Mill creeks and Feather River Hatchery	Eggs or Juveniles	Conservation Facility	600	1-3
Butte, Deer and Mill creeks and Feather River Hatchery	Eggs or Juveniles	Conservation Facility	2,700	4-8
Butte, Deer and Mill creeks and Feather River Hatchery	Eggs, fry, or parr-smolts	Translocation to SJR	250,000a eggs, 100,000b fry or 4,000c parr-smolts	1-8
Butte, Deer and Mill creeks and Feather River Hatchery	Adults	Translocation to SJR	75 pairs	1-8
Other Central Valley Rivers	Adult Spring-running others	Translocation to SJR	opportunistic	1-8
All Central Valley Rivers	Adults	Remote site-egg take	50 pairs	1-8
Delta collection (trawls and salvage)	Juveniles	Conservation Facility	600	1-8

aAssumes a 40% survival rate from egg-to-fry, 4% from fry-to-smolt, and 2.5% from smolt-to-adult to produce 100 returning adults.
bAssumes a 4% survival rate from fry-to-smolt, and 2.5% from smolt-to-adult to produce 100 returning adults.
cAssumes a 2.5% survival rate from smolt-to-adult to produce 100 returning adults.

1.10.2) Proposed annual fish release levels (maximum number) by life stage and location.

Release levels will be determined at the time of release, based on river conditions and the restoration progress; release levels will not exceed the river's carrying capacity, after accounting for any natural production. FMP Population Objective 7 states that "Ten percent of juvenile production for spring-run Chinook salmon should consist of age 1+ yearling smolts," but the actual percent will depend on river conditions. The carrying capacity will be established as part of the river conditions monitoring, described in HGMP Section 11. If, based on initial calculations, the carrying capacity is determined to be significantly higher than anticipated natural and hatchery production, carrying capacity may not be calculated annually. Appendix 1 provides a range of possible release levels, by year. HGMP Section 10 provide additional details on the methods to be used for release.

1.11) Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.

There are no current data for these measures, because the Conservation Facility has not yet begun operations.

Though survival rates vary from program to program, the Conservation Facility will seek to achieve 85-90% survival from egg to fry stages and 75% or better survival from egg to smolt stages over the duration of the program and a 50% or better survival from smolt to adult (Pollard and Flagg 2004).

1.12) Date program started (years in operation), or is expected to start.

In keeping with the settlement agreement, reintroduction of spring-run Chinook salmon will commence by Dec. 31, 2012. The Interim Facility will rear spring-run Chinook from 2012 – 2014, and the full-scale facility will begin operations in 2014, pending budgeting. The first full-scale releases will occur in 2017 to 2018, depending on the method of reintroduction and the age of the introduced fish.

1.13) Expected duration of program.

The duration of the Program will depend on the Program's success in establishing a self-sustaining population of spring-run Chinook salmon in the San Joaquin River. Ten years following releases from the full-scale facility in 2017, the goal is that less than 15% of the Chinook salmon population should be of hatchery origin.

Dec. 31, 2019 marks the conclusion of the Reintroduction period identified in the TAC recommendations. The return target for 2019 should be 500 wild fish, and if returns do not meet this target in 2019 or any year thereafter, monitoring data will be reviewed and restoration strategies and efforts assessed by the TAC in consultation with the implementing agencies to recommend refinements in management actions to improve returns.

Jan. 1, 2020 marks the beginning of the Interim period identified in the TAC recommendations. The minimum population size should be 500 wild fish returning throughout the Interim period, through Dec. 31, 2024. During the interim period, the 5-year running average target is 2,500, per TAC recommendations. Based on projected broodstock collections, the first larger returns of fish, from the full-scale Conservation Facility, should be in 2020. The 2020 escapement should provide information on the ability of the river and ocean to support the run at that time.

Per the FMP Population Objectives, "Ten years following reintroduction, less than 15% of the Chinook salmon population should be of hatchery origin," and the Settlement agreement states that a self-sustaining population should be established by 2024, per the settlement agreement. If the population does not meet these targets, monitoring data should be reviewed and restoration strategies and efforts should be assessed by the TAC in consultation with the implementing agencies to recommend refinements in management actions to improve returns.

The Settlement Agreement provides a deadline of December 31, 2024 for re-establishment of a self-sustaining spring-run Chinook salmon population. When natural production consistently meets the restoration targets outlined in HGMP Table 1.1, anticipated to by 2025, hatchery production should be suspended. Additional production may be required in years of very low escapement.

1.14) Watersheds targeted by program.

Middle San Joaquin-Lower Chowchilla Watershed, USGS Unit: 18040001.

1.15) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

A primary goal of the SJRRP, mandated by the Settlement, is restoration of a naturally reproducing and self-sustaining population of spring-run Chinook salmon in the San Joaquin River. The FMWG and genetic subgroup (GSG) have evaluated potential source populations and reintroduction strategies. Since all source populations are considered 'threatened' under FESA and CESA, the FMWG and GSG recommendations are aimed at minimizing the risks to these stocks while meeting the Settlement.

Because all local stocks of spring-run Chinook salmon have been extirpated from the Southern CV, and because there have not been consistent natural runs of salmon in the upper San Joaquin River for almost 60 years, natural recolonization is unlikely to achieve the program goals. Moreover, natural recolonization would likely lead to low genetic diversity and bottleneck effects that would undermine a new population's ability to adapt to the San Joaquin River. Managed reintroduction of fish from selected source populations can promote genetic diversity and ensure the genetic integrity of the reintroduced fish. Artificial propagation in a Conservation Facility can allow for significantly higher survivorship (higher progeny to parent ratios) than is experienced in the wild, thereby amplifying the number of individuals released into the San Joaquin River while maintaining the genetic characteristics similar to the source population.

Alternative actions that have been considered include direct transfer and reintroduction of wild eggs, juveniles, and/or adults from founding stock to San Joaquin River. These actions would be limited in number by availability of threatened CV spring-run stocks and the expected high mortality during collection, transfer, and direct planting. Direct wild egg or fish transfers are not being proposed as the primary reintroduction method because they are higher risk, higher effort, and less likely to meet the restoration objectives due to the limited availability of source fish. In order to grow a population to the size necessary for a successful near-term reintroduction goal (e.g., 500-2,500 adults), the Program needs to initially introduce 200,000-1,120,000 juveniles; see the FMP for calculation details. Collecting this number of juveniles from the threatened source populations would be infeasible and probably not allowed by the 10(a)1(A) permit from NMFS, due to impacts to source populations.

SECTION 2. PROGRAM EFFECTS ON NMFS ESA-LISTED SALMONID POPULATIONS.

2.1) List all ESA permits or authorizations in hand for the hatchery program.

The Conservation Facility should obtain a 10(a)1(A) enhancement of population permit for taking source broodstock by 2012. The subsequent released population will be designated as an experimental population under section 10(j) of the FESA. The Conservation Facility operations will be authorized under the 4(d) regulations that will be promulgated for the experimental population. NMFS is tasked with providing all permitting decisions and population designations by April 30, 2012.

2.2) Provide descriptions, status, and projected take actions and levels for NMFS ESA-listed natural populations in the target area.

There are no ESA-listed fish populations in the target area at this time. The Conservation Facility is reintroducing an experimental San Joaquin River population of the listed spring-run Chinook salmon. The broodstock will come from listed populations outside of the restoration area.

2.2.1) Description of NMFS ESA-listed salmonid population(s) affected by the program.

Table 2.1 provides an overview of available life history data for the ESA-listed potential source populations.

2.2.1.a) NMFS ESA-listed population(s) that will be directly affected by the program.

Up to four NMFS ESA-listed populations will be directly affected by the program. The three potential source populations that will be directly affected are the three largest stocks of spring-run Chinook salmon in the Central Valley: the Feather River, Butte Creek, and Deer/Mill Creek Complex stocks. This section provides some background on these populations and then presents spatial distribution information based on data from the Stock Selection Strategy attachment to the FMP. Please see that document for more detailed information. Section 6, Broodstock Origin and Identity, compares the stocks and discusses the final selection of broodstock for this hatchery. Indirect effects, including increased competition and other interactions with listed fish during outmigration and ocean rearing, are discussed in HGMP Section 3.

The fourth population that will be affected is the experimental San Joaquin River spring-run Chinook salmon population that will result from the Program. Because this stock does not yet exist, no detailed review is possible at this time. Information on the experimental San Joaquin River spring-run Chinook salmon, including population size, adult age class structure, sex ratio, size range, migration timing, spawning range, spawn timing, juvenile life history strategies, and spatial and temporal distribution relative to hatchery fish release locations, will be

developed as a part of the ongoing monitoring and research identified in the standards and indicators and throughout this HGMP.

Life History Characteristics	Feather River		Butte Creek		Deer/Mill Creeks	
Adult Run Timing	April - May		February – June, peaking in mid-April.		March – early July	
Spawning Timing	September		Late-September to early-November, peaking in early-October .		September	
Spawning adult age class structure*	Age 2	10.9%	Age 2	0%	Age 2	Unknown
	Age 3	46.9%	Age 3	53%	Age 3	Unknown
	Age 4	41.2%	Age 4	47%	Age 4	Unknown
	Age 5	0.68%	Age 5	0%	Age 5	Unknown
Sex Ratio (M:F)**	1.2:1		1:1.18		Unknown	
Size Range (FL)	Females**** - 782 mm Males**** - 829 mm		Females*** - 762 mm. Males*** - 793 mm.		410 mm to 1002 mm with the majority 600-800 mm.	
Outmigration Timing (all three population show two primary life histories for young, fry emigrating within weeks of emergence and juveniles remaining in the river for roughly one year before emigrating)	Emergence: Nov. – Apr., peaking in Jan. Outmigration of yearlings: Unk. Outmigration of fry: Dec. – June, peaking Feb. to Apr.		Emergence: Nov. – Apr., peaking in Jan. Outmigration of yearlings to the Delta: Nov. – Apr. Initial outmigration of fry to Sutter Bypass – Nov. to Feb. Final outmigration of fry from Sutter Bypass to the Sac. River and Delta – Feb. to May.		Emergence: Nov.- Apr. peaking around Feb. Outmigration of yearlings: Oct. – Apr. Outmigration of fry: Feb. – June	
Straying Rate	High		Unknown		Unknown	

* Feather River data are average percent by age of spring-run and fall spawning run returning to hatchery, 2000-2004. Butte Creek data based on tag recoveries in 2007, although age varied widely in the Butte Creek population. Age 3 fish were a much higher percentage in 2002, '02, '04, and '05, and Age 4 were much higher in 2003 and 2006. 2007 data based on scale aging for all fish, including untagged fish suggested a much higher percentage of age 3 returns for both the Feather River and Butte Creek, at 68% and 72%, respectively (Grover and Kormos 2007).
** Feather River data are averaged from 1997 through 2007. Butte Creek data averaged 2001-2006, from carcass surveys.
*** 2001-2007 Averages.
**** Based on 2006-2008 spring-run broodstock (pers. comm. Ryon Kurth, CA DWR).

Table 2.1. General Life History Characteristics for Feather River, Butte Creek, and Deer/Mill Creek spring-run Chinook salmon Populations

(a) Feather River Stock

Background Information

The Feather River spring-run are difficult to characterize as an entity. First, the Feather River spring-run stock consists of both hatchery-spawned and naturally spawned salmon, and there is a general lack of data on the naturally spawned portion of the population. Second, it is not a historical entity, in that the population of spring-running Feather River fish only began

spawning below the dam as a single population after construction of the Thermalito Dam in 1968 (Lindley et al. 2004). Third, the Feather River spring-run has significant historical and ongoing hybridization with fall-run Chinook, although the Feather River Hatchery (FRH) is taking steps to create a more genetically isolated spring-run. Genetic analysis suggests that the remaining spring-run fish are heavily introgressed with fall-run genes (Garza et al. 2008), to the point that it is called a genetically fall-run fish (Id.). Given that the Feather River spring-run Chinook salmon are not genotypically distinguishable as a spring-run fish in the same way that Butte and Mill/Deer salmon are, it may more accurately be described as a spring-running fish, not necessarily a spring-run Chinook salmon. However:

> the FRH "spring-run" run retains remnants of the phenotype and ancestry of the Feather River spring-run [and] it may be possible to preserve some additional component of the ancestral Central Valley spring-run genomic variation through careful management of this stock that can contribute to the recovery of the ESA-listed Central Valley spring-run ESU, although it will not be possible to reconstitute a "pure" spring-run stock from these fish [Garza et al. 2008].

For this reason, the FRH spring-run Chinook salmon may be included as a broodstock and are therefore included in this discussion of NMFS listed stocks directly impacted by the Conservation Facility program. It is considered part of the listed Central Valley spring-run Chinook ESU.

Understanding the nature of the Feather River spring-run requires some background information on the hatchery portion of the population, reviewed in detail in the FRH Draft HGMP (Cavallo et al. 2009). The hatchery broodstock for Feather River spring-running salmon consists of fish from up to two sources.

First, the FRH fish ladder is opened from April through June, and all fish entering the fish ladder during this period are marked with two individually numbered Hallprint external tags and then returned to the Feather River. The ladder is closed from the end of June and then reopened around September 15. This practice, opening the ladder during the spring-run period and marking the fish that enter, began in 2004 (Cavallo et al. 2009); prior to that time, the hatchery did not have a dependable method of parsing early spring arrivals ("spring-run") from those arriving during the latter fall run period ("fall-run fish").

Fish entering the ladder with the tags indicating that they first entered the ladder during the open April to June period are the primary source of fish for the FRH spring-run Chinook salmon program and make up the majority of the spring-running broodstock. Other fish entering the ladder from September on are all considered fall-run and are used for the fall-run broodstock, regardless of their actual parentage or time of entry into the river. The only exception to this practice occurs when marked spring-run fish are insufficient to meet required spring-run production.

In such a case, when an insufficient number of spring-run tagged fish enter in the fall, the FRH integrates a second set of fish into the spring-run broodstock. These fish, identified by coded wire tag as individuals whose parents expressed the spring-run phenotype, are identified among the fish entering the ladder in the fall that do not bear the Hallprint external tags indicating that they entered the hatchery in the spring. While these fish do have spring-running parents, it is unknown if these fish are phenotypically spring-run because they did not enter the ladder in the spring-run. Offspring of spring-running parents return in the fall run at high rates (CDFG 1998, Lindley et al. 2004). Between 2004 and 2007, an average of 82.4% of offspring from spring-running fish and 49.1% of fall-run offspring were correctly identified based on run timing (Cavallo et al. 2009). The hatchery is planning to adjust the ladder operations in the fall to better separate spring-run offspring from fall-run fish, beginning in Fall 2010 (pers. comm. Ryon Kurth, California Department of Water Resources).

To recapitulate, the spring-run broodstock in the FRH consists primarily of fish that exhibited the spring-running phenotype and entered the fish ladder between April and June. When this source is insufficient to meet broodstock demand, the FRH also includes fish identified as having spring-running parents, although the actual run timing of these fish is unknown.

The level of mixing between spring-run- and fall-run fish in the naturally spawning portion of the population is unknown, although the genetic analysis indicates significant introgression in the past. The impact of the new hatchery practices, designed to protect and enhance the spring-running phenotype, is as yet unknown.

Spatial Distribution

Feather River Chinook migrate until they reach the Fish Barrier Dam, 1 kilometer below Oroville Dam. Adults begin holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April (CA DWR 2007, NMFS 2009). See watershed map in Figure 2.A. Natural spawning occurs in the river from late September to late October (Reynolds et al.1993, Yoshiyama 2001), from the Fish Barrier Dam downstream approximately 8 miles to the Thermalito Afterbay Outlet (NMFS 2009). Approximately two-thirds of natural Chinook salmon spawning in the Feather River occurs in the Low Flow Channel (LFC) between the Fish Barrier Dam and the Thermalito Afterbay Outlet (NMFS 2009), with the greatest portion crowded in the upper three miles of the LFC (Sommer et al. 2001). The remaining spawning occurs between the Thermalito Afterbay Outlet and Honcut Creek (RM 59 to 44) (CA DWR 2007).

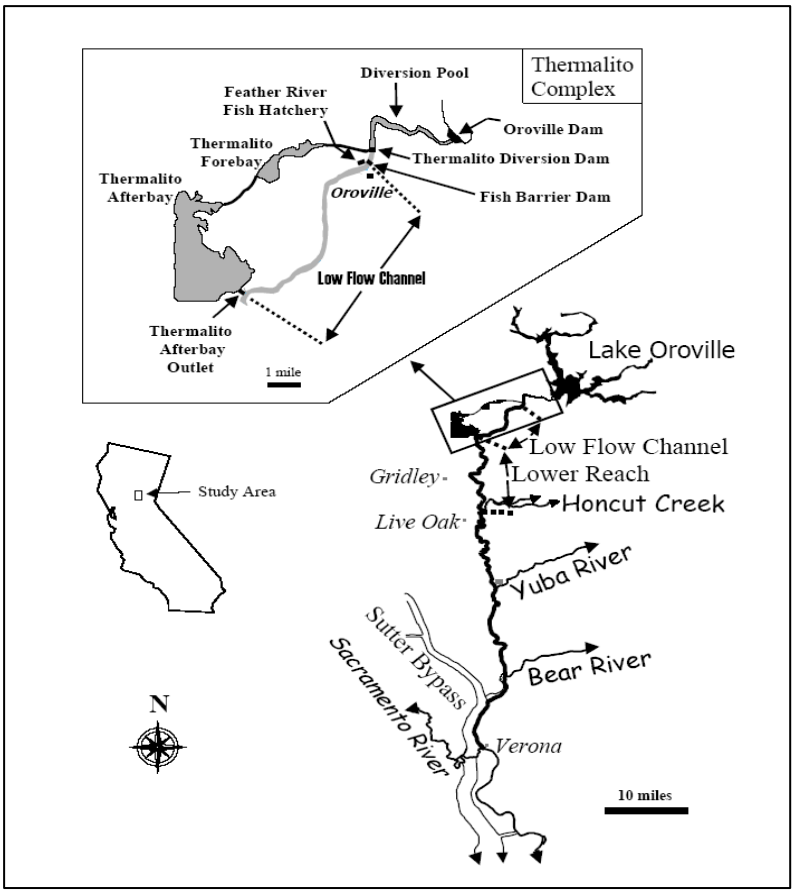

Figure 2.A. Feather River below Lake Oroville.

There are two primary life history patterns for offspring. Most juveniles outmigrate as fry (DWR unpublished data), but some juveniles hold over the summer in deep pools within the LFC five miles below Oroville Dam and the downstream Thermalito Afterbay Outlet (Reynolds et al. 1993, Yoshiyama 2001). The primary rearing location(s) is unknown, although in wetter years it appears that many young salmon rear for weeks to months in the Yolo Bypass floodplain immediately downstream of the Feather River before migrating to the estuary (Sommer et al. 2001).

(b) Butte Creek Stock

Background Information

The Butte Creek stock is a genetically distinct and independent population of spring-run Chinook salmon in the Central Valley (NMFS 2009). See watershed map in Figure 2.B. Genetic analysis of the Butte Creek population shows no hatchery influence, in spite of the addition of 200,000 juvenile Feather River spring-run Chinook salmon hatchery fish in 1986 to supplement low returns (Garza et al. 2008, Moyle et al. 2008). Based on the analysis thus far, the planted fish appear to have made no significant genetic contribution to the natural Butte Creek population. Aside from the 1986 planting, Butte Creek has not been planted with hatchery fish, and surveys consistently fail to detect significant straying into Butte Creek from other populations (McReynolds and Garman 2008). Small numbers of fall-run, late fall-run, and/or winter run fish may also spawn annually in Butte Creek, although no introgression has been found with these other runs.

Spatial Distribution

Adults migrate up Butte Creek to holding pools in two primary locations, within the upper most 3 miles nearest Quartz Pool and directly below the Centerville Powerhouse. From 2001-2005, approximately 61% of the fish held above the Centerville Powerhouse and 39% held below it (Ward et al. 2007). The best spawning habitat for the spring-run Chinook salmon is within an approximately 11-mile stretch of the river, from Quartz Pool downstream to the Centerville Covered Bridge (Ward et al. 2007). The highest quality and quantity spawning gravel (approximately 82%) is within the first 5 miles directly below the Centerville Powerhouse (Ward et al. 2007). During the 5-year period 2001-2005 approximately 48% of the fish spawned above the Centerville Powerhouse and 52% below.

Butte Creek spring-run young follow two general life history patterns. First, Butte Creek spring-run Chinook salmon generally outmigrate as fry from November through February, and rear below the Parrott-Phelan Diversion Dam. The Sutter Bypass offers the highest quality and quantity of juvenile rearing habitat for Butte Creek spring-run Chinook salmon, and most juveniles rear there from February through May. In May, juveniles move to the Delta.

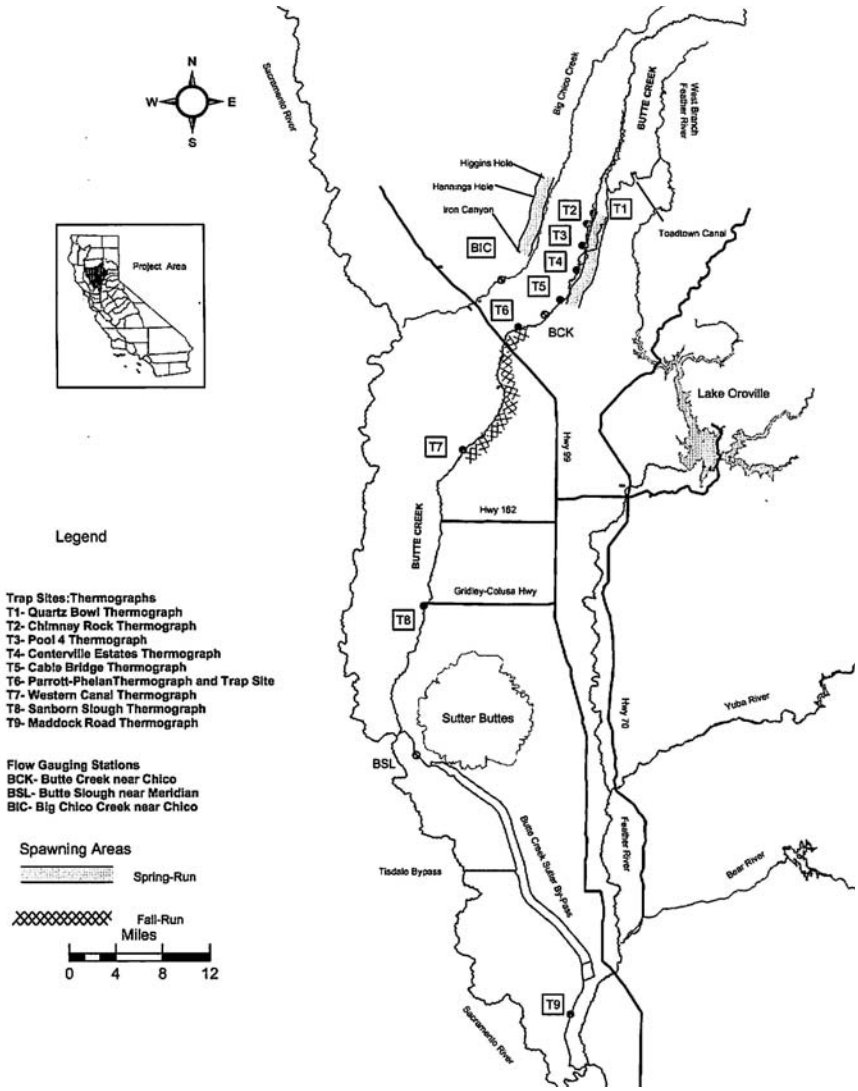

Figure 2.B. Butte Creek and Big Chico Creek watersheds with trap locations, gauging stations, and salmon spawning areas indicated. From: McReynolds et al. 2007.

Second, a low number of juveniles rear above Parrott-Phelan Diversion Dam, in the mainstem of Butte Creek. These fish grow to approximately 150 mm fork-length and remain in Butte Creek above the Parrott-Phelan Diversion Dam for 12 months or more before leaving Butte Creek and outmigrating to the Delta as yearlings (Ward et al. 2004).

Deer and Mill Creek Complex Stock

Introduction

Deer and Mill creeks are eastside tributaries to the upper Sacramento River. See Maps in Figures 2.C and 2.D. Deer Creek enters the Sacramento River at RM 220 and Mill Creek enters at RM 230. They both support populations of spring-run Chinook salmon (CDFG 1998, Lindley

et al. 2007) that are genetically distinct from spring-run populations in Butte Creek and the Feather River. While the Mill and Deer Creek stocks are marginally genetically distinct, it is not clear that the slight differences in observed allele frequencies are biologically significant and due to anything other than family structure. As such Banks et al. (2000) and Garza et al. (2008) concluded that the two stocks should be treated as a single complex due to the high degree of gene flow and similar phenotypes. These two stocks do have a higher degree of genetic differentiation than that found between the Feather River fall- and spring-run fish. However, other commentators suggest the phenotypic differences between the Feather River spring-run and fall runs warrant their treatment as two separate populations. Mill and Deer creeks appear genetically similar compared to the other genetically distinct, self-sustaining spring-run Chinook salmon populations in the Central Valley and likely function together demographically as a metapopulation (Garza et al. 2008).

There is currently no hatchery program supplementing the populations on either of these streams. Between 1902 and 1940, the U.S. Bureau of Fisheries established a hatchery on Mill Creek near Los Molinos, but no spring-run Chinook salmon were spawned (Hanson et al. 1940). Further, between 1941 and 1946, about 13,000 adult spring-run Chinook salmon from the upper Sacramento River were introduced into Deer Creek (Cramer and Hammack 1952). According to Harvey (1997) some of these may have been winter- and/or fall-run Chinook salmon. Small numbers of fall-run and/or late fall-run may also spawn annually in Deer and Mill creeks (Harvey-Arrison 2007). In spite of these additions and other populations, there does not appear to be introgression between the Deer and Mill Creek spring-run fish and other runs.

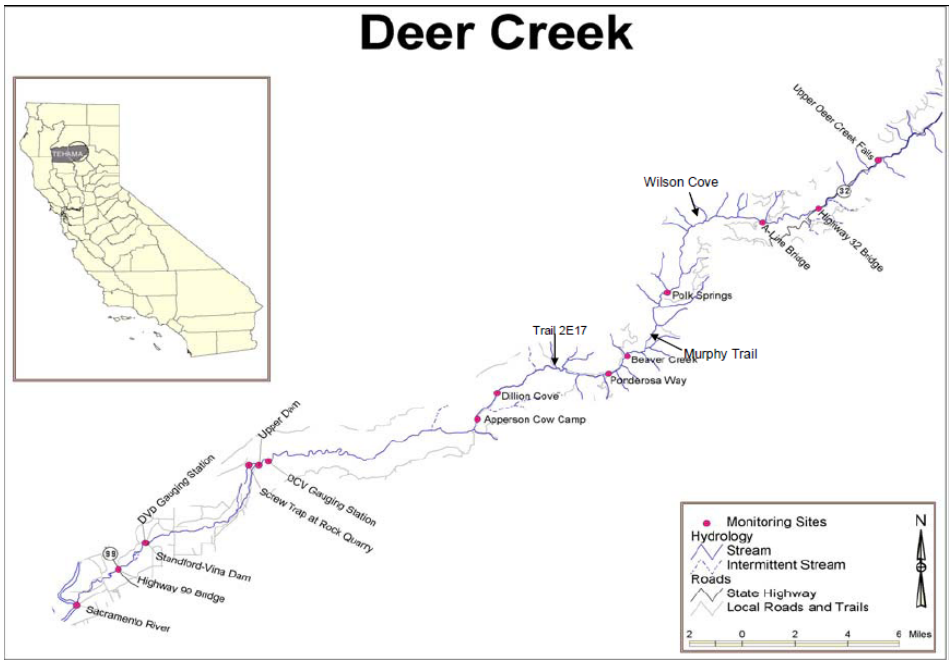

Figure 2.C. spring-run Chinook salmon holding and spawning habitat in Deer Creek. Source: Harvey-Arrison 2008.

<u>Deer Creek Spatial Distribution</u>

Deer Creek is 60 miles long and its watershed drains 200 square miles (USFWS 1995). Deer Creek originates on the northern slopes of Butte Mountain at an elevation of approximately 7,320 feet. It initially flows through meadows and dense forests and then descends rapidly through a steep rock canyon into the Sacramento Valley. Deer Creek flows for 11 miles across the Sacramento Valley floor, entering the Sacramento River at approximately 180 feet elevation (USFWS 1995) where most of the flow is diverted. In many years, diversions at three dams deplete all of the natural flow from

mid-spring to fall. Each of these diversion structures have fish passage structures and screens, so Deer Creek spring-run Chinook salmon have access to 100% of their historic habitat when flows permit (NMFS 2009).

Deer Creek spring-run Chinook salmon migrate upstream from March through early July, ending when flows are insufficient to pass adults and water temperatures begin to approach lethal limits low in the watershed. Spring-run Chinook salmon hold over a 25 mile reach, from Upper Falls downstream to near the confluence of Rock Creek. Within this area, 30% of the area is represented by pools. Of 166 total pools, 98 (or 60%) are holding pools (> 6 foot in depth). Because maturing adult spring-run Chinook salmon enter streams during the spring months and spend the summer holding in deep pools (prior to fall spawning), they are present in the stream system when temperatures are at their peak (generally July and August). Spawning occurs throughout the holding area, with precise locations varying based on water flow and changes in bed composition.

Monitoring data indicate that juvenile spring-run Chinook salmon emergence begins in November, peaks around February and ends in April. These data are derived from an egg-temperature model to predict emergence based on redd placement and also from direct observation of newly emerged juveniles (Harvey-Arrison 2007).

Deer and Mill Creek young generally follow one of two basic life history patterns. First, some fish outmigrate shortly after emergence. This fry outmigration occurs from February through June, but since traps are located within fall-run spawning area, these fry migrations are a mix of fall-run and spring-run progeny. Second, many juveniles stay in the river for a significant period of time. These fish emigrate during the wet season more than a year after being spawned (Big Chico Creek Watershed Alliance 2000). Based on annual surveys by the CDFG, outmigration of yearling spring-run typically occurs from October or November through March or April, depending on the year.

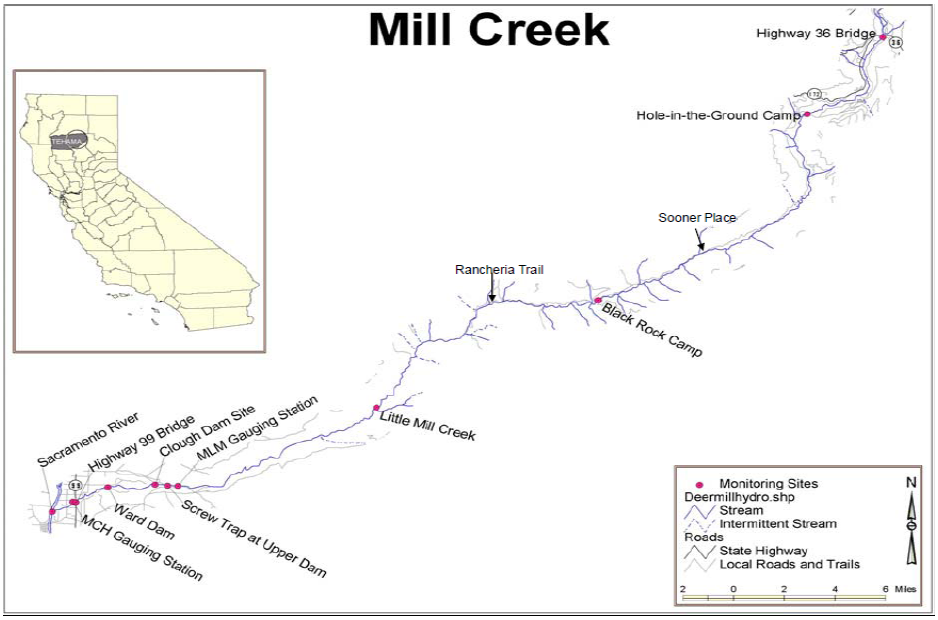

Figure 2.D. spring-run Chinook salmon holding and spawning habitat in Mill Creek. Source: Harvey-Arrison 2008

Mill Creek Spatial Distribution

Mill Creek originates from spring runoff in Lassen Volcanic National Park at an elevation of approximately 8,200 feet and descends to 200 feet at its confluence with the Sacramento River. Mill Creek initially flows through meadows and dense forests, descends rapidly through a steep canyon, and then flows 8 miles across the Sacramento Valley floor. Its total length is approximately 58 miles to its confluence with the Sacramento River. The Mill Creek watershed encompasses 134 square miles. During the irrigation season, three dams on the lower 8 miles of the stream divert most of the natural flow, particularly during dry years.

While adult spring-run have been observed migrating in Mill Creek as early as February, a 10-year study from 1953 to 1964 (CDFG 1966) documented the majority of upstream migration as occurring between mid-April and the end of June.

There are two geographically important sections of holding habitat available on Mill Creek, Upper Mill Creek and Lower Mill Creek (Canyon). Upper Mill Creek, defined as the upper 7.6 miles of Mill Creek between the Lassen Volcanic National Park boundary and Mill Creek campground, and Lower Mill Creek (canyon reach), which is downstream of the Mill Creek campground (Figure 2.D). Spring-run Chinook salmon holding habitat appears to be limited in Upper Mill Creek, based on stream survey data collected in 1990 that found pools made up only 5% of the area, none were classified as holding pools. Holding habitat is more abundant in Lower Mill Creek; survey covering roughly 13 of approximately 20 miles of stream found 13% of the area consisted of pools, 23% of which were holding pools. Additional suitable holding habitat may be present (Airola and Marcotte 1985).

Mill Creek spring-run Chinook salmon are unique for spawning at an elevation of more than 5,000 feet, the highest elevation known for salmon spawning in North America (Armentrout et al. 1998). In Mill Creek, sediment loading is greater than in Deer Creek and fines are notable especially in areas of deposition. High gravel embeddedness has been observed in some areas of spawning use (M. McFarland 1990, memo to the files). The conditions observed, however, do not appear to limit salmon from spawning. Spring-run Chinook spawning surveys are conducted in Mill Creek from the Hwy 36 bridge crossing downstream to Pape Place, below Black Rock Camp (Figure 2.D). Timing for emergence and outmigration are as outlined in the Deer Creek section above.

2.2.1.b) NMFS ESA-listed population(s) that may be indirectly affected by the program.

Chinook salmon, Winter-run, *Oncorhynchus tshawytscha* (Endangered). The winter-run Chinook salmon are a state and federally listed endangered species. Reintroduction of spring-run Chinook salmon may impact these fish through competition or indirect ecological interactions in the Delta. HGMP Section 3 discusses these impacts in more detail.

Steelhead, Central Valley, *Oncorhynchus mykiss* (Threatened). There is little data on the Central Valley ESU steelhead in the San Joaquin River, although a small number are present in the system, particularly in the Stanislaus, Tuolumne, and possibly the Merced river systems

(SJRRP 2009). Escapement estimates are not available. Currently, returning steelhead are directed away from the restoration area by the Hills Ferry Barrier, when in place(SJRRP 2009). As the restoration progresses, steelhead are likely to stray or be reintroduced into the San Joaquin, where they may be encountered during monitoring activities; any fish incidentally collected would be released unharmed. The steelhead population is likely to benefit from the improved habitat conditions in the restored river, but in the interim, the potential for impacts of the hatchery operations on Central Valley ESU steelhead is unknown, due to the lack of data on this population. General impacts to steelhead are discussed in HGMP Section 3.

Green sturgeon, *Acipenser medirostris* (Endangered). While green sturgeon occasionally are present in the lower reaches of the San Joaquin, they are not generally known to be present in the Restoration Area. Given their transitory presence and the general lack of interactions between the hatchery operations and sturgeon, it is unlikely that hatchery operations would negatively impact the green sturgeon. Improved river conditions are likely to benefit the Green sturgeon.

2.2.2) Status of NMFS ESA-listed salmonid population(s) affected by the program.

Lindley et al. (2007) surveyed the Central Valley spring-run Chinook salmon ESU, and concluded that it was not viable in its current state, although the status of individual populations varied widely. See Table 2.2, based on Table 6-4 in the Stock Selection Document. However, recent escapement has diminished substantially and an updated assessment should be completed to determine current viability. Moyle et al. (2008) also concluded that there was a high likelihood of spring-run Chinook salmon going extinct in the next 50-100 years, due to both their vulnerability to catastrophic events and their narrow physiological tolerances in the summer, which leaves them vulnerable to climate change.

Year	Deer/Mill Creeks		Butte Creek***	Feather River		Year	Deer/Mill Creeks		Butte Creek	Feather River	
	Deer*	Mill**		River	Hatchery		Deer	Mill		River	Hatchery
1960	2,368		8,700			**1985**	121	301	254		1,632
1961	1,245		3,082			**1986**	291	543	1,371		1,433
1962	1,692		1,750			**1987**	90	200	14		1,213
1963	1,315	2,302	6,100	600		**1988**	572	371	1,290		6,833
1964	1,539	2,874	600	2,908		**1989******	563	84	1,300		5,078
1965			1,000	738		**1990**	844	496	250		1,893
1966			80	297		**1991**	319	479			4,303
1967			180		146	**1992**	237	209	730		1,497
1968			280		208	**1993**	61	259	650		4,672
1969			830		348	**1994**	723	485	474		3,641
1970	1,500	2,000	285		235	**1995**	320	1,295	7,500		5,414
1971	1,000	1,500	470		481	**1996**	253	614	1,413		6,381
1972	500	400	150		256	**1997**	202	466	635		3,653
1973	1,700	2,000	300		205	**1998**	424	1,879	20,259		6,746
1974	1,500	3,500	150		198	**1999**	560	1,591	3,679		3,731
1975	3,500	8,500	650		691	**2000**	544	637	4,118		3,657
1976			46		699	**2001*****	1,100	1,622	9,605		4,135
1977	460	340	100		185	**2002**	1,594	2,185	8,785		4,189
1978	925	1,200	128	2	202	**2003**	1,426	2,759	4,398		8,662
1979			10		250	**2004**	998	804	7,390		4,212
1980	500	1,500	226	400	269	**2005**	1,150	2,239	10,625		1774
1981			250	531	469	**2006**	2,432	1,002	4,579		2,061
1982	700	1,500	534	90	1,910	**2007**	644	920	4,943		2,674
1983		500	50		1,702	**2008**	140	362	3,935		1,418
1984	191		23		1,562	**2009**	213	220	2,059		989

* For the CVPIA doubling period 1967-1991, the average spawning escapement of spring-run Chinook salmon in Deer Creek was 1,300 (USFWS 1995). From 1991 to present the average is 1,152.
** For the CVPIA doubling period 1967-1991, the average spawning escapement of spring-run Chinook salmon in Mill Creek was 800 (USFWS 1995). From 1991 to present the average is 646.
*** Butte Creek population averages for the last thirty, twenty, and ten years are 3,000, 4,400, and 7,400, respectively.
**** Surveys prior to 1989 used various methods with varying precision. For the non-Feather River populations, snorkel surveys implemented since 1989 are thought to significantly underestimate the actual population size and should only be used as an index. For the non-Feather River populations, Spawning surveys results for 2001 – 2006 were generated by a modified Schaefer Model carcass survey. Feather river estimates since 2004 are based on the fish entering the fish ladder during the spring-run period.
***** Butte Creek number previously reported for 2001 (22,744) in error (Ward et al. 2004).

Table 2.2. Estimated population levels for Deer/Mill Creek, Butte Creek, and Feather River spring-run Chinook salmon populations, 1960-2007. Originally Table 6-4 in the Stock Selection Document. Data from GrandTab 2010.

Note on the Feather River Population Estimates

Overall census size information for this population is not available. There are essentially four components to the population, but no count covers all five (pers. comm. Ryon Kurth, CA DWR).

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
[b] Decline within last two generations to annual run size $\leq$ 500 spawners, or run size > 500 but declining at $\geq$ 10% per year. Historically small but stable population not included.
[c] Run size has declined to $\leq$ 500, but now stable.
[d] Catastrophes occuring within the last 10 years.
[e] Decline < 90% but biologically significant.
[f] See Figure 1 for assessing hatchery impacts.

Figure 2.E. PVA terms and definitions. From Lindley et al. 2007.

First, some spring-running fish enter the fish ladder during the April – June period and then return to the hatchery after September 15 and are used in the spring-run hatchery spawning.

Second, some spring-running fish enter the fish ladder during the April – June period and then are not seen again, either spawning in the river, migrating out, dying before spawn, or being taken by fishermen.

Third, some spring-running fish do not enter the ladder during the April-June period, even though they are in the river during this time and then enter the hatchery during the fall period. These fish may be spawned as spring-run fish if the hatchery needs additional spring-run fish to meet its targets, but if not, the hatchery may not take the steps to determine the origin of these fish. If they do not determine the origin, the fish may be spawned as fall-run fish.

Finally, some spring-running fish never enter the hatchery but spawn in the river (pers. comm. Ryon Kurth, CA DWR).

Data are only available for the fish that enter the hatchery in the spring, and the spawning escapement reported here is the number of fish that entered the hatchery during the April-June period. We do not have reliable estimates of the total number of spring-

run fish, but scientists working with this population believe that the natural portion of the population is larger than the hatchery escapement (pers. comm. Ryon Kurth, CA DWR).

2.2.2.a) Describe the status of the listed natural population(s).

Based on Lindley et al.'s (2007) analysis, Butte Creek and Deer Creek spring-run Chinook salmon were then at low risk of extinction. See Figure 2.E for information on the classification system used in this analysis. Lindley et al. (2007) found that the Mill Creek spring-run population was at moderate extinction risk based on a Population Viability Assessment (PVA), although other criteria classify it as a low risk population. Considered together, the Mill/Deer Creek complex as a whole is at a low risk of extinction. Finally, due to the data deficiencies for the naturally spawning component of the Feather River spring-run, Lindley et al. (2007) was unable to assign an extinction risk to the population.

Since 2007, escapement to these streams has dropped substantially, coincident with declines of other salmon populations in California and an updated status review is currently being prepared, which will provide additional guidance on the status of these populations.

2.2.2.b) Provide the most recent 12-year (e.g. 1998-present) progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for the listed population. Indicate the source of these data.

Progeny-to-parent ratios and survival data by life-stage are not available for all populations. However, Lindley et al. (2007) documented population annual growth rates for Butte Creek, Mill Creek, and Deer Creek of 11.4%, 17.9%, and 7.65%, respectively, although these rates are being updated by Lindley et al. Spawning escapement data were obtained from California Department of Fish and Game's 2005 GrandTab database, available from the Fisheries Branch, 830 S Street, Sacramento, CA 95814. Data deficiencies prevent productivity assessments for the Feather River.

2.2.2.c) Provide the most recent 12-year (e.g. 1998-2010) estimates of annual proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known.

There does not appear to be any hatchery influence on the Butte and Deer/Mill Creek populations, suggesting a negligible proportion of hatchery-origin fish on those natural spawning grounds or negligible success for any fish that are present.

We do not have reliable estimates of the total number of spring-run fish in the Feather River generally, and there are no data on the proportion of natural origin- vs. hatchery-origin fish, but biologists working with the population believe that the natural portion of the population is at least larger than the hatchery escapement (pers. comm. Ryon Kurth, CA DWR). No instream counts are available to verify this.

2.2.3) Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of NMFS listed fish in the target area, and provide estimated annual levels of take (see "Appendix 2" for definition of "take").

2.2.3.a) Describe hatchery activities that may lead to the take of listed salmonid populations in the target area, including how, where, and when the take may occur, the risk potential for their occurrence, and the likely effects of the take.

Initially, taking of listed salmon should only occur during broodstock collection. Once the spring-run Chinook salmon are reestablished in the San Joaquin River, take of the experimental population will also occur during broodstock collection in the San Joaquin, and in connection with research and monitoring activities in the San Joaquin River

Broodstock collection will result in take of listed spring-run Chinook salmon in the selected populations though screwtrap operations, collection of juveniles to be reared for broodstock, and collection of eggs from redds. In addition to the direct take of fish and eggs for rearing, trapping and handling devices and methods may lead to injury of listed fish through descaling, delayed migration and spawning, or latent mortality as a result of stress, injury, or increased susceptibility to predation. Finally, if research is conducted on gene expression related to thermal tolerance, disease resistance, and/or susceptibility to contaminants, it will lead to lethal take on a small number of juveniles and adults from broodstock populations.

Once the San Joaquin River run is reestablished, these same kinds of take could occur with respect to those fish in the experimental population, depending on activities permitted by the 4(d) rule. A maximum of 10% of the naturalized run may be collected to serve as broodstock, unless returns are so low that the naturalized run is unlikely to produce enough offspring to expect an escapement in future years. This can be accomplished by collecting every tenth NO return for use in the broodstock.

Handling of naturalized adults for research purposes has a high potential to result in take, although most take should be sublethal. Handling will include taking fin clips for genotyping the returning adults. Lethal take associated with research activities is expected to be minimal, well less than 1%. Post mortem, scales and otoliths will be collected from spawned fish and in-river carcasses.

2.2.3.b) Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish.

This hatchery program has not yet been initiated; there are no data regarding past takes.

2.2.3.c) Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

HGMP Table 1.2 outlines direct take levels that result from capture: 100-200 eggs or juveniles harvested from both Butte Creek and Feather River in both 2012 and 2013; 50-100 eggs or juveniles harvested from both Deer and Mill Creek in both 2012 and 2013; 300-900 eggs or juveniles harvested from both Butte Creek and Feather River in 2014, 2015, 2016, 2017, 2018, and 2019; 150-400 eggs or juveniles harvested from both Deer and Mill Creek in 2014, 2015, 2016, 2017, 2018, and 2019. Similar levels of take may continue beyond 2019, but collections beyond 2019 will be addressed in the 5-year update of the HGMP.

The harvest of these numbers will also result in the incidental take of a small number of additional fish, due to bycatch or redd disturbance, among other factors, and the level of incidental take is difficult to estimate or measure.

2.2.3.d) Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

The take should be limited since the number of broodstock collected will be consistent with guidelines and protocols in the HGMP and the 10(a)1(A) permit. Given the relatively low numbers of fish or eggs to be collected and the non-automated manner of collection, excess take is unlikely and take can be suspended once the targets are achieved. Any excess take would be communicated to NMFS via email and letter, per 10(a)1(A) permit conditions. Collection operations will be suspended pending discussions with NMFS.

SECTION 3. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

3.1) Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. *Hood Canal Summer Chum Conservation Initiative*) or other regionally accepted policies (e.g. the NPPC *Annual Production Review* Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.

There is no ESU-wide hatchery plan for the Central Valley spring-run Chinook salmon. More broadly, NOAA has published a technical memorandum establishing a conceptual framework for conservation hatchery strategies for Pacific Salmon (Flagg and Nash 1999). This conceptual framework establishes recommendations for a conservation hatchery; the recommendations, organized by the considerations they address, and any proposed deviations from these are identified below. Details on the hatchery conditions are presented in HGMP Section 9. These plans are also consistent with the existing conservation hatchery guidelines for Coho salmon in the Coho salmon Recovery Strategy.

Inbreeding, Outbreeding, Domestication Selection, and Other Genetic Considerations
Conservation hatcheries should provide fish with minimal genetic divergence from their natural counterparts to maintain long-term adaptive traits. It is recommended that they:

- *Identify and follow hatchery protocols which avoid or minimize the processes of domestication selection, inbreeding, and outbreeding*
- *Release only smolts which have the fitness and diversity characteristics of their wild cohorts*

The San Joaquin River spring-run Chinook salmon program will follow hatchery protocols as identified in this HGMP to minimize domestication selection and inbreeding. In order to maximize the genetic diversity of the experimental population, the hatchery mating protocols may allow for crossing of broodstock from multiple source populations during operation of the interim facility if preliminary instream observation indicate a benefit in crosses between source populations and if deemed appropriate by the Hatchery Technical Team. Even if the fish are not crossed in the hatchery, using multiple broodstock will likely lead to eventual outcrossing in the stream. Allowing the crosses in the hatchery allows researchers to gather data on the performance a range of possible spring-run "hybrids". While this does increase the risk of outbreeding depression, the added genetic diversity created in the experimental population should counterbalance any risks, and the returns from these crosses will inform future mating practices. Controlled crosses if conducted would allow researchers to learn about the nature of hybrid vigor, outbreeding depression, and inbreeding depression in these populations. If the outcrossed fish perform poorly (i.e. return in proportionately smaller numbers, rate higher in stress evaluations of percent eye up, fair worse in early life stage survival and performance), the in-hatchery outcrossing would be eliminated.

Initially, there will be no wild smolt cohort for comparison with the hatchery fish. Fall-run Chinook smolts from the Merced River may provide a baseline for comparison for some parameters, such as percent return. Once significant natural spawning occurs in the San Joaquin

River, the wild smolts may be significantly different than the hatchery smolts in genetic makeup and fitness, given that they or their parents will have been exposed, during at least part of their lifecycle, to natural selection in the San Joaquin River system. The hatchery smolts will come predominantly from the source rivers. This may slow adaptation of the experimental population to the San Joaquin River, but continued interbasin transfers are vital to capture as much of donor stock genetic diversity as possible. After 8 years (two full generations) of interbasin transfers, any additional production of hatchery smolts will seek to release smolts that have the fitness and diversity characteristics of their wild cohorts by collecting broodstock that capture the genetic diversity of the wild population and rearing them in a manner designed to result in a size and condition comparable to wild fish of the same age.

Broodstock Sourcing

Conservation hatcheries should use locally adapted broodstock to maintain long-term fitness traits. It is recommended that they:

- *Select broodstock after careful analysis of environmental relationships and life history parameters, following the best genetic principles*
- *Provide options, such as captive broodstock for critical populations*
- *Integrate wild and hatchery populations to avoid divergence and selection of maladaptive traits*
- *Maintain the necessary management and security of the stocks*

The Conservation Facility will follow these recommendations. See HGMP Section 6. Broodstock Origin and Identity, below. The Conservation Facility will begin to integrate natural-origin and hatchery-origin populations once naturalized adults begin returning in sufficient numbers.

Broodstock Maturation and Reproduction

Conservation hatcheries should manage and rear broodstock to maintain appropriate seasonal timing of maturation, ensure high quality gametes, and minimize precocious maturation of male fish. It is recommended that they:

- *Maintain broodstock on natural photoperiod and water temperature below 12°C*
- *Select a diet and growth regime which reduces excessive early maturation of male fish*

The Conservation Facility will generally follow these recommendations, although water temperatures may on occasion exceed 12°C, matching San Joaquin River conditions.

Enriched Environments

Conservation hatcheries should have incubation and rearing vessels with options for habitat complexity to produce fish more wild-like in appearance, and with natural behaviors and higher survival. It is recommended that they:

- *Provide matrix substrates and darkened environments for egg incubation and alevin development*
- *Promote development of body camouflage coloration in juvenile fish by creating more natural environments in hatchery rearing vessels, for example, overhead cover, and in-stream structures and substrates*

- *Condition young fish to orient to the bottom rather than the surface of the rearing vessel by using appropriately positioned feed delivery systems*
- *Exercise young fish by altering water-flow velocities in rearing vessels to enhance their ability to escape predators*
- *Improve foraging ability of young fish by supplementing diets with natural live foods*
- *Reduce rearing densities to more natural spatial distributions*

Providing enriched environments can be problematic in a hatchery setting if not administered appropriately. Gravel bottoms and in-tank structure can alter the self-cleaning efficiency of the rearing vessel and therefore can degrade water quality fouling and increase stress associated with more frequent tank maintenance. The Conservation Facility will provide enriched environments for fish targeted for release to the wild per the recommendations, unless those requirements reduce survival and fitness; any proposed changes would be listed in the Facility's Annual Reports. Broodstock that are reared their entire life in the hatchery and are never released into the wild would receive less benefit from enriched environments; less emphasis will be place on providing enriched environments for hatchery broodstock.

Growth Rate Modulation

Conservation hatcheries should base their goals for growth patterns of hatchery fish and size at emigration on natural population parameters. It is recommended that they:

- *Determine spawning, hatching and emergence times of local populations, and duplicate these in the hatchery by controlling water temperature to natural profiles*
- *Measure growth rates, body size, and proximate composition of fish in the local population at critical periods: viz., first summer and fall prior to over-wintering, and spring-run growth/smolt size at migration*
- *Simulate growth rate, body size, and proximate composition by controlling water temperature, diet composition, and feeding rates*

The Conservation Facility will follow these recommendations once naturalized adults begin returning in significant numbers. Before naturalized adults return, the water temperatures will follow the water temperatures in the San Joaquin River near the Conservation Facility. As noted above, in the interim, fall-run Chinook smolts from the Merced River may provide a baseline for comparison to develop strategies to minimize competition between these two stocks. These fish, while fall-run, are in a watershed that experience similar conditions to those the Program expects in the restored San Joaquin River. Growth rates will be managed on an adaptive basis as natural spawning begins to occur in the San Joaquin River.

Rearing Density

Conservation hatcheries should use low rearing densities to improve juvenile survival during rearing and to increase adult return percentage. It is recommended that:

- *Density criteria for rearing juveniles in conservation hatcheries should be hatchery-specific, as the potential impact of density may depend strongly on the incidence of existing clinical and sub-clinical infections [Until further data are available, the maximum density index proposed by Banks (1994), and Ewing and Ewing (1995) is 0.15 lb/ft^3/in for spring-run and fall-run Chinook salmon. . . . Banks (1994) speculated that the adult*

return of spring-run Chinook salmon might be further improved in the range of 0.08-0.11 lb/ft^3/in.]

- *Rearing densities are reduced to produce quality smolts*

The Conservation Facility will follow these recommendations for fish that will be released. Because the lower speculative figures have not been evaluated, the Facility will use a maximum density of 0.15 lb/ft^3/in and will seek to achieve lower densities if space and broodstock population levels permit. Broodstock that will not be released may be raised at higher densities. In case of low survival, densities will be lowered to ensure that crowding is not impacting survival rates.

Anti-Predator Conditioning

Conservation hatcheries should have options to apply anti-predator conditioning methods in hatchery rearing vessels. It is recommended that they:

- *Foster higher in-stream survival by exposing fish to a variety of anti-predation and training exercises*
- *Evaluate and improve various training methods*

The Conservation Facility will investigate these recommendations for fish that will be released for restoration. Anti-predation training may include chemical stimuli, artificial predator simulations, and/or actual predation encounters, with the actual method selected via experimental trials on fall-run Chinook salmon, as discussed in HGMP Section 12. Broodstock that will not be released will not be involved in anti-predator conditioning.

Release Size

Conservation hatcheries should release smolts at a size which equals the size distribution of smolts in the wild population. It is recommended that they:

- *Release smolts within the size range of wild smolts from which the population is derived, except a case when imminent extinction requires maximal survival.*

The Conservation Facility will follow these recommendations for fish that will be released once naturalized adults begin returning in sufficient numbers. Before naturalized adults return, smolts released will be targeted to the size range of wild smolt from the source populations. Approximate fork length at time of emigration of sub-smolts is 35-40 mm. Because all three source populations have at least two primary emigration life history strategies, releases will accommodate both young-of-year and yearling migrants. Smolt size at release will be reported in the Annual Report, and any plans to change average smolt size will be subject to NMFS review and approval.

Release Time and Volitional Release

Fish from conservation hatcheries should be released on their own volition and out-migrate during windows for natural downstream migration of the stock. It is recommended that conservation hatcheries:

- *Practice volitional release strategies which maintain within-population variability in out-migration timing by programming liberation windows which mimic the natural time and*

age patterns found in wild populations of the fish under culture
- *Allow non-smolts (parr) to remain, and either smolt, residualize, or perish through natural selection*

The Conservation Facility will follow these recommendations for fish that will be released once river conditions in the Restoration Area are suitable for salmon. The Facility will employ fish holding facilities that allow for volitional release to mimic the natural time and age patterns in fish migration. After leaving the facility, fish will be allowed to remain in-river until they emigrate of their own accord.

Imprinting and Homing
Conservation hatcheries should adopt practices to reduce straying, such as on-site rearing and release, and other promising imprinting or homing techniques. It is recommended that they:
- *Rear fish for their entire juvenile freshwater lives in water from the intended return location to imprint natural odors and reduce straying of returning adults*
- *Acclimate juveniles at selected release sites where this approach is not possible*

The Conservation Facility will follow these recommendations. Most fish will be reared for their entire juvenile freshwater lives in water from the intended return location. Initially, while the restoration process in the upper river is still underway, releases downstream in the San Joaquin River may be necessary to accommodate limited passage opportunities.

Habitat Carrying Capacity
Conservation hatcheries should program their production to accommodate the natural spatial and temporal patterns of abundance in wild fish populations. It is recommended that they:
- *Adopt strategies for releasing numbers of hatchery-reared juveniles to equal (or not exceed) carrying capacities of receiving waters*
- *Formulate an Ocean Productivity Index as the basis of modulating fish hatchery production in fisheries management plans*

The Conservation Facility will follow the objectives for production found in the FMP and the TAC recommendations. These objectives, highlighted in Section 1, are based on historical and current estimates of San Joaquin River and Ocean carrying capacity. Hatchery production will be moderated when natural returns begin to accommodate the natural production without exceeding the carrying capacity.

3.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

This Conservation Facility is part of the SJRRP, whose charge is to execute a legal settlement from the lawsuit *NRDC v. Rodgers*. After more than 18 years of litigation, the Settling Parties reached a Stipulation of Settlement Agreement (Settlement). The Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, agreed on the terms and conditions of the Settlement, which was subsequently

approved on October 23, 2006. The Settling Parties also signed a concomitant Memorandum of Understanding. This HGMP is consistent with the settlement agreement. It is also consistent with the enabling act for the Settlement Agreement, Omnibus Public Land Management Act of 2009 Public Law 111-11, Title X.

Other cooperative agreements, memoranda of understanding, or memoranda of agreement may be developed as the restoration and reintroduction progresses. Any additional agreements will be included here and in the annual hatchery reports, discussed in HGMP Section 11.

3.3) Relationship to harvest objectives.

	Ocean Landings				Percent of Potential Source Population Escapement*
Brood Year	**Age 3**	**Age 4**	**Age 5**	**Total**	
1995	1,571	6,785	196	8,552	37.1%
1996	816	3,599	258	4,674	35.1%
1997	1,318	5,796	378	7,491	60.2%
1998	1,379	4,998	445	6,822	18.9%
1999	769	3,456	562	4,786	33.4%
2000	802	3,559	321	4,681	34.3%
2001	486	2,236	756	3,478	17.4%
2002	718	3,271	710	4,700	21.9%
2003	610	2,782	633	4,025	18.9%
2004	1,021	4,490	292	5,803	30.2%
2005	3,624	4,751	323	8,698	35.5%
2006	3,914	5,131	349	9,393	48.3%
Totals	17,028	50,854	5223	73,103	30.6%
Means	1,419	4,238	435	6,092	28.8%

*Calculated as harvest/(harvest+escapement)

Table 3.1. Estimated ocean landings (harvest) of Central Valley spring-run Chinook salmon by brood year and age (calculated from Cramer et al. 2005 and Table 2-2 in Cavallo 2009).

The Pacific Fishery Management Council (PFMC), established by the 1976 Magnuson/Stevens Fishery Conservation and Management Act to manage near-shore ocean fisheries, works with the California Department of Fish and Game to manage the ocean salmon fishery off the California Coast. The PFMC manages fisheries based on a number of objectives, detailed in its Salmon Fishery Management Plan (FMP) and evaluated annually in its Review of Ocean Salmon Fisheries. The objectives include stock-specific conservation objectives (e.g. Sacramento River fall-run Chinook spawner escapement goal of 122,000 to 180,000 hatchery and natural adults, Klamath basin natural area spawning escapement of no less than 40,700 fall-run Chinook adults and a spawner reduction rate of no more than 67%). The FMP does not offer

conservation objectives for any Central Valley spring-run fish, because harvest related take is regulated through annual ESA consultation and seasonal closures and gear and location restrictions influence the escapement of spring-run Chinook salmon in the Central Valley (Cavallo et al. 2009). Finally, because the stocks are commingled in the ocean, ocean fishing restrictions are often based on protecting the most vulnerable stocks. For example, fishing was restricted in 2006 to protected Klamath River Chinook, and in 2008 and 2009 to protect Sacramento River fall-run Chinook.

3.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years (1988-99), if available.

The San Joaquin River spring-run Chinook salmon program is an integrated recovery hatchery, which is not primarily intended to produce adult salmon for harvest but rather to promote recovery. Harvest may be an ancillary benefit. There are active ocean commercial and ocean and inland recreational fisheries for salmon in California, and some San Joaquin River spring-run Chinook salmon will likely be taken in those fisheries. No fisheries have benefited from the Program as yet, as the Program is new. Spring-run Chinook salmon are a part of the salmon harvest in California, and estimates of the spring-run Chinook salmon ocean harvest are available from 1995 to 2006. See Table 3.1. As noted in the FMP, harvest rates of CV spring-run Chinook salmon likely ranged from 55% to nearly 80% between 1975 and 1995. From 1995 to 2005, estimated harvest rates ranged from 17.4% to 60.2%, with a mean of 28.8%. This harvest rate likely overestimates the harvest percentage, because the escapement figures include only the three largest runs of spring-run Chinook salmon in the Central Valley. Ocean and most freshwater salmon fishing in California were prohibited in 2008 and 2009 due to low returns of Central Valley fall-run Chinook salmon.

The CDFG seeks to minimize take of Central Valley spring-run Chinook salmon in freshwater fisheries via special regulations in Mill, Deer, Butte, and Big Chico creeks, and the regulations developed for Sacramento River winter-run Chinook salmon provide some additional protection (CDFG 1998). Figures are not available for the freshwater recreational take of spring-run Chinook salmon.

Estimated future harvest rates on fish propagated by this program are difficult to calculate. Ocean rates may remain similar to those estimated between 1995 and 2006, although ocean harvest rates will vary annually based on the regulations established by PFMC and CDFG. Freshwater recreational harvest should be minimal or nonexistent initially, although a recreational freshwater fishery may develop under 4(d) regulations when salmon begin returning in the significant numbers anticipated in the settlement agreement. Even if allowed under the 4(d) regulations, the USFWS has recommended the consideration of special regulations and closures on the San Joaquin River at least through the reintroduction period; the CA Fish and Game Commission has the power to establish such special regulations. If returns do not meet the numerical objectives identified in Section 1 of this HGMP, seasonal, gear, or location restrictions on ocean and freshwater fishing may be considered.

3.4) Relationship to habitat protection and recovery strategies.

The FMP provides detailed information on factors affecting natural production and the habitat protection efforts that should be taking place in the Restoration Area, and FMP Table 5-1 sets out the primary factors that may limit Chinook production from the reintroduction program. The FMP also establishes 6 Habitat Goals and 13 Objectives to measure achievement of those goals:

Habitat Goals

• Restore a flow regime that (1) maximizes the duration and downstream extent of suitable rearing and outmigration temperatures for Chinook salmon and other native fishes, and (2) provides year-round river habitat connectivity throughout the Restoration Area.

• Provide adequate flows and necessary structural modifications to ensure adult and juvenile passage during the migration periods of both spring-run and fall-run Chinook salmon.

• Provide suitable habitat for Chinook salmon holding, rearing, and outmigration during a variety of water year types, enabling an expression of a variety of life-history strategies. Suitable habitat will encompass appropriate holding habitat, spawning areas, and seasonal rearing habitat.

• Provide water-quality conditions suitable for Chinook salmon and other native fishes completing their life cycle without lethal or sublethal effects.

• Reduce predation losses in all reaches by reducing the extent and suitability of habitat for nonnative predatory fish.

• Restore habitat complexity, functional floodplains, and diverse riparian forests that provide habitat for spawning and rearing by native resident species during winter and spring-run.

Habitat Objectives

1. *A minimum of 30,000 square meters (m^2) of high-quality spring-run Chinook salmon holding pool habitat.*

2. *A minimum of 78,000 m^2 of quality functioning spawning gravel in the first 5 miles of Reach 1 should be present for spring-run Chinook salmon.*

3. *A minimum of 88,000 m^2 of floodplain rearing habitat for spring-run subyearling smolts and 126,000 m^2 of floodplain rearing habitat for fall-run subyearling smolts.*

4. *Provide passage conditions that allow 90% of migrating adult and 70% of migrating juvenile Chinook salmon to successfully pass to suitable upstream and downstream habitat respectively, during all base flow schedule component periods and water year types of the Settlement, except the Critical-Low water year type.*

5. *Provide appropriate flow timing, frequency, duration and magnitude enabling the viability of 90% of all life-history components of spring-run Chinook salmon.*

6. *Water temperatures for spring-run Chinook salmon adult migrants should be less than 68 °F in Reaches 3, 4, and 5 during March and April, and less than 64°F in Reaches 1 and 2 during May and June.*

7. *Water temperatures for spring-run Chinook salmon adult holding should be less than 59°F in holding areas between April and September.*

8. *Water temperatures for spring-run Chinook salmon spawners should be less than 57°F in spawning areas during August, September, and October.*

9. *Water temperatures for spring-run Chinook salmon incubation and emergence should be less than 55°F in spawning areas between August and December.*

10. *Water temperatures for spring-run Chinook salmon juveniles should be less than 64°F in the Restoration Area when juveniles are present.*

11. *Selenium levels should not exceed 0.020 milligrams per liter (mg/L) or a 4-day average of 0.005 mg/L in the Restoration Area.*

12. *DO concentrations should not be less than 6.0 mg/L when Chinook salmon are present.*

13. *Total ammonia nitrogen should not exceed 30-day average of 2.43 milligrams nitrogen per liter (mg N/L) when juvenile Chinook salmon are present or exceed a 1-hour average of 5.62 mg N/L when Chinook salmon are present.*

3.5) Ecological interactions.

The FMP provides presence and absence data on fish in the restoration area. See Table 3.2.

Species	Scientific Name	Native (N) or Introduced (I)	Current Presence*
Spring-run Chinook salmon	*Oncorhynchus tshawytscha*	N	No
Fall-run Chinook salmon	*O. tshawytscha*	N	Periodic
Rainbow trout/steelhead	*O. mykiss*	N	Yes
Pacific lamprey	*Lampetra tridentata*	N	Yes

Species	Scientific Name	Native (N) or Introduced (I)	Current Presence*
River lamprey	*L. ayersi*	N	Unknown
Kern brook lamprey	*L. hubbsi*	N	Yes
Western brook lamprey	*L. richardsoni*	N	Unknown
White sturgeon*	*Acipenser transmontanus*	N	Yes
Green sturgeon	*A. medirostris*	N	No
Hitch	*Lavinia exilicauda*	N	Yes
California roach	*L. symmetricus*	N	Yes
Sacramento blackfish	*Orthodon microlepidotus*	N	Yes
Sacramento splittail	*Pogonichthys macrolepidotus*	N	Yes
Hardhead	*Mylopharodon conocephalus*	N	Yes
Sacramento pikeminnow	*Ptychocheilus grandis*	N	Yes
Speckled dace	*Rhinichthys osculus*	N	Extirpated
Sacramento sucker	*Catostomus occidentalis*	N	Yes
Threespine stickleback	*G. aculeatus*	N	Yes
Prickly sculpin	*Cottus asper*	N	Yes
Riffle sculpin	*C. gulosus*	N	Yes
Sacramento perch	*Archoplites interruptus*	N	Extirpated
Tule perch	*Hysterocarpus traski*	N	Yes
Threadfin shad	*Dorosoma petenense*	I	Yes
Common carp	*Cyprinus carpio*	I	Yes
Fathead minnow	*Pimephales promelas*	I	Yes
Red shiner	*Cyprinella lutrensis*	I	Yes
Bullhead spp.	*Ameiurus sp.*	I	Yes
White catfish	*A. catus*	I	Yes
Striped bass	*Morone saxatilis*	I	Yes
Black crappie	*Pomoxis nigromaculatus*	I	Yes
Bluegill sunfish	*Lepomis macrochirus*	I	Yes
Green sunfish	*L. cyanellus*	I	Yes
Largemouth bass	*Micropterus salmoides*	I	Yes
Redear sunfish	*L. microlophus*	I	Yes
Spotted bass	*M. punctulatus*	I	Yes
White crappie	*P. annularis*	I	Yes
* CDFG Report Card Data, 2009			

Table 3.2. Fish Species with Possible Historic and Current Presence in the Restoration Area. Modified from FMP Table 2-1.

Of the species currently present in the San Joaquin River, only the anadromous form of rainbow trout (i.e., steelhead) is currently listed under the ESA (63 FR 13347, March 19, 1998 and 71 FR 834, January 5, 2006). Escapement data for the steelhead in the mainstem San Joaquin River are not available, and the anadromous fish are generally excluded from the restoration area by the Hills Ferry Barrier during the months of its operation (SJRRP 2009), but it is likely that the

steelhead will eventually be reintroduced or recolonize naturally once the barrier is removed. The Delta smelt is not historically present in the Restoration Area (Moyle 1992), and the Restoration Area is not part of its designated Critical Habitat (59 FR 65256, December 19, 1994).

3.5.1) *Salmonid and non-salmonid fishes or other species that could negatively impact program.*

The FMP identifies several fish that are risk factors for the reintroduction effort:

> Key predators to [juvenile] salmonids are thought to include native Sacramento pikeminnow, which feeds all year, introduced striped bass, which typically begins migrating into tributary habitats in April, and introduced centrarchids, when they begin feeding in April or May as water temperatures rise. These fish tend to use dredged habitats in the Restoration Area and Delta, including captured mine pits, the Stockton Deepwater Ship Channel, and canals leading to the [Central Valley Project] CVP and [State Water Project] SWP pumping facilities. Nonnative submerged aquatic vegetation provides habitat for nonnative predators.

Improvements in habitat conditions related to restoration flows and floodplain restoration should limit predation by many of the key predators. Other predators may include birds or aquatic mammals like seals, sea lions and otters. The FMP also notes that stocking of hatchery-reared catchable-sized trout in the restoration area could negatively impact the program through predation, although the 2010 Fish and Game Policies prohibit such releases in the Restoration Area, noting, "Domesticated or non-native fish species will not be planted, or fisheries based on them will not be developed or maintained, in drainages of salmon waters, where, in the opinion of the Department, they may adversely affect native salmon populations by competing with, preying upon, or hybridizing with them. Exceptions to this policy may be made for stocking drainages that are not part of a salmon restoration or recovery program" (CDFG 2010).

3.5.2) *Salmonid and non-salmonid fishes or other species that could be negatively impacted by program.*

The San Joaquin River above the Merced River does not have a persistent population of Chinook or steelhead, although some strays enter the river in higher water years. Because the spring-run fish are going to be reintroduced to a portion of the river with no fall- or spring-run population, many of the normal concerns with hatchery operations (introgression, predator attraction (Collis et al. 2001), behavioral influences, etc.) should not be a concern for other Chinook in the river during the initial stages of the introduction. As more significant numbers of naturalized fish return to the system, these potential impacts may be realized, although the continued reintroductions will be conducted under the Conservation Facility's HGMP to minimize these impacts. The continued reintroductions are likely to benefit the naturalized Chinook by bolstering their numbers and their genetic diversity. As outlined in Section 1, when

the naturalized populations are well enough established that they do not require the support of the hatchery, hatchery operations will be discontinued.

While the reintroduced salmon will not initially encounter other salmon in the river, they are likely to interact with San Joaquin River steelhead and other salmonids while outmigrating or rearing in the Delta, and in the ocean. The reintroduced fish are likely to interact with other listed salmonid populations, including the endangered winter-run Chinook salmon, and the threatened Central Valley steelhead. The reintroduced fish may negatively impact other salmonids through a variety of interactions, most notably induced behavioral changes in wild fish, competition for limited resources, depensatory predation, and disease transfers in areas where they commingle (Reisenbichler et al. 2004). While in freshwater, juvenile salmon feed predominantly on aquatic insects and other invertebrates and should not be significant predators on other salmonids (Unger 2004, Rundio and Lindley 2007).

Finally, returning adults are likely to stray into other San Joaquin River tributaries,, where they may interbreed with other Chinook salmon. The small numbers of spring-run Chinook salmon in the San Joaquin River tributaries, and the lack of genetic analysis on them, makes analysis of potential genetic effects very difficult. The hatchery will be employing conservation hatchery protocols to reduce domestication selection, and the salmon will be in the hatchery at some point in their lives for one or a maximum of two generations, so there may be some reduction in fitness relative to the wild population (Reisenbichler and McIntyre 1977; Leider et al. 1990, Sekino et al. 2002; Araki et al. 2007).

3.5.3) *Salmonid and non-salmonid fishes or other species that could positively impact program.*

If fall-run Chinook salmon or steelhead begin returning to the San Joaquin River in significant numbers, they would benefit the program via ecosystem enrichment with marine-derived nutrients. The fall-run would be excluded from the spring-run breeding areas with the fish barrier, but the carcasses from the fall-run would enrich the system as a whole. Other ecological interactions may directly or indirectly benefit the program, but are not well documented.

3.5.4) *Salmonid and non-salmonid fishes or other species that could be positively impacted by program.*

Ecosystem enrichment via inputs of nutrients from smolts and eventually returning adults should benefit other fish populations in the San Joaquin River, particularly the predatory fish that would benefit from an increased prey base. Aquatic and nearby riparian ecosystems generally benefit from the nutrients brought into the system via returning adult salmon (Cederholm et al. 1999). Other salmonids in the San Joaquin River, the Delta, or the ocean may benefit from compensatory fishing and predation, if the presence of reintroduced fish reduces their mortality. Straying of returning adults may increase the genetic diversity of recipient populations.

SECTION 4. WATER SOURCE

4.1) Provide a quantitative and narrative description of the water source (spring-run, well, surface), water quality profile, and natural limitations to production attributable to the water source.

Water for the Conservation Facility will be supplied from Millerton Lake. Millerton Lake, created by Friant Dam, has a total capacity of 520,500.0 acre-feet (642,027,296.4 cubic meters) between its streambed and the top of the active conservation level. The watershed above Friant Dam drains 1,638.0 square miles (4,242.4 square km) on the western slope of the Sierra Nevada in Fresno and Madera counties, and is bounded on the north by the watersheds of the Merced and Fresno rivers, and on the south by the watershed of the Kings River. The topography of the watershed is primarily granitic. It extends east to the crest of the Sierra Nevada with a general ridge elevation of about 10,000 feet above mean sea level (3,048.0 meters), and occasional peak elevations greater than 13,000.0 feet (3,962.4 meters), and westward to Friant Dam about 25 miles (40.3 km) north from Fresno at an elevation of about 350 feet (106.7 meters) (SJRRP 2009).

The new Conservation Facility will be located adjacent to the existing CDFG San Joaquin State Fish Hatchery in Friant, California. The San Joaquin State Fish Hatchery has successfully hatched and raised trout at the site since 1955 due to favorable water temperature and water quality conditions. The source water for the hatchery is a continuous 35 cfs supply gravity fed directly from Friant Dam. Prior to reaching the hatchery, the water passes through the Fish Release Hydropower Plant, which is owned by the Orange Cove Irrigation District. The flows are delivered to the power plant through two different pipelines: a 24-inch diameter pipeline from two Friant Dam penstocks, and a 30-inch diameter pipeline that takes water from the Friant Kern Canal penstock near the left dam abutment. The temperature of the water in each pipeline varies throughout the year, and valves are used to control the flows to create favorable temperature conditions at the hatchery. Temperatures are typically maintained between 45-55 F (7.2-12.8 C) throughout the year, occasionally dipping as low as 42 F (5.6 C) or as high as 58 F (14.4 C). Water temperatures between the hatchery water and the adjacent river water is of the same origin and is fairly similar in quality and temperature, however, the temperatures of the hatchery water are more moderated due to the ability to adjust water temperatures at the mixing valves located at the Fishwater Release Hydropower Plant. The water flowing from the Hydropower Plant is delivered to a 44-inch diameter pipeline for delivery to the fish hatchery (approximately 1 mile from the dam). The 44-inch line has been calculated to have the capacity to convey an additional 30 cfs to the hatchery. Planning is currently in progress to secure a portion of the unused capacity to convey the required supply water for the Conservation Facility. Water flow at the existing hatchery has been exceptionally reliable in its 65 years of operation with only one known disruption to flow in recent history due to an underground pipe break. Water flow at the proposed hatchery is anticipated to be equally as reliable.

The existing hatchery operates under the Clean Water Act NPDES permit No. CA0004812 (Order No. R5-2004-0118), through the California Regional Water Quality Control

Board Central Valley Region. The new facility will have a separate discharge from the existing hatchery and will operate under an independent NPDES permit. Because of the high flow rates intended at the Conservation Facility to provide sufficient flushing and to provide optimal conditions, temperature increase in Conservation Facility water is anticipated to be minimal and will remain within the guidelines provided by the Regional Water Quality Control Board.

4.2) Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

The Conservation Facility will be designed to conform to NMFS screening guidelines for effluent discharge. The Conservation Facility intake line originates in Lake Millerton above Friant Dam where there are no known listed fish species. Solid waste from fish culture tanks from the full-scale Conservation Facility will be concentrated as a side stream using micro screen filtration, stored in a solid waste sump, dried and removed from the premises. The Interim Facility will be small enough to fall below the NPDES permit requirements, and, as noted above, the full-scale facility wills secure its own NPDES permit, and outflows should have no negative impact on downstream fish. Current water quality data are presented in Table 4.1.

Water Quality Parameter	**Values**
Temperature (C)*	5.6-14.8
Dissolved Oxygen (% saturation)*	80-95%
Ammonia as N (mg/L)**	<0.50
NH_3-N (mg/L)**	0.0008
Alkalinity (mg/L)**	13.5
Fecal Coliform (#/100ml)**	29
Total Coliform (#/100ml)**	536
Turbidity (NTU)	3
pH**	6.7
*Typical conditions at San Joaquin River Hatchery	
**Values derived from Bureau of Reclamation water quality data from 9/30/2009-11/17/2009 sampled at Lost Lake Park just below San Joaquin Fish Hatchery	
Table 4.1. Influent Water Quality Data for the San Joaquin Fish Hatchery	

SECTION 5. FACILITIES

This HGMP is atypical in that it is being developed prior to the existence of hatchery facilities and even prior to final approval for hatchery construction. Therefore, it is difficult to provide complete details for the facilities. While preliminary facility designs have been developed, designs will certainly change during the planning process to best meet Program needs, with the goal to provide considerable flexibility in design in order to respond to the adaptive management nature of the project. This HGMP will be updated annually to provide updates to changes as funding constraints, construction timelines, facility need, etc. are further elucidated. See Figures 5.1 and 5.2 for conceptual facility designs.

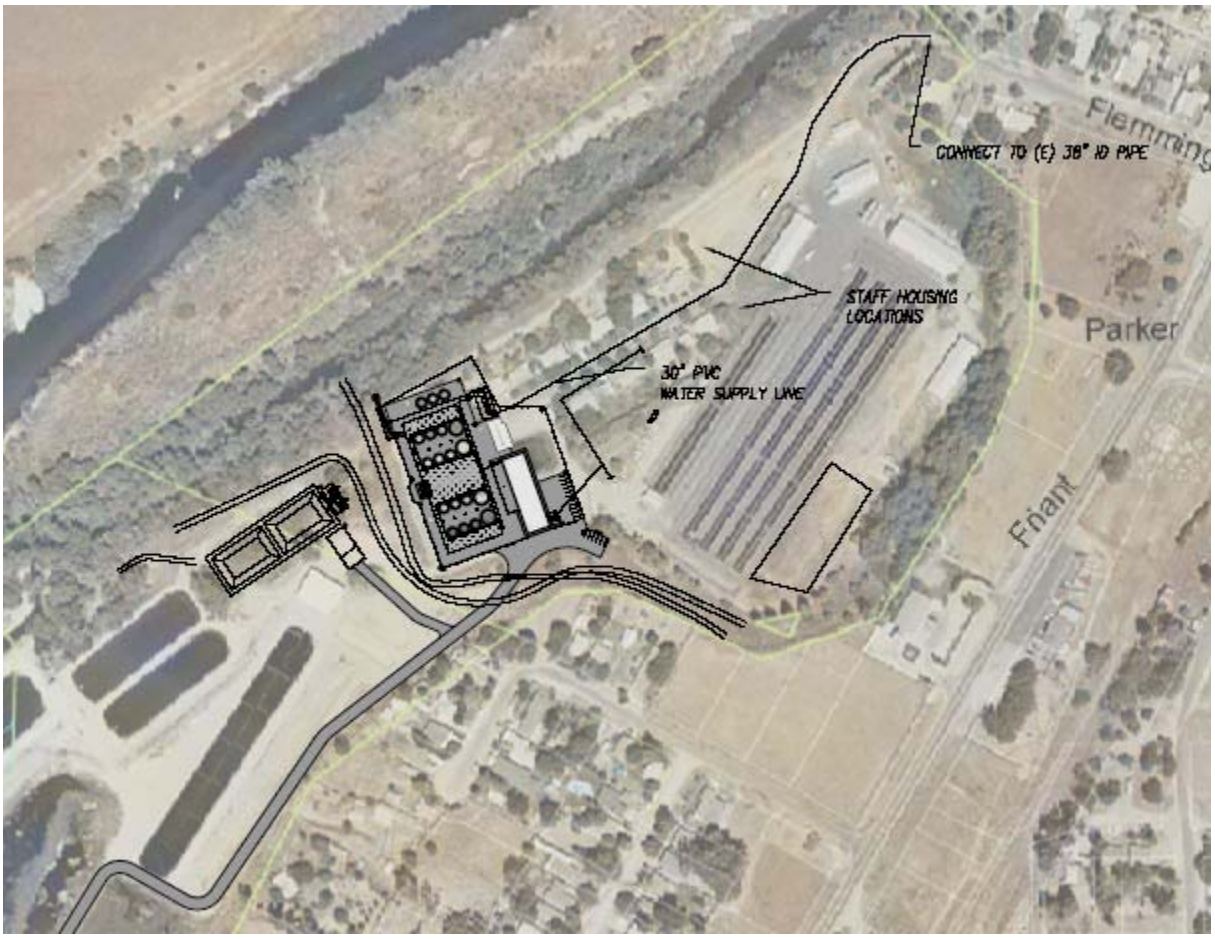

Figure 5.1. Conceptual design of the San Joaquin River Salmon Conservation and Research Facility in Friant California, adjacent to San Joaquin Fish Hatchery.

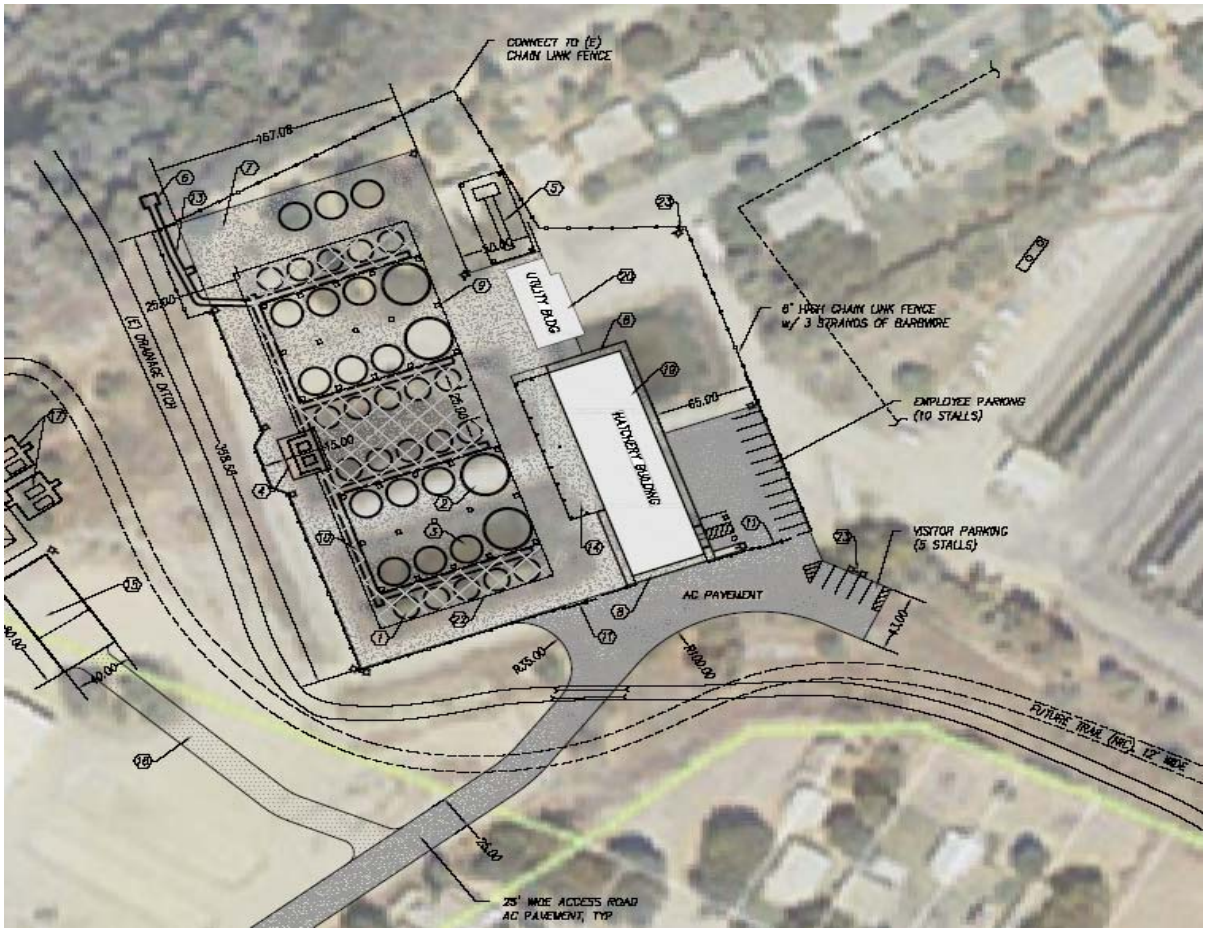

Figure 5.2. Detailed conceptual design of the San Joaquin River Salmon Conservation and Research Facility.

5.1) Broodstock collection facilities (or methods).

The Conservation Facility may use multiple methods to collect broodstock at several life stages. Broodstock will likely be collected from Butte Creek, Mill Creek, Deer Creek, Feather River. As the Program progresses, broodstock also will be collected from the San Joaquin River.

Broodstock collection methods and life stage will depend on the specific objectives of the collection, take guidelines provided by NMFS, potential impact to the source populations and specific site conditions that will dictate which life stage is most appropriate for collection. Broodstock collection methods will aim to maximize broodstock genetic diversity by collecting over the spatial and temporal range of the targeted life stage.

Adult Broodstock Collection

Use of FRH will facilitate sourcing and spawning adult fish for the Program. The FRH spring-run Chinook salmon spawning program may be used for the collection of gametes or for the production of juvenile fish. The FRH spring-run Chinook salmon broodstock sources are described in HGMP Section 2. FRH fish for the Conservation Facility would be collected using FRH facilities. To reduce disease transfer potential, disinfected eyed-eggs collected from a maximum number of parental crosses may be transferred from FRH to the Conservation Facility.

It is anticipated that few adult salmon will be collected from the remaining source populations (Butte Creek and Deer/Mill Creek) due to the difficulty associated with holding and transporting adult wild Chinook salmon, correctly anticipating spawn timing for instream egg collection, and the potential loss of reproductive potential associated with the removal of adult fish. However, fish may be taken in salvage operations, if available, or if the adult escapements for these systems are larger than estimated carrying capacity. Collection of wild, adult spring-run Chinook salmon strays may also occur in the Stanislaus, Mokelumne or Yuba Rivers or Battle or Clear Creeks for direct transfer into the San Joaquin River or to the Conservation Facility. Generally, broodstock contributed by populations in Butte, Deer, and Mill Creeks will be collected as outlined below.

The Program is currently developing options for collecting the adult spring-run Chinook salmon that will return to the San Joaquin River after the reintroduction. Returning adults may be collected at various locations along the river above the confluence with the Merced River. Collection options include a fish trap at Hills Ferry Barrier, future facilities further upstream with use of a collection weir, or seining or electrofishing.

Juvenile Broodstock Collection

In order to minimize the impacts to the source populations, the Program will target small numbers of juvenile fish for use as broodstock through captive rearing. The Program has identified three independent populations of spring-run Chinook salmon (Butte Creek, Feather River and Mill/Deer Creek)for use as sources for the San Joaquin River experimental population. Use of screw traps is the preferred method for collecting juveniles due to the presence of existing screw trap programs. Where screw traps are not feasible because of the presence of indistinguishable fall-run Chinook, fish will be collected further upstream to target collection of spring-run Chinook exclusively. In this case, alternative collection techniques may include electro-shock or use of seine nets or other forms of fish trap. The Program will also investigate utilizing the existing Interagency Ecological Program (IEP) trawling stations in the Sacramento-San Joaquin Delta to collect spring-run Chinook smolts that are incidentally caught in the trawls, particularly during the early phases of reintroduction, or when sources of donor fish are in short supply.

Offspring of the returning adults to the Restoration Area may be collected by screw trap, seining, or electro-shocking at locations to be determined in the future. These returns won't start until 2014 at the earliest, and may not begin until 2020, so additional details will be included in

the 5 year update of this HGMP. Collection of broodstock as juveniles as opposed to eggs from the offspring of wild returning adults that have successfully spawned in river would benefit the Conservation Facility's captive rearing program by further reducing the effects of hatchery-induced selection. Details on collection methods are presented in HGMP Section 7.

5.2) Fish transportation equipment (description of pen, tank truck, or container used).

Both juvenile and adult salmon will be transported by a 500 gallon insulated aluminum fish hauling tank. The tank will incorporate mechanical aeration and diffused gaseous oxygen. Fish will be transferred "in-water" in purse-style stretchers that hold both fish and water (e.g. water-to-water transfer). Direct netting of fish will be minimized to the greatest extent possible to reduce injury and fish stress.

5.3) Interim Facility

A small-scale, Interim Facility will begin operation in Fall 2010 with fall-run Chinook salmon to provide the Program practical experience captive rearing juvenile Chinook salmon in the new facilities prior to working with FESA and CESA listed fish. See Figures 5.3 and 5.4. Once capital funding has been secured, construction of the full-scale Conservation Facility will begin, ideally in 2011, although delays in the state budget process or delays in allocation of the funding may delay construction. In 2011, the permit to work with listed spring-run Chinook salmon will still be under review, and the Interim Facility will continue its work with fall-run Chinook salmon. Information gained from the Interim Facility will be used to improve the design features of the full-scale Conservation Facility.

Figure 5.3. Interim Conservation Facility conceptual diagram.

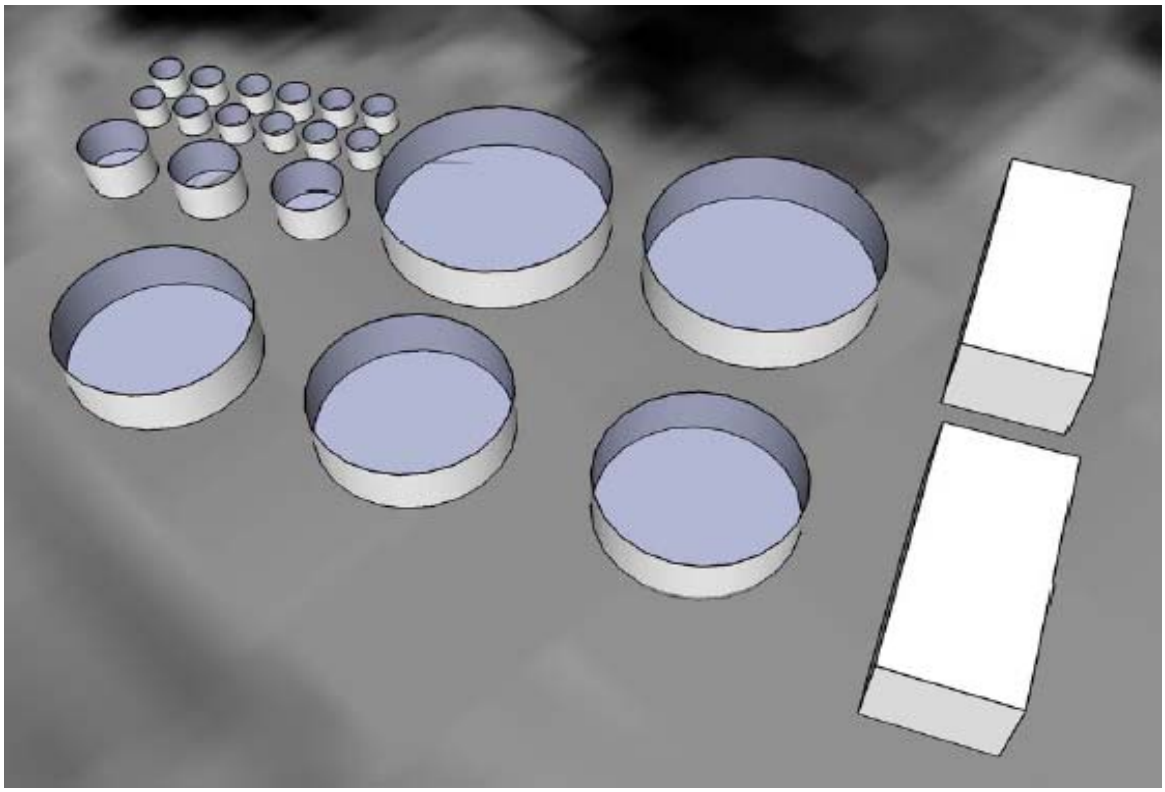

Figure 5.4. Interim Conservation Facility conceptual diagram, detailed view.

5.3.1) Broodstock holding and spawning facilities (Interim Facility)

Initially, Broodstock holding facilities will be composed of twelve 3-ft circular tanks, three 6-ft circular tanks, three 16-ft circular tanks and two 20-ft circular tanks. The system will be designed to spawn a total of approximately 50-100 adult salmon annually. Gravity-fed water will be delivered to each tank. Tanks will be covered by portable carports and each tank will be individually screened to prevent fish from jumping out.

5.3.2) Incubation facilities (Interim Facility).

The Interim Facility will have available two 12-stack vertical tray incubators, two deep matrix incubators, and one moist air incubator (See details in section 5.4.2 below).

5.4 Full-scale Conservation Facility

If there are no budget delays, the full-scale facility should begin operations in 2014, at which time the Interim Facility will be integrated into the full-scale facility.

5.4.1) Broodstock holding and spawning facilities (Full-scale Conservation Facility)

A pre-engineered metal shell spawning shed will be equipped with spawning tables, egg processing equipment and associated plumbing. Fish will be able to swim from their culture tanks to the spawning shed for processing.

5.4.2) Incubation facilities (Full-scale Conservation Facility)

The incubation room (10-ft x 50-ft) will be part of a common hatchery building, with an entrance from the outside, and an entrance to a fry production room. Each entrance will be fitted with a disinfection foot-bath and a hand sanitizing station. The room will provide low light conditions for incubation and will use multiple styles of incubators for egg development. The incubation system will allow segregation of a total of 980 individual crosses.

- **12 Tray Vertical Egg Incubators** (MariSource, Fife, WA)
  - 10 units total, each with a 120,000 egg capacity, totaling of 1.2 million eggs
  - Four sections per tray, providing increased segregation for parental crosses, allowing 480 individual crosses
  - Opaque panels to provide dark conditions during incubation

- **Moist-Air Incubator** (ARED Inc., Wrangell, AL)
  Each unit includes the following:
  - 220 individual trays per unit to allow isolation and tracking of individual parental crosses, totaling the ability to hold 440 crosses simultaneously
  - Capacity for hatching 600,000 Chinook salmon eggs
  - Ability to perform precise thermal marking of otoliths
  - Ability to control temperature and speed or slow egg development, or mimic in-river conditions
  - Provides a dark environment for incubation

- **Deep Matrix Full Immersion Incubator** (ARED Inc. Wrangell, AL)
  - Hatches approximately 200,000 eggs
  - Provides a substrate for hatching to mimic in-river conditions by requiring "emergence".

5.5) Rearing facilities

Rearing facilities are organized into three main areas; fry production, smolt production, and captive rearing. The fry production facility is part of a larger common hatchery building that contains the following:

Hatchery Building

1. Fry Production: Fish will be reared from the unfed fry stage to approximately 3 grams each.

a. Culture tanks – 72 small circular tanks – 36-inch wide x 30-inch high
b. Automatic 24 hour belt feeding system
c. Natural lighting and available artificial lighting
d. Space heaters
e. Roof ventilators
f. Associated plumbing
g. Work benches and storage cabinets
h. Chemical storage: built-in shelving
i. Mud room / Lockers: gear lockers
j. Freezer: built-in walk-in freezer
k. Laboratory: built-in counters, HVAC and general lighting
l. Research / Isolation: built-in counters, HVAC and general lighting
m. Office Space: manager's office and open office for two staff. HVAC and general lighting
n. Break Room and Storage: sink and counter, HVAC and general lighting
o. Restrooms: separate male and female restroom, HVAC and general lighting
p. Covered Work Area: metal roof covering over the concrete slab, 24' x 110'

Utility Building

A utility building to provide the following:

1. 2-bay vehicle garage: overhead doors
2. Dry feed storage: overhead doors
3. Work area: built-in counters and cabinets, general lighting
4. Storage space and pump room

Exterior Hatchery Area

1. Outdoor Smolt Production: four banks of culture tanks (five 16-foot tanks in each bank), automatic feeders, netted or solid roof bird enclosure. Flow-through water system. Used for smolt production from 3 grams to 7.5 grams and yearling production from 7.5 grams to 75 grams.
2. Captive Rearing: four banks of culture tanks (one 30-foot tank and three 20-foot tanks in each bank), automatic feeders, solid roof bird enclosure and possible water reuse system. Used for adult production from yearlings (75 grams) to adults (> 1 kilo)
3. Volitional Release Channel: 3-foot wide, between fish culture tanks to be used for volitional release and transporting fish to the adjacent spawning shed.
4. Ultraviolet water treatment will be used on a portion of water supply after exiting the aeration assembly.
5. Effluent from hatchery building and bottom drains from fish culture tanks to be directed via gravity flow to micro-screen drum filters. Filtered water is directed to a common discharge point on the river. Sludge from drum filters to be directed to drying pond for disposal. Existing settling ponds to be lined, refurbished, and used for additional effluent treatment as required.

5.6) Acclimation/release facilities

Three 20-ft diameter x 5-ft high circular tanks to be used for fish holding, quarantine and acclimation of all wild fish entering the Conservation Facility will be located at the perimeter of the facility. Each tank will have an independent water flow (flow through) and will allow for disease treatments with the ability to properly dispose effluents that contain treated water. Water entering these tanks will be prescreened using a micro-screen drum filter with a minimum screen pore size of 80 micron. In addition, water will be pretreated with UV radiation for disinfection. Fish health will be monitored by CDFG pathologists. Treatment methods prescribed by fish pathologists for disease outbreaks and treatment protocols will be carried out by hatchery staff. Depending on the nature of an outbreak, treatment methods may vary. Salt (NaCl), potassium permanganate ($KMnO_4$), formalin, or hydrogen peroxide may be used, as allowed by the hatchery discharge permit. Other Investigational New Animal Drugs (INAD) such as ivermectin may be used in accordance to United States Food and Drug Administration guidelines. Treatment of bacterial infections could include the use of oxytetracycline, florfenicol or other approved antibiotics. All treatment will follow veterinary guidance and will be used and monitored according to wastewater discharge requirements (NPDES). Diagnostic procedures for pathogen detection will follow American Fisheries Society professional standards as described in AFS-FHS 2007..

5.7) Describe operational difficulties or disasters that led to significant fish mortality.

Water deliveries have been very reliable to the existing adjacent trout hatchery which receives water from the same major supply line as the proposed Conservation Facility. In the past 55 years, there was one major interruption to water flow that occurred in 1992 when a work crew accidentally ruptured the main line.

Flooding occurred at least once in recent history when in 1997 the trout hatchery raceways were inundated by floodwater due to high river flows. At that time, many fish from the trout hatchery escaped to the adjacent San Joaquin River. In the event of future flooding, it is possible that fish from both facilities will again be released to the river. Fish tanks will be designed to withstand full emersion during a flooding and tanks will be netted to prevent escape.

5.8) Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

The culture system will be designed to prevent fish loss due to system failure. Water for the fish culture system will be gravity fed, thereby reducing risk of interruption to flow by eliminating the use of electric pumps that are susceptible to failure by power outages. In addition, each tank will contain a water monitoring and alarm system that will alert culturists of low dissolved oxygen levels, interruption to water flow, high or low water temperatures, or high or low water levels. The monitoring system will be integrated with a backup oxygen system that

will trigger a solenoid for the supply of gaseous oxygen from compressed oxygen cylinders in the event of low oxygen conditions.

The facility will be staffed with three fulltime personnel. The planned facility is adjacent to the present trout hatchery housing and it is anticipated that two additional residences will be added to the site to provide housing for the new hatchery staff and to further improve security at the new hatchery. Personnel will be trained on emergency procedures, conduct drills on response timing to alarms; and the development of a fish release plan.

5.9) Possible off-site rearing facilities

5.9.1) University of California Davis CABA facility

The Conservation Program may at times utilize the Center for Aquatic Biology and Aquaculture (CABA) at the University of California Davis (UC Davis) for the purpose of research or short-term holding and rearing. CABA was established to provide leadership, focus, and support to UC Davis researchers in addressing problems associated with California's cultured and wild aquatic biological resources. CABA and its aquatic research facilities provide the basic infrastructure to allow departments within the College of Agriculture and Environmental Sciences, as well as campus-wide, to conduct multidisciplinary and interdepartmental research and associated programs. These activities provide the scientific base to sustain California's natural populations of aquatic species, support the technological framework of the state's marine and freshwater aquaculture industries, and create sustainable aquaculture production.

The heart of CABA's aquatic research and student training program is a five-acre facility housing laboratories and aquatic animal containment resources. There is research and student training space for a wide range of programs, including fish ecology, reproduction, nutrition, genetics, endocrinology, disease and pathology, aquaculture engineering, aquatic toxicology, and general aquatic biology.

5.9.2) Mokelumne Hatchery

The Conservation Program may at times utilize the CDFG's Mokelumne River Fish Hatchery (MRFH) for offsite emergency captive rearing. MRFH would be used to rear a single year class of Chinook to maturity in the event that the San Joaquin facilities were not available. Fish would be hatched in the incubation room and later transferred to 10-ft to 16-ft circular isolation tanks that are located at the facility's perimeter. Mature fish reared at MRFH would be spawned and the fertilized eggs would be immediately transferred to the Conservation Facilities in Friant for incubation, hatching and eventually released to the San Joaquin River.

MRFH is located in Northern California in northeast San Joaquin County at the base of Camanche Dam on McIntire Road. Facilities are located on property owned by East Bay Municipal Utility District and include a fish weir, fish ladder, gathering and holding ponds,

rearing ponds, various hatchery, office, shop, and storage buildings, fish transportation equipment, percolation ponds, and miscellaneous equipment and supplies.

Mokelumne River Fish Hatchery incubation building contains 34 incubator stacks with 16 trays in each stack. Water from an overhead 3-inch pipe provides water to the top tray of each stack, which is empty to buffer the force of the cascading water. The hatchery building also has 48 fiberglass troughs and 96 upwelling jars in the fiberglass tanks.

The hatchery building uses 7 cfs (3,141 GPM) of water during peak production. Supply water to the hatchery building is filtered through sand media filters with 10 micron particle removal capacity, and can be chilled (1.0 to 3.5º C cooler than ambient). The tandem 65-ton chiller unit is used when water temperatures to the hatchery building exceed 14.5°C and is typically only used about 6 weeks each year (Lee 2009).

Figure 5.5. Mokelumne River Fish Hatchery.

SECTION 6. BROODSTOCK ORIGIN AND IDENTITY

Describe the origin and identity of broodstock used in the program, its ESA-listing status, annual collection goals, and relationship to wild fish of the same species/population.

For a more detailed review of potential broodstock and the broodstock identity decision, please see the Stock Selection Strategy: spring-run Chinook salmon

6.1) Source.

The Conservation Facility has not yet begun operation, so there are no historical sources of broodstock for the program.

The Conservation Facility plans to use a simultaneous multiple stock reintroduction, adaptively managed to accommodate broodstock availability and to adapt to new information on reintroduction successes. Stock will be sourced from Feather River, Butte Creek and/or the Deer/Mill Creek complex. Due to low genetic diversity within these stocks, reintroduction should include at least two and potentially three stocks, although reintroduction may proceed with one stock if viability criteria preclude use of additional stocks.

6.2) Supporting information.

6.2.1) History and Annual size.

Please see HGMP Section 2, above, for information on run history and run size for the potential broodstock.

6.2.2) Past and proposed level of natural fish in broodstock.

The Program will natural (non-hatchery) fish, that is, fish whose parents are not identified as hatchery progeny; however, if necessary, FRH fish may be utilized. While the Program is using the Interim Facility, and the full-scale Conservation Facility is under construction, the Program will seek to collect enough juvenile fish and eggs each year to year a total of 50-100 relatively unrelated females and 50-100 relatively unrelated males to breeding age, coming from up to three source populations, depending on availability. The Program should include fish from at least two and up to three of the potential broodstock source populations.

Once the full-scale facility is in use, the Program will collect more broodstock, up to enough juvenile fish and eggs each year to rear 150-450 adult pairs, 50-150 from each of the three source populations annually, for four years to eight years, or longer, depending on availability. Returning naturalized adults may be incorporated into the broodstock, although returns are not expected until 2015 or later.

The total number of broodstock collected from each source population, over the course of the reintroduction, will depend on the viability of those stocks and the effects of removal on the

associated risk factors. While source population viability will likely limit the number of fish collected, collection goals are based on the number of fish necessary to capture the genetic diversity of the source stocks. Because all three potential source populations are distinct, they must be considered independently when setting collection goals. If large numbers of fish are available from all three source populations, broodstock collection could be undertaken at a higher rate to assist in meeting Program escapement goals. All three populations should be used in roughly equal proportion; using one population at a much higher level than the others would overwhelm the genetic diversity in the other, smaller populations.

The benefits of protecting genetic diversity in Salmonid populations are well documented; Table 6.1 provides a partial list of the benefits of maintaining genetic diversity. The total number of fish collected from each source population determines the effective population size of the founding population (N_e), which in turn determines the amount of genetic diversity from the source population that is initially represented in the new population. For salmon, if one assumes that N (adult census size) = N_e, N_e can be estimated as the number of

Function of salmonid genetic diversity	**References**
Maximizes the potential for species to respond to environmental change	Utter (1981); Waples (1991, 1995); Ryman et al. (1995)
Protects the progenitors of future biodiversity (e.g., new species)	Bernatchez (1995); Taylor (1999); see also Bowen (1999)
Reduces the likelihood of extinction	Waples (1995); Dodson et al. (1998)
Long-term species persistence	Utter (1981); Waples (1991); Ryman et al. (1995); Taylor (1999)
Short-term population viability	Dodson et al. (1998)
Maintenance of natural evolutionary processes	Waples (1991, 1995); Dodson et al. (1998)
Protection of different habitats, and potentially ecosystem functioning	Waples (1991, 1995); Allendorf et al. (1997)
Maintenance of local adaptations	Waples (1991, 1995); Dodson et al. (1998)
Maintenance of ecosystem stability	Riddell (1993)
Permits humans to understand how salmonid biodiversity arises	Taylor (1999)
Development of proper restoration guidelines if some natural systems are conserved	Riddell (1993); Fraser and Bernatchez (2008)
Potential future resources for humans	Waples (1991); Fraser et al. (2006)
Potential future resources for aquaculture programs	O'Reilly and Doyle (2007)

Table 6.1. Benefits of conserving genetic diversity in Salmonids. Originally Table 3 in Fraser et al. 2008.

breeders per year

(N_b) summed over salmon's four year generation time (Waples 1990). While this assumption is generally not good, the Conservation Facility can approximate the assumption by using broodstock composed of nearly equal proportions of males and females, with roughly

equal family sizes. A four year generation time is appropriate here because, as noted in HGMP Section 2, above, the source populations for which data are available all have significant portions of the adult population returning at ages three and four. The assumption that $N = N_e$ depends on unrelated spawners, an equal sex ratio and equal family sizes, which can be approximated in a hatchery using factorial mating. Thus, for a hatchery that uses 50 adult fish per year ($N_b = 50$), generational N_e is approximately 200 fish, if hatchery conditions approximate the assumptions.

Recommendations on the ideal number of fish to use for broodstock vary. Frankel and Soule (1981), Miller and Kapuscinski (2003), and Moyer et al. 2008 recommended 50 individual fish from each source population as the bare minimum. Kincaid (1983) recommended 50 breeding pairs, and Allendorf and Ryman (1987) recommended a minimum of 100 breeding pairs from each source population. These recommendations for the minimum number of fish all produce significantly less diversity in the broodstock than is found in the source population (Table 6.2). For example, if a hatchery uses 50 fish per year for four years, the chance of losing a rare allele with a frequency of 0.5% in the source population is over 10%. Garza et al. (2008) examined 20 microsatellites in the Feather River spring-run, and found 373 alleles for those microsatellites (Table 6.3). Of those 373 alleles, 55 (~15%) were present at a frequency of .005 or less, and a hatchery following the minimum collection numbers presented above would lose, on average, just over 7 alleles. More broadly, any effort to capture the genetic diversity of a source population inherently makes tradeoffs between Program capacity (and resilience of the source population to fish collection) and the genetic diversity represented in the broodstock population.

Allele frequencies for very rare alleles are both extremely difficult to estimate accurately and are ephemeral, varying substantially every year and every generation. Moreover, even calculating the frequencies accurately at a single point in time require very large sample sizes due to the rarity of the alleles. For example, an allele found only once in the Feather River population would have a frequency of 1/(276*2) = 0.0018, because the sample size for the Feather River was 276 fish and each fish has two alleles for each locus. The lowest calculable allelic frequencies for the other 3 source populations is higher, given their smaller sample sizes. Further, It is important to distinguish the genetic marker variation that is measured by relatively small sets of microsatellite and SNP markers from the quantitative genetic variation that is the actual material for natural selection and adaptation. Migration and mutation may introduce important genetic variation during the program period that would counteract the loss of diversity due to genetic drift/founder effects. In particular, outcrossing may provide combinations of alleles in the experimental population that are not found in the source populations. In the face of selective factors in the restored San Joaquin River, these novel combinations may provide adaptive potential that is not adequately represented by measures such as heterozygosity and allelic richness of a small set of marker genes. Because the frequencies for very rare alleles cannot be accurately calculated, and because the frequencies of marker genes are only a proxy for the quantitative genetic variation, the goal N_e will have to be chosen largely based on the theoretical figures in Table 6.2, with the aim of achieving as high an Ne in the hatchery as possible.

Larger broodstock populations will generally better capture genetic diversity in the source populations (Allendorf and Ryman 1987; Frankham et al. 2002), provided that there is minimal variance in family size/relatedness in the source population collections. Fraser et al. (2008) reviewed recommendations for the level of diversity that should be maintained in hatchery populations over time and found recommendations ranging from retention of 90% of genetic diversity (e.g. allelic richness, heterozygosity) over a 100-year period (Frankham et al. 2002) to a decrease in mean heterozygosity of 1% per generation (Franklin 1980, Frankel and Soule 1981). However, Fraser et al. concluded:

> [T]here is currently no empirically or theoretically justifiable answer to the question 'how much genetic diversity is enough to conserve a species or population?' Additionally, a rate of loss of heterozygosity of 1% per generation might be acceptable in benign agricultural environments but has not been tested on captive reared salmonids or other fishes that will be released into the wild (Naish et al. 2008). In reality, the goal of any captive breeding program should be perhaps to conserve as much genetic diversity as possible [2008].

Faced with this lack of concrete guidance, a breeding program should seek to capture a representative sample of the source population diversity, minimize founder events and the consequent loss of the natural populations' diversity through genetic drift, while also recognizing that natural selection and adaptation in the restored San Joaquin River may result in lower diversity due to the consequent variance in family size. Measures of marker genetic variation could be further affected by genetic hitchhiking effects. An N_b of 300 fish per year for 4 years, producing an N_e of 1200 fish, should capture the vast majority of the genetic diversity in a given source population. As seen in Table A, an N_b of 300 fish has a less than 1% chance of not including alleles present at a frequency of only 0.002 in the source population and a less than 10% chance of not including alleles present at a frequency of 0.001 in the source population. An introduction using 300 fish per year for 4 years from each source population should produce a broodstock with marker genetic diversity very similar to the source populations, assuming a relatively unrelated broodstock and a 1:1 ratio of males to females and similar family sizes. If the source populations are unable to support this level of extraction, a lower number of fish may be used, but the hatchery may need to continue importing natural fish from the source populations for a longer period (Moyer et al. 2009) to improve the odds that the variation in the source populations will be present in the experimental population. However, as naturalized fish begin to return and fish are outcrossed or outcross naturally, the frequencies of particular alleles will vary significantly from the source populations. Continued genetic monitoring can determine the degree to which the broodstock captures the genetic diversity in the source population, and the extent to which returning adults reflect the diversity in the broodstock; the monitoring results should guide the Conservation Facility's continuing broodstock collection.

Finally, taking a larger or smaller number of broodstock from one source population may reduce some of the benefits of using multiple sources, so broodstock should optimally be taken at the same level from all source populations. Taking a larger or smaller number from one population may reduce some of the benefits of using multiple sources for broodstock. If this is

not possible because one of the three populations cannot support removal of a significant number of fish, the hatchery may compensate by drawing natural fish from that population for a longer period than from the other sources, which will increase the diversity captured from that population.

	Feather River	**Butte Creek**	**Deer Creek**	**Mill Creek**
Frequency of allele	373 total alleles	293 total alleles	296 total alleles	278 total alleles
Less than .005	55	32	NA	NA
Less than .004	42	20	NA	NA
Less than .003	34	0	NA	NA
Less than .002	2	NA	NA	NA
Less than .001	NA	NA	NA	NA

Table 6.2. Number of alleles found below 5 levels of low frequency in the source populations. Allele frequencies below .002 for Butte Creek and below .005 for Deer and Mill Creek cannot be calculated using available data. Based on data from Garza et al. 2008.

	N_e	100	200	400	800	1200	1600	2000	2400
	N_b	25	50	100	200	300	400	500	600
Frequency of allele in population	0.01	13.40%	1.80%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.009	16.40%	2.69%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.008	20.06%	4.02%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.007	24.54%	6.02%	0.36%	0.00%	0.00%	0.00%	0.00%	0.00%
	0.006	30.01%	9.01%	0.81%	0.01%	0.00%	0.00%	0.00%	0.00%
	0.005	36.70%	13.47%	1.81%	0.03%	0.00%	0.00%	0.00%	0.00%
	0.004	44.86%	20.12%	4.05%	0.16%	0.01%	0.00%	0.00%	0.00%
	0.003	54.83%	30.07%	9.04%	0.82%	0.07%	0.01%	0.00%	0.00%
	0.002	67.01%	44.90%	20.16%	4.06%	0.82%	0.17%	0.03%	0.01%
	0.001	81.86%	67.02%	44.91%	20.17%	9.06%	4.07%	1.83%	0.82%

Table 6.3. Chance of not including an allele in the broodstock, given the size of the broodstock population and the alleles frequency in the source population.

6.2.3) Genetic or ecological differences.

The three potential source populations exhibit some genetic and ecological differences, and additional differences can be inferred based on their instream habitat use. HGMP Section 2 presents information on run timing and habitat preferences; this section addresses genetics and temperature tolerances.

6.2.4) Genetic Differences

The three potential source populations are genetically distinct, when the Mill Creek and Deer Creek populations are treated as a single population for purposes of stock selection (Banks et al. 2000, Garza et al. 2008). While the Mill and Deer Creek stocks are marginally genetically

differentiated, it is not clear that the slight differences in observed allele frequencies are biologically significant and due to anything other than family structure. As such Banks et al. (2000) and Garza et al. (2008) concluded that the two stocks should be treated as a single complex due to the high degree of gene flow and similar phenotypes. The degree of genetic differentiation found between the Feather River fall and spring-run fish is similarly slight; however, the phenotypic differences between the Feather River spring-run and fall-runs warrant their treatment as two separate populations for reintroduction purposes.

Three studies have evaluated the relative genetic diversity of the three potential spring-run source populations. Banks et al. (2000) conducted a microsatellite study of the Mill/Deer Creek and Butte Creek stocks, excluding fish from the Feather River spring-run stock and found that the observed heterozygosity was essentially identical in the two stocks – 0.61 vs. 0.62 in the Mill/Deer and Butte Creek stocks, respectively. They found that the allelic diversity, as measured by the average number of alleles observed per locus, was about 6% higher in the Mill/Deer Creek stock than in the Butte Creek stock (6.60 vs. 6.18 respectively), although the difference did not appear to be statistically significant.

Garza et al. (2008) supplies a second dataset, consisting of data for 20 microsatellite loci from Chinook salmon sampled in 2002 & 2003. These data are discussed above, in HGMP Section 6.2.3. To recap the salient results, the observed heterozygosities were 0.77, 0.77, 0.74 and 0.78 for Mill Creek, Deer Creek, Butte Creek and Feather River stocks, respectively. The mean allelic richness per locus of the Mill Creek, Deer Creek, Butte Creek and Feather River stocks were 11.09, 10.85, 9.76 and 11.25, respectively. The statistical significance of these differences was not reported, but all of the values appear to be relatively low and suggest a lack of diversity and the presence of past bottlenecks in these populations.

Finally, the third dataset consists of recent unpublished data from 169 single nucleotide polymorphism (SNP) loci developed by the Genetic Analysis of Pacific Salmonids (GAPS) consortium and by the Molecular Ecology and Genetic Analysis Team of the Southwest Fisheries Science Center (Garza unpublished). In this study, Deer and Mill Creeks were considered as one population. Data were available for the Deer/Mill Creek (N=71), Butte Creek (N=54) and Feather River (N=94) spring-run stocks. The SNP dataset found the observed heterozygosity was 0.29, 0.26 and 0.31 in the Mill/Deer Creek, Butte Creek and Feather River stocks, respectively. The mean number of alleles was 1.91, 1.88 and 1.91 in the Mill/Deer Creek, Butte Creek and Feather River stocks, respectively. Again, the statistical significance of any differences in these means was not reported.

While the significance of the observed differences is not reported for these three studies, the measures of genetic diversity in all three of the datasets were the lowest for Butte Creek, intermediate for Mill/Deer Creek and the highest for Feather River spring-run fish. The biological significance of these data in terms of spring-run are unclear, given the known introgression of fall-run genes in the spring-run fish in the Feather River population (tagging studies have found that some offspring from Feather River spring-run mating return as fall-run fish, and vice versa (CDFG 1998)). The higher allele number and higher heterozygosity in the Feather River are likely due, at least in part, to this observed introgression. The higher diversity

in Mill/Deer Creek is consistent with the small differentiation between those populations and the larger mean estimated census size in that combined population. Further, while the data do not allow strong conclusions about the relative risks of inbreeding depression in each stock, all three stocks have low genetic diversity and should not be used as a sole source for the reintroduction due to the high risk of inbreeding and reduced adaptive potential.

6.2.4.1) Temperature Tolerances

Figures App. 4.A and App. 4.B in Appendix 4 provide an overview of water temperatures in the potential source watersheds. Figures App. 4.C through App. 4.F in Appendix 2 offer data on restoration area temperatures for comparison. Figures App. 4.C through App. 4.E in Appendix 2 present data on current temperature conditions at varying distances downstream from Friant Dam. Figure App. 4.F presents computed temperatures for the period from 2000 to 2004, under a settlement operation simulation, at varying distances from the dam. Figure App. 4.G. presents temperatures in the San Joaquin Fish Hatchery in 2001, 2008, and 2009; the Conservation Facility will draw its water from the same source as the San Joaquin Fish Hatchery and should have similar water temperatures.

Figure App. 4.A provides temperatures for the highest elevation locations in Butte, Deer, and Mill Creeks for which consistent temperature data were available over the period of interest. Figure App. 4.B provides temperatures for the lowest elevation locations in Butte, Deer, and Mill Creeks for which consistent temperature data were available over the period of interest. Both figures include Feather River Hatchery water temperatures, and temperatures from the bottom of the Low Flow Channel (LFC) of the Feather River, where two-thirds of spring-run spawning takes place. Temperatures in the High Flow Channel (HFC) of the Feather River are higher, up to 71-77°F, although most spring-run Chinook salmon outmigrate from the Feather River as fry and do not experience those high temperatures. In contrast, many juveniles from Butte, Deer, and Mill creeks outmigrate as yearlings and are exposed to a wide range of water temperatures.

Water can be released from Oroville Dam through a multilevel outlet to provide appropriate water temperatures for the operation of the Feather River Hatchery and to protect downstream fisheries (NMFS 2009), which results in more consistent water temperatures for the Feather River than for the other three populations. In the LFC, peak temperatures range from 61°F upstream of the Feather River Fish Hatchery to 69°F upstream of the Thermalito Afterbay Outlet (FERC 2007). Peak water temperatures in the HFC range from 71 to 77°F, and river cooling begins in late August, with minimum temperatures of 44 to 45°F reached by January or February.

The other three source streams all vary widely throughout the year, based on flow conditions and air temperatures. Generally, water temperatures in all three remain within roughly 5 degrees of one another (Figures App. 4.A and App. 4.B), and at lower elevations, Butte Creek is generally the warmest of the three.

Finally, as noted in the Stock Selection Strategy, disease outbreaks within the Butte Creek spring-run Chinook salmon population have generally occurred during the summer

holding period, ranging from a low in 2004 of 418 pre-spawn mortalities out of an estimated population of 10,639 to a high in 2003 of 11,231 pre-spawn mortalities out of an estimate population of 17,294 (Ward et al. 2007). In 2003, fish mortality was attributed to the high number of fish concentrated in limited holding pools with high water temperatures, and an outbreak of two diseases *Flavobacterium columnare* (Columnaris) and the protozoan *Ichthyophthirius multiphilis* (Ich) (Williams 2006). The mortalities during 2002 and 2003 coincided with significant daily average water temperatures above 19.5°C (67 °F). This population appears to experience strong ongoing selection for high water temperatures, although Deer and Mill Creek may be undergoing similar selection. Spring-running salmon in the Feather that spend significant periods of time in the High Flow Channel may experience similar selection.

6.2.5) Preferred Alternative and Reasons for Choosing

The Technical Advisory Committee (TAC), required by the settlement agreement, crafted recommendations to drive the stock selection process. The broodstock selection process aims to identify the stock(s) with the highest likelihood of establishing a self-sustaining naturally reproducing population in the San Joaquin River restoration area. The TAC developed seven criteria for considering the most appropriate stock(s) for reintroduction on the San Joaquin River:

(1) stock should be of local or regional origin from the Central Valley;

(2) stock should be genetically diverse;

(3) stock should take into account the status of the source population;

(4) stock should not jeopardize existing Chinook salmon stocks in the San Joaquin River basin;

(5) stock should have life-history characteristics that maximize probability of successful reintroduction into the San Joaquin River;

(6) stock should have behavioral and physiological characteristics that fit conditions expected to occur on the San Joaquin River; and

(7) stock should not be of hatchery origin, except under extreme circumstances.

Using these criteria, the TAC undertook an initial review of the available stocks and made the recommendations paraphrased below (Numbering follows the TAC recommendations document):

Recommendation 12: The founding stock should be selected from currently existing stocks inhabiting the Central Valley to maximize the likely success of local adaptation to the San Joaquin River.

Recommendation 13: The founding stock should have adequate genetic material (i.e., population abundance and genotypic/phenotypic diversity) to allow San Joaquin River specific pressures to eventually produce a locally adapted stock.

Recommendation 14: Factors that should be considered when selecting the founding stock(s) include current trends in abundance of source spring-run Chinook salmon populations (e.g., Butte Creek population), whether existing habitat conditions within a source watershed are fully used (e.g., are "surplus" fish available for relocation with minimal or potentially beneficial effects), logistic conditions affecting the ability to successfully collect and transport adults, eggs, or juveniles, and the genetic characteristics of the founding stock.

Recommendation 16: A founding stock should be selected that has behavioral and life history characteristics most compatible with the anticipated conditions on the San Joaquin River.

Recommendation 17: Wild stocks should be evaluated from various Central Valley rivers as a founding stock with the goal of maximizing, to the extent possible, the genetic diversity of the founding stock to support the greatest degree of local adaptation to the San Joaquin River and to match the compatibility of life history characteristics with anticipated future environmental conditions.

Recommendation 18: A technical report should be developed that compiles, synthesizes, and integrates information on the life history characteristics and genetics of candidate stocks along with an assessment of the compatibility of each stock with anticipated future environmental conditions on the San Joaquin River to support a recommendation regarding the selection of one or multiple founding stocks for the reintroduction strategy.

Finally, the TAC recognized several risks and uncertainties in broodstock selection:

- Selected broodstock(s) may not capture the genetic variation needed to promote a long-term naturally self-sustaining population in the Restoration Area.
- An overlap in migration run-timing and lack of spatial separation between mature spring-run and fall-run Chinook salmon in the Restoration Area are expected to result in the genetic introgression of the two populations.
- Removal of broodstock fishes from source population(s) may increase the risk of extirpation of the source population(s).

Per the last recommendation, the Genetics Subgroup of the FMWG developed the Stock Selection Strategy, which provides a detailed discussion of the stock selection process and the justification for the decision to pursue a multistock approach. Briefly, the Genetics Subgroup limited consideration of source populations to the largest three populations of spring-run Chinook salmon in the Central Valley, the populations on Deer/Mill Creek, Butte Creek, and the Feather River. Other populations were considered and rejected as too small, too ephemeral, or not well characterized. The Genetics Subgroup focused on genetic considerations, current

(census) population size, compatibility of life history characteristics to anticipated restored Restoration Area conditions, and availability of broodstock.

Genetic Considerations

Genetic considerations include effective population size (and risk of inbreeding), hatchery influence, and hybridization.

As noted above, all three source populations have low genetic diversity, with minimal differences in diversity between the three populations. While the Feather River generally shows marginally higher diversity than the other two populations, many of the genetic markers used to study these populations are in linkage disequilibrium in the Feather River population, suggesting recent or ongoing hybridization with the fall-run salmon. This hybridization results in higher genetic diversity for the population. This higher diversity does not necessarily indicate a larger effective population size of pure spring-run fish. Using any single population would likely result in a reintroduced population with depauperate genetic diversity. No additional conclusions about which population should be used can be drawn based on their relative genetic diversity.

The Feather River alone has a strong hatchery influence. The Deer/Mill Creek Complex has no history of spring-run hatchery introductions, and the introductions of Feather River fish to Butte Creek does not appear to have had any appreciable genetic impact, perhaps due to poor returns or a high degree of straying. Further, observed introgression between fall- and spring-run populations is only present in the Feather River population, and only the Feather River run is more genetically similar to fall-run populations than to other spring-run populations. Feather River fall-run fish may return during the spring-run, and some spring-run offspring return during the fall (J. Kindopp, pers. comm.). As noted in the Stock Selection Strategy, these factors have prompted the Technical Advisory Committee of the SJRRP to recommend against the use of the Feather River Hatchery stock or any other hatchery origin stock for use in reintroduction (Meade 2007). Nevertheless, the Genetic Subcommittee believes that several factors indicate that the Feather River should not be disqualified:

- Feather River stock may possess remnant alleles from the four presumably independent populations that once existed in the four Feather River tributaries above Oroville Dam.

- Lindley et al. (2004) indicated that of all 18 historic independent populations of spring-run Chinook salmon in the Central Valley ESU, the historic environmental conditions in the Feather River most resembled historic conditions in the San Joaquin River.

- Presumed adaptations to Oroville Dam (Bunn and Arthington 2002, Angilletta *et al*. 2008) could potentially benefit the Feather River stock, which would experience similar conditions in the Restoration Area.

- Feather River spring-running fish will benefit from release into a location where they may be spatially distinct from fall-run fish.

- Feather River fish possess increased genetic diversity that, although likely a result of introgression with fall run fish, may nevertheless allow it to achieve higher survival rates in a stochastic environment like the Restoration Area.

- Ease of accessing the Feather River stock in years of normal to high escapement.

Population Size

Population size data are reviewed in HGMP Section 3. While all three populations have declined in recent years, the use of juvenile fish or eggs to develop a broodstock of up to 300 adults per year for four years should result in a *de minimus* impact on any one of the source populations. For an average wild Chinook salmon population, out of 100 eggs, only 40 will hatch and emerge as fry (Quinn 2005). Only 10 fish from the original 100 eggs will survive to smoltification (Quinn 2005). Ninety-seven percent of the smolt will die before becoming adults (Quinn 2005). Factoring in adult mortality, removal of the maximum number of eggs and juveniles discussed here, 950, would be equivalent to the removal of a very small number of adult spawners, on the order of one to three fish from any population, at the high end. In contrast, hatchery survival rates are much higher, and taking 950 eggs or juveniles will allow the hatchery to produce at least 300 broodstock fish.

Of the three populations, Butte Creek has the largest census size according to the GrandTab database, although the size of the Feather River population is very difficult to estimate, as discussed in Section 3. However, the Feather River population is the only population under active hatchery supplementation, so taking fish from the Feather River population should have impacts that could be more easily mitigated through increased production at the FRH.

Life History and Phenotypic Characteristics

Table 3.1 in HGMP Section 3 provides an overview of the life history characteristics of the three source populations. The extent to which these characteristics are caused by phenotypic plasticity driven by habitat characteristics in each source watershed as opposed genotypic characteristics of the population is unknown, so drawing accurate conclusions about the populations' life histories in the restored San Joaquin River is not possible at this time. Nevertheless, potentially pertinent differences were identified:

- Deer and Mill Creek fish spawn and hold at high elevations, while the restored San Joaquin River habitat will be at a low elevation. While the target temperatures identified in the FMP habitat goals are in line with the temperatures experienced by these populations in their native streams, if the temperatures on the San Joaquin River exceed the targets by a wide margin, these populations may be more susceptible to higher temperatures than the Butte Creek fish.

- Deer and Mill Creek juveniles experience colder winter water temperatures and thus a larger proportion of them stay in their natal watersheds until emigrating as yearlings due to suitable temperatures. If the habitat in the restored San Joaquin River is not suitable for rearing yearlings, this life history strategy would be selectively disfavored. It is unknown to what extent this life history characteristic is due to phenotypic plasticity based on growth rates and favorable conditions.

- Butte Creek spring-run fish experience selective pressures that may be similar to those of the restored upper San Joaquin River, including (1) low elevation of holding and spawning habitats, (2) highly regulated hydrology, (3) warmer water temperatures, and (4) high air temperatures during the summer months.

- Feather River fish have undergone selection to altered conditions below the Oroville Dam (Bunn and Arthington 2002, Angilleta et al. 2008), which may be similar to conditions in the Restoration Area.

- Feather River fish possess increased genetic diversity that, although likely a result of introgression with fall run fish, may nevertheless give it increase life history flexibility that may allow it to achieve higher survival rates in a stochastic environment like the Restoration Area.

Preferred Alternative

After extensive consideration, the Genetic Subgroup members concurred that it would be nearly impossible to accurately predict the relative fitness of fish from the three potential spring-run source populations in the San Joaquin River Reintroduction Area. Even with additional data, unknown factors such as the restored conditions of the San Joaquin, the straying rate of reintroduced fish, and the populations' ability to adapt to new conditions would prevent a confident selection of the best stock for reintroduction. After considering several alternatives, discussed in the Stock Selection Strategies Document, the subgroup recommended reintroduction of spring-run Chinook salmon from all three potential source populations: the Deer/Mill complex, Butte Creek, and Feather River as the preferred alternative.

A single stock introduction is likely to have a low probability of success, due to the low genetic diversity that can be captured and the limits on the number of fish that can be harvested for use in the Project. Moreover, the novel selective pressures placed on reintroduced fish in the upper San Joaquin River are likely to result in significant evolution in whatever stock or stocks are reintroduced, and introducing a population of fish with high genetic diversity must be a priority for success. The simultaneous multiple stock reintroduction should be pursued as an adaptive management program, with monitoring and evaluation used to evaluate the relative fitness and success of fish from the different stocks at various life stages following the reintroduction. The Subgroup noted several benefits and risks to this approach:

- Benefits:
    - Increased genetic diversity and reduction in inbreeding.
    - Increased program flexibility to accommodate changes in source population availability.
    - Availability of diverse reintroduction methods.
    - Availability of larger number of broodstock, speeding reintroduction.
- Risks:
    - Outbreeding depression
    - Lower fitness of Feather River population due to past hatchery selection
    - Monitoring independent success of each source population's establishment in the Restoration Area will require extensive monitoring and evaluation, including genetic analysis.

Further, use of the Feather River stock increases the risk of introgression with the fall-run fish, due to past introgression in the FRH. As noted above, a portion of the Feather River spring-run progeny will return in the fall, which, left unchecked, could lead to increased mixing of the fall- and spring-run populations in the San Joaquin River. The Feather River hatchery has adopted new practices to reduce hybridization between spring- and fall-running fish, and the San Joaquin River restoration will require similar interventions to help preserve the spring-run phenotype. If the preferred alternative is selected as the final strategy, measures to reduce hybridization between the fall and spring-run fish should be a priority, and should consider the effectiveness of both use of an effective fish weir and adoption of long-term hatchery practices that identify and exclude fall-run fish from spring-run matings.

6.3) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices.

Several risks were identified above, and risk aversion measures will be adopted to address each of these risks:

- Selected broodstock(s) may not capture the genetic variation needed to promote a long-term naturally self-sustaining population in the Restoration Area.
    - Simultaneous multiple stock reintroduction will dramatically increase the diversity of the reintroduced population, above the genetic diversity of any one of the introduced populations. Moreover, genetic monitoring of salmon collection and the broodstock will assist the Program in capturing as much genetic diversity as possible from the source populations. If collection efforts fail to capture a significant portion of the diversity in the source populations, additional years of collection (beyond the 4-8 years currently planned) may be required.

- An overlap in migration run-timing and lack of spatial separation between mature spring-run and fall-run Chinook salmon in the Restoration Area are expected to result in the genetic introgression of the two populations.
    - The use of the Feather River stock exacerbates this risk. If the preferred alternative is selected as the final strategy, maintenance of the spring-run will require measures to reduce hybridization between the fall - and spring-run fish, including both use of an effective fish weir and adoption of hatchery practices that identify and exclude fall-run fish from spring-run matings.
- Removal of broodstock fishes from source population(s) may increase the risk of extirpation of the source population(s).
    - NOAA, USFWS (as the permit holder) and CDFG will determine to what extent the Program is able to mine fish from the three source populations. If determined that the risks to any of the source population(s) is too high, it is likely that the SJRRP will use one or two stocks, collecting a total of 300 eggs or juvenile fish. This is less than the removal of eggs from one wild female, with potentially minimal impact on any of the source populations. Based on high survival rates of hatchery fish, this level of collection is also expected to result in 50 hatchery adult breeding pairs. This is sufficient for the interim program, though higher numbers or collection over a longer term will be required for the full-scale program.
    - The increased risk to the source population(s) should be weighed against the benefits of representation and redundancy afforded by an additional spatially separated population of spring-run Chinook salmon in the Central Valley. An additional population decreases the demographic and environmental risks inherent in an ESU consisting of one or a few small populations.
- Outbreeding depression may result from crossing distantly related populations of salmon. Monitoring independent success of each source population's establishment in the Restoration Area will require genetic analysis.
    - Genetic monitoring of the reintroduced population using parentage analysis should provide the Program with information on the frequency of outcrossed matings and their relative survival in the Restoration Area and whether to incorporate them into hatchery matings. If any cross type performs poorly, mating practices can be adjusted in the hatchery to reduce the proportion of these crosses. Over time, selection on the natural population should eliminate outbreeding depression as the reintroduced stocks mingle.

SECTION 7. BROODSTOCK COLLECTION

Detailed information on Broodstock Collection is presented in the Program's 10(a)1(A) permit application. The information below is summarized from that document.

7.1) Life-history stage to be collected (adults, eggs, or juveniles).

The life-history stage of broodstock collected will vary based on several factors including the population status of each source population, the potential impact to the source population, the accessibility of each life-stage, stipulations of collection permits, and guidance from the adaptive management process.

The age at the time of collection influences the degree of impact to the source population. However, collection of each life stage has its own associated risks and benefits (Table 7.1). Early life stages experience high mortality in the wild, lowering the probability of individuals contributing to the population. Removal of adults from a population has a larger per capita effect on the status of the source population. If appropriate, the Program will use multiple life stages to capture the desired genetic and phenotypic characteristics and to meet other specific Program objectives. Collection methods will be tested prior to use, evaluated for success, and refined over time. Genetic analysis will be used in attempt to identify collection method biases in the relatedness of fish collected as broodstock and its effect on genetic diversity of the broodstock. Poor representation of genetic diversity will require changes to broodstock collection methods.

The primary collection strategies will focus on use of hatchery eggs and juveniles and the use of wild juveniles and possibly the use of fertilized eggs from redd extraction. Hatchery eggs and juveniles will be sourced from Feather River Hatchery, from parents who were not themselves hatchery fish. Redd extraction may be used at Butte Creek and Deer/Mill Creeks, but may not be used on the Feather River due to the difficulty in distinguishing between fall- and spring-run Chinook salmon redds which occur simultaneously at this location.

Juvenile collections may also be used by the Program. This approach allows early selection pressure to occur in the wild rather than in the Conservation Facility, as opposed to the selection for hatchery conditions that occurs with egg collections. The technique would likely be used on Butte Creek and Deer/Mill Creeks, but probably not on the Feather River, again due to the difficulty in distinguishing between fall and spring-run Chinook wild juveniles that occur in the river.

Adult collections will be used primarily at the FRH stock for sourcing eggs and juveniles. The Program does not anticipate collection of wild adults from Butte Creek or the Deer/Mill Creek populations due the sensitivity of these populations and mortality concerns, although adults may be taken in salvage situations or if escapement greatly exceeded carrying capacity of available spawning and rearing habitat.

Captive rearing programs are increasingly favoring use of redd extraction due to better control of genetic variation and reduced risk of disease transfer (pers. comm. Barry Berejikian, NOAA Fisheries). Seining of juveniles has a higher risk of collecting an over representation of siblings and can produce odd sex ratios. Using individual redds provides a high likelihood of a single cross. Additionally, and what some view as most important in captive rearing programs, use of eggs minimizes disease transfer. Many diseases are not transfer in the egg stage and eggs can be more thoroughly disinfected than juveniles.

Relative Risks and Benefits Associated with Various Hatchery Broodstock Collection Methods	**Redd Pumping**	**Redd Excavation**	**Juvenile Collection**	**Adult Collection**
Risk of Mortality	Unknown	Unknown	Moderate	High
Disease Transfer Risk	Low	Low	Moderate	Moderate
Ease of Transport	High	High	Moderate	Low
*Ability to control genetic diversity	High	High	Moderate	Low
Risk of excessive relatedness	Low	Low	Moderate	High
Hatchery-induced selection associated with early life-stage hatchery rearing	High	High	Low (High for FRH fish)	High
Ability to collect spatial diversity	High	High	Moderate (Low for FRH fish)	Low
Ability to control temporal diversity	High	High	Moderate	Low
Risk to source population	Unknown	Unknown	Low	High

Table 7.1. Influence of life-history stage on the risks and benefits of collecting hatchery broodstock. *Some designations are subjective and dependent on use of specific techniques. Designations assume that eggs are hatched and raised to provide broodstock, juveniles are grown to provide broodstock, and adults are mated and the eggs hatched and raised to provide broodstock.

7.2) Collection or sampling design.

Collection methods will include eyed-egg collections through redd extraction, egg and juvenile collections from Feather River Hatchery, and juvenile collections through stream seining and use of screw traps when appropriate. Adult collections and handling may also occur when appropriate by seining or fish trapping and through opportunities such as salvage operations. Sampling design will occur as follows:

7.2.1) Redd Extraction

Redd extraction may be used on Butte and Deer/Mill Creeks and potentially the Feather River. Depending on the specific on-site conditions, either redd pumping or redd excavation may be used as the preferred extraction method, as described below. On-site decisions will be based on water clarity, water velocity, water depth, risk to non-target eggs and safety considerations of field staff.

Eggs would be collected approximately 20-30 days post-spawning, depending on water temperatures. Eggs are most resistant to disturbance after 200 accumulated temperature units (ATU's in degrees C), which occurs 20 days post-spawning at 10° C. Eggs would be collected prior to 480 ATU's, which is when hatching can begin for Chinook eggs. Spawning surveys would be conducted roughly twice weekly during the spawning season and redds marked with the approximate date of spawning. Redds would be selected to provide spatial and temporal diversity by sampling multiple spawning locations during different times of the spawning season. Water temperatures will be monitored to assess the stage of egg development to enable egg collection to occur during the desired stage of development to maximize egg mortality.

Eggs would be removed from each redd until the desired number reached (≤ 50 eggs). This equates to approximately < 1% of the eggs from an individual female, assuming a fecundity of 5,000 eggs. Therefore, a take of 1% of the eggs from a female at this lifestage should be sustainable as long as survival of the non-taken eggs can be maintained. Egg to fry survival rates in the Conservation Facility are anticipated to exceed 50 percent, with a target of 70% or greater. Egg to fry survival in naturally spawned eggs generally ranges between 25-50% (29% calculated for winter Chinook on average). Total eggs collected will depend on redd availability and permitting decisions by NMFS.

Following collection, eggs will be placed into coolers with equal volumes of eggs and river water. Ice will placed in a separate compartment of the cooler such that it is in contact with the water but not with the eggs. The ideal temperature for transport is in the 5 – 10° C range. Prior to entering the Conservation Facility, eggs will be disinfected with an iodophore at 100 parts per million (ppm) of free iodine.

7.2.1.1) Redd Pumping

As described by Murdoch and Hopely (2005), eggs will be collected from redds using a small portable backpack mounted water pump (ARED®) with a 49 cc 4 stroke motor that uses a general purpose centrifugal self-priming pump. See Figure 7.A for an example of the pump. The variable speed pump can operate up to 72 GPM with a total of 125' Total head lift, 26' Suction head lift and 54 psi of maximum pressure. All controls are accessible by operator while unit is on operators back. An aluminum probe is inserted into the redd. The probe is designed with an air intake, which creates a Venturi effect that combines water and air. The mixture of air and water is used to float eggs to the surface. An aluminum frame basket covered with 3.2 mm wire mesh is on three sides and a 1.6 mm cloth net bag on the downstream side will be used to collect eggs. The basket will be placed over the portion of redd to be sampled. In an effort to

minimize impacts to the redd, hydraulic sampling will begin at the farthest most downstream point of the tail spill and progressed systematically upstream as necessary. This method ensures that disturbance to the redd is confined to the furthest downstream portion of the redd, decreasing the probability of impacts from personnel (i.e., stepping on egg pockets) or the sampling process (e.g., changing the hydraulics of the redd). Each redd will be sampled carefully until the first egg is collected and the developmental stage verified (i.e. eyed-egg stage). Eyed-eggs will be removed from the collection net by hand or with a small dip net and placed in small buckets. The eggs will be inventoried and buckets labeled with redd number and egg count. Buckets will then be placed in coolers on ice for transport to the Conservation Facility. Excess eggs will be re-injected into the redd using the hydraulic egg planter or carefully returned to the redd by hand.

Figure 7.A. Sample of Hydraulic Redd Pumping (Venditti et al. 2002)

7.2.1.2) Redd Excavation

This method will consist of carefully hand-digging into the tailspill of identified spring Chinook redds to obtain live fertilized eggs. The specific redds from which we will obtain eggs will be selected from areas of shallower water and gentle velocities to facilitate obtaining eggs without loss. Gravel will be carefully removed from the tailspill of the redd by hand until eggs are reached. The digging process will proceed slowly so that a clear view of the excavated area can be maintained throughout the process. Snorkel gear will be used to get a clear underwater view of the excavated area. A fine mesh dipnet will be used to retrieve the eggs. Eggs will be placed into a five gallon bucket of river water, maintained at or below the temperature of the river, as they are removed from the gravel. They will be counted as they are placed into the bucket until the desired number of eggs is reached (≤ 50 eggs). Once the eggs are obtained from the redd, gravel will be carefully replaced into the area from which it was removed until the pre-disturbance substrate contour is re-created.

7.2.2) Feather River Hatchery Broodstock Collection

Spring-run Chinook broodstock collection protocols will be conducted according to methods described in the FRH HGMP (Cavallo et al. 2009). See HGMP Section 2 for details. Only fish entering the FRH between April 1 and June 30 and then reentering the FRH in September, as identified by Hallprint tags, and not of direct hatchery origin will be used for broodstock for the Conservation Facility. These may be crossed according to FRH protocols.

7.2.3) Stream Seining

Stream seining of juveniles will likely be deployed on Butte Creek and Deer/Mill Creeks. Seining is a well-established method of juvenile collection in streams and rivers (Hoffnagle et al. 2008). Fish will be seined at multiple locations along each source population in attempt to capture spatial diversity and reduce capture of siblings. Swimmers would be used to corral fish to seine nets. While unlikely, electrofishing may be used in conjunction with hand netting or seining. For seined fish, juvenile to adult survival rates are expected to exceed 50 percent. Fish collected in remote areas will be place in backpack-style live fish containers (Figure 7.B.) and packed to a temporary fish holding station before transfer to the Conservation Facility for disinfection and rearing.

7.2.4) Screw Traps

Screw traps are operated in each of the source populations, but their downstream location allows the capture of both fall- and spring-run Chinook salmon. In these scenarios, larger yearling spring-run on Butte Creek and Deer/Mill Creeks may be targeted as they are most readily distinguished from fall-run Chinook. Feather River does not produce a substantial yearling production and therefore, collection of Feather River fish may be solely from the FRH unless spring-run identity of naturally spawning fish can be verified.

Rotary screw traps (RSTs) are the most common gear used to collect and monitor juvenile salmon abundance in tributaries in the California Central Valley. When placed properly and calibrated, RSTs provide reliable estimates of juvenile abundance. The RST consists of a funnel-shaped cone that is screened and suspended above the water between floating pontoons. The cone rotates as water flows past the trap, guiding the fish moving downstream into a live box that is attached to the rear of the trap cone. The RSTs are usually installed at a fixed location and they can continuously sample for extended periods. Fish are confined to the live trap and therefore the RST will be checked frequently (2X per day) to process fish and remove debris. Juvenile spring-run salmon are collected on rivers using this method (e.g., Butte Creek). When monitored at the appropriate time interval relative to the number of fish being collected, RSTs result in low mortality rates.

7.3) Identity

All broodstock will be genotyped before spawning by using single nucleotide polymorphism analysis. Where fall- and spring-run Chinook salmon juveniles coexist, larger juveniles will be presumed to be yearling spring-run, whose identity will be later verified by genotype analysis. Feather River fish present a unique challenge, due to their extensive introgression and the difficulty in assigning parentage to fall- or spring-run fish. All eggs or juveniles taken from the Feather River will be from parents who both enter the hatchery in the spring, reenter in the fall and are not known to be offspring of other hatchery fish. Some of these fish may be fall-run offspring, but at this time these two runs cannot be differentiated.

Broodstock reared at the Conservation Facility also would be tagged using a PIT after reaching a minimum length of 85 mm (Harvey and Campbell 1989). Sterilized tags would be injected into the peritoneum using an implant gun or syringe-style implanter. PIT tags would be used for monitoring individual fish throughout captivity. Prior to spawning, adult fish would be tagged intramuscularly with Petersen disc tags for easy visual identification (Harvey and Campbell 1989). The tag would consist of two plastic buttons which are held to the sides of the fish by a stainless steel pin passed through the muscle tissue beneath the dorsal fin. The discs would be colored or marked with letters or numbers. Adult fish would be anesthetized during all tagging activities using MS-222, CO_2, or Tricaine-S. The dosage of the anesthetics would be adjusted to avoid fish mortality.

All hatchery juveniles would be adipose fin clipped and coded wire tagged prior to release (Harvey and Campbell 1989). Coded wire tags are small (less than 1 mm) lengths of wire that are implanted into the snout of each juvenile using specialized automated equipment. The tags (indicated by the removed adipose fin) would allow fish to be identified as belonging to a particular Conservation Facility cohort when it is either captured as an adult in commercial or sport fisheries, or when it returns to the San Joaquin River to spawn and the carcass is recovered. Some adipose fin clips would be used for additional genetic analysis.

7.4) Proposed number to be collected

7.4.1) Program goal

Final collection allotments have not been determined and will depend on viability and extinction risk of the source populations, as well as how collection for broodstock would affect those factors. The goal of the Conservation Program is to collect sufficient eggs and juveniles to successfully re-establish a run of spring Chinook on the San Joaquin River. See HGMP Section 8 for details. The number of eggs and juveniles collected for the Conservation Facility will be based on estimated survival rates and production strategies from similar conservation programs. Egg to smolt survival rates in salmon hatcheries are typically quite high, averaging approximately 80%. Between 1994-1998 smolt to adult survival rates at the Manchester Spring Chinook Broodstock Project averaged 71% for five consecutive brood years. During this period, adult survival increased over time resulting in an average of 85% during the final two years (McAuley et al. 1996).

The Conservation Facility will be deployed in three phases to allow for experimental rearing and preliminary reintroductions while full-scale Conservation Facility is under construction. The three phases are experimental production, interim production, and full-scale production. Each phase will have a target number of adults to produce and spawn.

During the experimental phase (October 2010 – October 2012) the Program will use an Interim Facility, adjacent to the existing San Joaquin trout hatchery, until the completion of Conservation Facility (targeted for 2014). During this phase, fall-run Chinook will be used to test rearing systems and to fine tune conservation hatchery techniques. In year one of experimental production, approximately 500 eyed-eggs will be collected from Merced River

Hatchery for experimental captive rearing. In year two of experimental production, 300-500 fall-run Chinook smolts will be captured by redd pumping on the Merced River (Snelling, CA) or by other collection method, also for experimental captive rearing. The fall-run fish will be reared through adulthood and spawned and will provide two year-classes of fish that will precede the rearing of spring-run Chinook, allowing the personnel practical experience with Chinook salmon captive rearing. The eggs resulting from the spawning of the experimental fall-run fish will be returned to the Merced River or Merced River Hatchery for hatching, unless other uses are deemed appropriate by the hatchery technical team and are acceptable to NMFS.

October 2012 will mark the beginning of interim production (phase 2) and the beginning of spring-run Chinook collection and captive rearing for the Program. During this period, the Conservation Facility will limit collections to a total of 300-600 juveniles (or 20% more if eye-eggs are used) per year, to be collected from one or more of the three proposed source populations. During full-scale Conservation Facility production (phase 3, fall 2014), based on the genetic considerations explored in HGMP Section 6.2.3, above, the goal is to spawn a minimum of 50 pairs from each of the three source populations, and ideally 150 pairs from each of the three source populations, per HGMP Section 8, or a total of 150-450 spawning pairs. A total of 900-2700 eggs/juveniles will be used to achieve this number. The actual number of fish per population per year will be limited by viability factors, such as annual escapement, but the duration of the Conservation Facility's collection program (8 years total, encompassing two full generations) should provide enough fish to capture much of the diversity in the source populations and avoid founder effects, including excessive inbreeding or genetic bottlenecking, per HGMP Section 8.

7.4.2) Broodstock collection levels for the last twelve years (e.g. 1988-99), or for most recent years available:

No fish have been collected over the last 12 years.

7.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs.

In order to produce adequate numbers of adult broodstock, an ample number of spring-run Chinook salmon may be collected, which may result in surplus broodstock. Periodically over the lifespan of the captive rearing, surplus fish will be removed, likely as yearlings, and preferably released to the San Joaquin River. This will depending on river conditions and suitability for spring-run Chinook salmon, for reintroduction and research purposes, or held in the Conservation Facility for other research purposes. Research may include temperature tolerance testing, with associated mortality. Instream research will depend on the life stage at release, and fish will be monitored for false migration pathways, predation, spawning behavior, and other life history traits.

7.6) Fish transportation and holding methods. Transportation and holding methods will vary depending on life stage and collection method. After collection of eyed-eggs from redds or the FRH, eggs will be disinfected with 10-minute bath treatment with 100 ppm of free iodine. Eggs will not be disinfected if they are near hatching, which can be

Figure 7.B. Modified backpack and aerator for transporting live fish.

detrimental to the embryos. Disinfected eggs will be place in a specialized Styrofoam shipping container. Eggs will be cooled and kept moist using ice and transported in a dark environment. Prior to entering the Conservation Facility, eggs will be disinfected again, re-hydrated and tempered to the receiving water by 1 ºC per hour and enumerated.

When capturing salmon in remote locations, fish will be transported by backpack or by mule using fish pack cans (pers. comm. Stan Stephens) to a staging area. Backpacks will be modified using heavy mil plastic bags or solid plastic containers and battery-powered aerators. At a staging location, fish will be transferred to a 500-gallon transport tank and trailer. The tank will be filled with stream water immediately prior to transport using a portable, screened pump. When necessary for isolating phenotypic characteristics (i.e. spawning location), individual groups of fish will be separated using small cages suspended within the transport tank. The transport water will be oxygenated using bottled oxygen with oxygen stones and impellor driven aerators. Dissolved oxygen levels will be monitored and maintained near saturation during transport. Transport water will be supplemented with sodium chloride to provide a physiologically isotonic concentration to minimize ionic disturbances. When possible, fish will be moved in and out of the transport truck using a water filled vessel (i.e. water to water transfer) and without netting to minimize stress and loss of slime. Transport times may be as long as 8 hours. Water will be tempered to two degrees Celsius of the facility receiving water before transferring fish. Prior to combining the fish at the Conservation Facility with other fish, salmon will be quarantined for two weeks for appropriate prophylactic treatment and disease monitoring.

7.7) Describe fish health maintenance and sanitation procedures applied.

A biosecurity program will be instituted to (1) reduce the risk that pathogens will be introduced to the facility, (2) reduce the risk that pathogens will spread throughout the facility and (3) reduce conditions that can increase susceptibility to infection and disease. Overall fish health maintenance and sanitation procedures will include:

1. For the entire facility, the water supply will be micro-screened with a minimum pore size of 80 microns to reduce pathogen loads. The water supply for egg incubation, hatching and early rearing will be further treated with ultraviolet filtration.

2. Transport tanks and equipment will be disinfected prior to use with an iodophore to prevent disease transmission. Similarly, all surgically related equipment (i.e., needles for egg harvest, and tissue collection utensils) used for broodstock spawning will be disinfected in alcohol or iodophore prior to use.

3. Feed will be stored and used according to manufacturer recommendations to avoid fish health problems related to mycotoxins and rancidity.

4. Captured juveniles brought to the Conservation Facility will be treated with an eight hour oxytetracycline bath followed by a three day course consisting of a one hour formalin drip at 170 parts per million. During the quarantine period, the fish will be screened for the presence of specific pathogens, and they will be treated as directed by the pathologists. Following a two-week quarantine period, the captured juveniles will be combined with other individuals from the same watershed group, or individually PIT tagged for identity if combined with other watershed groups.

5. Technology will be used to reduce human to fish contact to reduce stress and lower opportunity for disease transfer.

    a. Tank rotational water velocities to be maintained at speeds that allow self-cleaning to minimize need for brushing tanks.
    b. Use of automated feeders.
    c. Minimal traffic in fish rearing areas.
    d. Sufficient cover for shade and predator avoidance.
    e. Use open canals for moving fish to minimize handling.

6. All cleaning equipment and nets will be disinfected in an iodine-based disinfectant prior to use, and separate cleaning instruments are designated to each rearing tank.

7. Weekly prophylactic salt flushes will be administered to salmon throughout the duration of captive broodstock holding.

8. Fish will be maintained at minimum densities (12.5 $lb/ft^3/in$) and flushing rates will be maintained at a minimum of one turnover per hour to reduce stress and disease potential.

9. Feed will be carefully administered to avoid uneaten feed accumulating at the bottom of the rearing tanks.

10. Entryways will be minimized and a disinfectant foot bath will be deployed and maintained at each entryway.

11. Dead or moribund fish will be removed promptly from each rearing tank and necropsied. Moribund fish will be humanely euthanized immediately after removal from rearing tank.

12. Fish will be monitored daily for behavior and physical abnormalities. Fish exhibiting abnormal behavior will be screened for pathogens. Sick fish will be promptly examined by the California Department of Fish and Game Fish Health Lab.

7.8) Disposition of carcasses.

The Facility will dispose of salmon carcasses in two ways. First, some carcasses arising from hatchery mortalities will be frozen and generally disposed of through the hatchery solid waste disposal system, which involves ultimate disposal at the municipal disposal facilities. Second, carcasses derived from mortalities that have undergone adequate depuration following chemical treatment may be used to provide nutrient loading in streams. The Program will investigate the nutrient status of the river system to determine if the current level of nutrient inputs from urban and agricultural sources warrant the need for additional nutrient loading.

7.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program.

Techniques for egg, juvenile and adult collection, transportation methods and fish health maintenance procedures will be followed as described above and in this section and as prescribed in the 10(a)1(A) incidental take and enhancement of species permit that is to be issued by NMFS. Fishery techniques will be reviewed by the Hatchery Technical Team and NOAA Fisheries prior use by the Program. Newly approved techniques and procedures not described in this document will be detailed in the Conservation Facility's Annual Report. Juveniles and eggs from source populations will be collected and transported to the Conservation Facility using the following general guidelines (Carmichael et al. 2001):

1. Reduce the number of stressors
2. Reduce the severity of stressors
3. Minimize the duration of stressors
4. Minimize plasma ion disturbances
5. Minimize increases in metabolic rate

All methods will be tested within the Program using non-listed fall-run Chinook salmon during the interim stage to determine stress and mortality rates associated with procedures. A quality control supervisor will be assigned during each egg and juvenile collection operation to supervise and document activities. Techniques will be modified appropriately if stressors are identified. Any technique observed to create undue stress on fish and eggs will be immediately aborted and reported to the quality control supervisor and the Hatchery Technical Team. During each fish and egg handling operation water quality will be monitored and dissolved oxygen levels will be maintain 80% saturation and water temperatures will not be allowed to exceed 70°F.

SECTION 8. MATING

8.1) Describe fish mating procedures that will be used, including those applied to meet performance indicators identified previously.

Generally, consistent with the operational standards for using captive propagation technology to recover populations of ESA-listed anadromous salmonids (Pollard and Flagg 2004), the following guidelines will be followed:

1. Spawn all available adults.
2. Retrieve all possible eggs from mature females.
3. Use spawning protocols that maximize the effective population size of hatchery-spawning fish:
    a. Factorial or (with greater numbers of parents) single-pair matings.
    b. Cryopreserved sperm (Benefits of using cryopreserved sperm should be weighed against potential for loss of viability, especially when the number of eggs is low. Additional straws from the same male may be used to counter low viability).
    c. Induced spawning with GnRHa implants or other methods.

Mating protocols are required for all hatchery breeding, which may include a variety of scenarios, depending on availability of fish from the source populations and naturalized adults returning to the San Joaquin River Restoration Area, as well as hatchery capacity in the interim and full-scale facilities. For example, the interim facility may only be able to handle 50 mating pairs (roughly 100 adult fish), which could come from one, two, or three source populations. See Table 8.1 for a breakdown of potential scenarios and mating protocols.

8.2) Selection method.

All males and females which have been collected for broodstock will be examined weekly during the spawning season to determine ripeness, and all fish will be spawned when ripe. To allow the hatchery to identify close relatives and minimize mean kinship, all potential spawners will be genetically analyzed and a relatedness estimate (e.g., Queller and Goodnight 1989; Mxy, Blouin et al. 1996) will be developed for all pairs of broodstock fish (Kozfkay et al. 2008; Sturm et al. 2009), both potential breeding pairs (to evaluate potential mates) and same-sex pairings (to detect full-siblings). Based on the molecular relatedness estimate, a spawning matrix will be constructed following Sturm et al. (2009). Briefly, the matrix will be organized by female, with all potential male mates listed below her in order of preference, based on their coefficient of relatedness (most desirable male is the least genetically-related). Actual pairings will involve the five males highest on the list when the female is ripe, but no matings will involve fish related at the level of half-sibling or higher. Eggs from each female will be divided into five groups of roughly equal size and each will be fertilized by a different male. Each male will be used with no more than five different females. Eggs and fry from each cross should be kept separately until the major period of in-hatchery mortality is passed to allow for evaluation

of the success of the cross. Depending on hatchery resources, a ratio of 1:4 females to males may be used in place of the 1:5 ratio, with minimal loss of effective population size. This decision will be made by the hatchery technical team based on hatchery conditions and may vary between the interim facility and the final facility. If undertaken, matings between two different source populations will probably follow a different protocol, identified below, since inbreeding is not a concern for these crosses. Fish will be selected for outcrossing based on their mean pairwise relatedness estimate compared to all other fish in their source population; the fish that are most highly related to the other fish in their populations are at the highest risk for causing inbreeding

	Scenario 1 – One Broodstock (A)	**Scenario 2 – Two Broodstock (A&B)**	**Scenario 3 – 3 Broodstock (A, B, &C)**	**Scenario 4 – One Broodstock (A) and Returning Adults (RA)***	**Scenario 5 – Two Broodstock (A&B) and RA**	**Scenario 6 – Three Broodstock (A, B, C) & RA**
Crosses**	1 Cross: AxA	3 Crosses: AxA, AxB, BxB	6 Crosses: AxA, AxB, AxC, BxB, BxC, CxC	2 Crosses: AxA, AxRA	5 Crosses: AxA, AxB, BxB, AxRA, BxRA	9 Crosses: AxA, AxB, AxC, AxRA, BxB, BxC, BxRA, CxC, CxRA
Division among crosses ***	NA	Initially, 1/3 of A & B into each of the 3 crosses. May eventually vary based on returns from each cross.	Initially, 1/6 of A, B, & C into each of the crosses. May eventually vary based on returns from each cross.	Division will depend on the availability of RA. See notes below.	Division will depend on the availability of RA. See notes below.	Division will depend on the availability of RA. See notes below.
Mating Protocol****	Full or partial factorial mating	Partial factorial mating within each cross (1 female : 5 males)	Partial factorial mating within each cross (1:5)	Partial factorial mating within each cross (1:5)	Partial factorial mating within each cross (1:5)	Partial factorial mating within each cross (1:5)

* The RA stock will likely be the limiting factor in dividing broodstock among potential crosses. If they are not the limiting factor, spawners from available bloodstock should be divided evenly among the crosses in which they are involved (e.g. if A is used in 3 crosses, 1/3 of A should be used in each cross). Assuming RA availability is the limiting factor, broodstock division will depend on the sex of the RA spawners. RA females should be crossed with males from other available broodstock in a ratio of at least 1:4, although the ratio could be changed to 1:6 to allow an even contribution from each broodstock if more than one broodstock is available. The fraction of males used from each broodstock to cross with RA females should not exceed one over the number of crosses in which the broodstock is involved (e.g. if A is used in 3 crosses, a maximum of 1/3 of A males should be crossed with RA females.) RA males should be crossed with 5 or 6 females, depending on how many broodstock are available, and the fraction of females used from each broodstock to cross with RA males should not exceed one over the number of crosses in which the broodstock is involved (e.g. if A is used in 3 crosses, a maximum of 1/3 of A females should be crossed with RA males.). Assuming the RA spawners are the limiting factor, the excess broodstock from other sources should be evenly divided among the remaining crosses.

** Crosses between spring-run populations may be undertaken if hatchery capacity, broodstock availability, spawn timing, and other factors permit and if recommended by the Hatchery and Monitoring Technical Team.

*** Fish with the highest mean relatedness within each broodstock population should be used for the crosses between broodstock populations.

**** Individuals will be paired based on a spawning matrix discussed below.

Table 8.1. Potential Mating Protocols, by Broodstock Scenarios.

depression and are the least likely to have alleles otherwise not present within their populations. In the outcrossed fish protocol, females will be paired with five outgroup males randomly selected from the males chosen for outcrossing, and fertilization and rearing will proceed as describe for within population crosses, above. Alternatively, the Program may use the same relatedness approach for these individuals as is explained above for the other hatchery stocks.

Any returning naturalized adults in the San Joaquin River that are included in the broodstock should be evaluated using the same relatedness estimate approach identified above. Returning adults can be identified based on genetic or coded wire tags inserted before their initial release. Fish identified as strays may or may not be used as hatchery broodstock, depending on their origin. The natal origin for these fish will be determined based on otolith analysis (Barnett-Johnson et al. 2008) or genetic analysis. Use of these fish and of the returning adults generally will be governed by the recommendations of the Hatchery and Monitoring Technical Team.

8.3) Males.

Some hatcheries, faced with low male fertility, use an approach where eggs are fertilized with a second male's milt to ensure fertilization. Initially, backup males will not be used at the Conservation Facility in order to avoid overrepresentation of some males due to advantages in sperm competition (Miller and Kapuscinski 2003, Campton 2004). Backup males may be required if infertility levels significantly reduce production below expected levels.

As available, two year old males (jacks) will be used to ensure representation of alternative life history strategies. Jack usage levels will be governed by the recommendations of the hatchery and monitoring technical teams and will attempt to represent contributions of jacks to reproduction at a rate similar to those of the source populations; Some facilities limit the use of jacks to two percent (Cavallo 2009), although a very large proportion of jacks or precocious males may necessitate a higher level of usage in order to meet genetic diversity population targets.

8.4) Fertilization.

Fertilization will follow the protocols in Table 8.1, above. In order to maximize the hatchery effective population size, sex ratios will be approximately equalized and all pairings will be 1:1, unless unexpectedly high infertility requires the use of backup males. Except as noted above, gametes will not be pooled to allow monitoring of pairwise breeding success and to avoid overrepresentation of some males due to sperm competition (Miller and Kapuscinski 2003, Campton 2004).

8.5) Cryopreserved gametes.

Cryopreserved gametes may be used if there is an excess of males or to accommodate males maturing before females are available. Cryopreserveation increases the pool of potential

mating partners for each female and can increase effective population size and ensure that there are sufficient unrelated male gametes for use future generations.

8.6) Use of Ovulation Stimulating Hormones

Description of GnRH implant (Ovaplant) Usage and Evaluation

Gonadotropin-releasing hormone (GnRH) may be used by the Program to stimulate ova release and sperm development. Ovaplant is the trade name of GnRH that is manufactured by Syndel International, Inc. and is used and described by CDFG Warm Springs Hatchery Coho Recovery Program in Geyserville, CA (White 2010, Unpublished Report).

A notice of claimed investigational exemption (FDA Form 3458) will be submitted to the Federal Drug Administration (FDA) for use of Oviplant. All packages containing Ovaplant cartridges will be labeled in accordance with Title 21 of the Code of Federal Regulations, Part 511.1B.

Ovaplant will be administered to broodstock during the course of ripeness sort activities. Ripeness sorts will take place weekly until all fish are spawned and administered to female broodstock to induce spawning only if they were deemed unlikely to complete final maturation. Generally, the female broodstock treated with Ovaplant are individuals that show signs of final maturation (e.g., coloration changes, abdominal softness, protrusion of the vent), but do not show signs of completing the final maturation process (egg hydration, ovulation). A portable ultrasound unit will be used to assist with monitoring gonadal development and sex identification. Ovaplant will be administered to male broodstock if needed to enhance milt production, facilitate milt extraction, and ensure adequate milt volume during spawning.

After receiving an implant, fish will be returned to their holding tank and tested 5-7 days later for ovulation or milt production. The date of the implant injection will be recorded for treated fish and the date of the first observed gamete release will be recorded for both treated and untreated fish. Implants will be administered as whole pellets, and were delivered in a non-sterile fashion with a RalGun Pellet Injector, supplied by Syndel International, Inc. The site of the injection will be posterior to the dorsal fin, in the dorsal sinus or surrounding intramuscular tissue.

On the day of spawning, total fecundity will be estimated for each female by obtaining an average egg weight from the weight of ten individual eggs, and recording the total weight of eggs that are ovulated and used for fertilization, as well as eggs that remained attached to ovarian tissue. These data allow for a calculation of an ovulation rate for both treated and untreated females. Milt will be collected from males to be spawned with each female. Sperm motility will be examined for each male selected for spawning at 40X magnification given a subjective rating (1-4), as follows:

1: 75-100% of sperm cells moving
2: 50-74% of sperm cells moving
3: 25-49% of sperm cells moving
4: 0-24% of sperm cells moving

After fertilization, egg survival to the eyed stage will be estimated by removing all dead eggs, and estimating the average and total weight of the remaining live eggs.

8.7) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

The mating protocols identified above seek to minimize the likelihood for adverse genetic or ecological effects to listed natural fish due to hatchery operations. This hatchery will use a combined captive broodstock/adult spawning approach to take a small number of juvenile fish, fertilized eggs, or adults from appropriate spring-run Chinook source populations and carefully spawn them for maximum effective population size to produce a large number of offspring for release into the San Joaquin River. Ideally, such a program would not change the genetic characteristics of the source population and would produce offspring for release that display the full range of genetic diversity found in the source population. While success in capturing the source population's diversity depends in part on adequate collection of broodstock fish, hatchery operations also carry genetic risks via inbreeding depression, domestication selection, and loss of genetic diversity through genetic drift.

Genetic diversity decreases through genetic drift, which increases with decreasing effective population size. Factorial matings with all available adults to produce families of approximately equal size maximize the effective population size (Fiumera et al. 2005, Frankham et al. 2000) and minimize loss of genetic diversity to random drift. While a full factorial scheme is most effective in increasing the effective population size, full factorial schemes can be prohibitively expensive in terms of time and labor. The partial factorial scheme above offers comparable effective population size with significantly less time and labor (Dupont-Nivet et al. 2006, Busack and Knudsen 2007). Busack and Knudsen (2007) demonstrated that incremental gain from increasing fish numbers in partial factorial designs diminishes quickly, with a considerable proportion of the full factorial advantage in the 1:5 design, and little gain in moving to a 1:10 design. While the effective population size is slightly smaller than what could be achieved with a full factorial mating or a larger partial factorial mating, given that the fish will be in the Conservation Facility for only one generation, the scheme set out here is a reasonable compromise. Family sizes may be affected by differential fertilization or differential survival in the hatchery; if a small number of families have significantly higher survival, some individuals from those families may be withheld from broodstock use and instead used for the research identified in HGMP Section 12.

Inbreeding depression is addressed directly by avoiding sibling breeding (Woodworth et al. 2002). Matings based on the allele-sharing relatedness estimates allow the hatchery to avoid

inbreeding even when parentage is not known (Kozfkay et al. 2008); cut-offs for related measures will be established once the broodstock has been genetically evaluated.

Outbreeding depression is also a risk. Even if fish from different source populations are not crossed in the hatchery, using multiple broodstock sources provides a high probability that natural outcrossing will occur in the Restoration Area. Salmon, like most other vertebrates, use mate choice mechanisms to evaluate mates and modulate between inbreeding and outbreeding. Genetic evaluation of the frequency of such matings, and the subsequent performance of their offspring, may be used to guide crossing strategies in the hatchery. If there are clear indications of inbreeding depression in the broodstock, then experimental crosses between fish from different source populations can be incorporated into hatchery mating practices, since the risk of outbreeding depression from such crosses will be counterbalanced by the reduced risks from inbreeding. Experimental crosses carried out in the hatchery would allow researchers to gather data on the performance of outbred crosses prior to release to the wild. The decision to cross broodstock from different source populations will be made on an annual basis by the Hatchery and Monitoring Technical Team.

Finally, domestication selection is reduced through the use of conservation hatchery practices, identified in HGMP Section 3, and by keeping the broodstock in the hatchery for only one generation.

The protocols in this section will be adaptively managed based on the results of monitoring and evaluation as described in HGMP Sections 1.9 and research projects in Section 12, to allow better representation of the diversity in the source populations, to increase effective population size, or for other risk aversion purposes and to increase performance of the Program.

While genetic impacts due to hatchery operations cannot be entirely avoided, the mating protocols identified above are designed to minimize loss of genetic diversity and to maximize the effective population size of the experimental population.

SECTION 9. INCUBATION AND REARING -

Specify any management *goals* (e.g. "egg to smolt survival") that the hatchery is currently operating under for the hatchery stock in the appropriate sections below. Provide data on the success of meeting the desired hatchery goals.

9.1) Incubation:

9.1.1) Number of eggs taken and survival rates to eye-up and/or ponding.

The Conservation Facility has not yet begun operation; no data are available.

The number of eggs taken will increase over time as the Program transitions from the Interim Facility to the full production at the Conservation Facility. The first egg take may occur in the fall of 2014 from a small number of adults produced at the Interim Facility that were collected as yearlings during the 2012/2013 outmigration. Egg take is anticipated at no more than 40,000 eggs. The following two years (2015-2016) the Interim Facility will target spawning 50 females per year with the goal of producing approximately 100,000 eggs annually, based on the anticipated 50% reduction in fecundity of captive reared females and associated mortality. Operation of the full-scale Conservation Facility is anticipated to begin in the fall of 2014. The goal of the Conservation Facility is to spawn a between of 150-450 females per year, resulting in collection of approximately 375,000-1,125,000 eggs, up to the maximum recommendations in Section 8. The number ultimately spawned in the Conservation Facility will be controlled by the NMFS permits.

Egg survival to hatch is anticipated to be similar to that experienced at FRH, which has been 85% in recent years (Cavallo et al. 2009). However, if semi-natural methods are used for incubation (i.e. deep matrix incubation), eggs survival may be substantially lower. Egg to smolt survival rates vary among similar programs. The Tucannon River spring-run Chinook salmon program (Gallinat et al. 2009) reported a seven-year average (2000-2006) for egg to smolt survival of 72.8% from the conventional hatchery program, but egg to smolt survival rates were only 37.6% in their captive broodstock program. Pollard and Flagg (2004) reported that egg-to-smolt survival rates for captive rearing programs are commonly greater that 75% and smolt to adult survival often exceed 50 percent.

Spawn Year	Brood Year of Adults Spawned	Comments	Number of Adults Produced	Estimated Number of Eggs Produced
2013	2011	Possible milt collection and storage from captive reared and wild jacks.	< or =20	0
2014	2011 - 2012	Begin use of full-scale Conservation Facility	< 20	< 40,000
2015	2011 - 2013	3-4 yr ♀ X 2-4 yr ♂	< 60	< 120,000

2016	2012 - 2014	3-5 yr ♀ X 2-4 yr ♂	< 60	< 120,000
2017	2013 - 2015	3-5 yr ♀ X 2-4 yr ♂	*	*
* Will depend on availability of broodstock during the 2014 broodstock collection.				
Table 9.1. Five-year target number of eggs produced by the captive rearing program.				

Egg incubation is anticipated to be similar to that found at the Feather River Hatchery, where spring-run Chinook salmon green eggs develop into eyed eggs from 490-550 Daily Temperature Units (DTUs), averaging 513 DTUs. Eggs at FRH are typically well eyed at 513 DTUs, which is when they are usually addled (Cavallo et al.2009).

9.1.2) Cause for, and disposition of surplus egg takes.

At the first indication that the Conservation Facility may exceed egg take goals, NMFS will be notified via email and letter. The hatchery technical team will discuss the possible alternatives and make a recommendation to NMFS regarding disposition of any excess eggs, fingerlings, or smolts beyond the current production goals. Surplus fish will be removed and preferably released to the San Joaquin River, depending on river conditions and suitability for spring-run Chinook salmon, for reintroduction and research purposes, or held in the hatchery for other research purposes. Research may include temperature tolerance testing, with some mortality. Instream research will depend on the life stage at release; fish will be monitored for false migration pathways, predation, spawning behavior, and other life history traits.

9.1.3) Loading densities applied during incubation.

The Conservation Facility intends to use three main types of incubators: Vertical flow incubators (Marisource® – Fife, WA), deep matrix incubators (ARED – Wrangell, AK), and moist air incubators (ARED – Wrangell, AK).

Each vertical flow incubator consists of 12 trays, and will be operated at the manufacture's recommended flow rate of 30-60 GMP, depending on the loading density. Loading densities will not exceed 8,000 eggs per tray. Individual family lots will be segregated into three or four sections per egg tray using segregation dividers. Opaque side panels will be added to the incubators to produce a darkened environment for incubation.

Deep matrix incubators are hatch boxes that simulate natural conditions by providing a substrate (plastic coke rings) where eggs hatch. The unit is a single pass flow through system and will be operated at the manufacture's recommended flow rate. Each unit has a recommended loading capacity of 200,000 salmon eggs.

Moist air incubation produces a fine mist for incubation to inhibit fungal growth and allow for accurate temperature control. Each incubator has 220 individual trays (1.2 liters) that each hold 2,700 eggs, with a total capacity of 600,000 eggs. The units recirculate 40 gallons of filtered water with 5 gallons of water, replaced daily. Filtration consists of 1 and 50 micron

particle filters, a 10 micron carbon filter and ultraviolet sterilization. The moist air units incubate green eggs through the eyed stage in a dark environment, after which the eggs are transferred to deep matrix or vertical tray incubators for hatching.

9.1.4) Incubation conditions.

All egg incubation will occur in darkened conditions. The deep matrix incubators and the vertical tray incubators will use ambient water temperatures, anticipated to be between 45-55 degrees F (7.2 - 12.8 C). Moist air incubators allow temperature control, and hatching temperatures will be based on the objectives of the Conservation Program and may include mimicking river temperatures, slowing or speeding development, or utilizing temperature to produce thermal marks on otoliths. Dissolved oxygen levels will be maintained near saturation. Eggs will be monitored twice daily, and dead eggs will be removed. Siltation is not anticipated to be a problem because of the water supply; the reservoir allows sediments to settle out before reaching the hatchery intake.

9.1.5) Ponding.

Hatchlings in the vertical tray incubators will be transferred into a 3-ft diameter circular fiberglass holding tank for initial feeding and monitored for early mortality. Hatchlings in the deep matrix incubators will volitionally swim from the unit into a 3-ft diameter circular fiberglass holding tank. After approximately 2 weeks, family groups will be combined in larger circular holding tanks (16- or 20-ft diameter).

9.1.6) Fish health maintenance and monitoring.

Eyed eggs that are introduced to the Conservation Facility will be disinfected with 10-minute bath treatment containing 100 ppm of free iodine. If necessary, eggs will be treated for fungus control with 150 ml of iodine per vertical incubator stack daily. At FRH, health inspection data for infectious hematopoietic necrosis virus (IHNV) and the bacteria *Renibacterium solmoninarum* is collected from ovarian fluid of returning adult females annually during spawning (Cavallo et al. 2009). When properly disinfected, horizontal transfer from infectious parents to juveniles can be prevented. As a preventative measure, eggs will be sourced from batches where testing of these pathogens is negative. Any adult females taken from other sources will be given the same analysis.

Fish health will be monitored by CDFG Fish Health Laboratory personnel. Diagnostic procedures for pathogen detection will follow American Fisheries Society professional standards as described in the American Fisheries Society Bluebook (AFS-FHS 2007). If disease is identified, appropriate treatments will be prescribed by a CDFG Fish Pathologist and follow-up examinations will be performed as necessary.

					Presence in California	
		Common/Acronym Name	**Scientific Name**	**Host**	**+/- Hatcheries**	**+/- Wild Fish**
Bacteria		Bacterial Hemorrhagic Septicemia	*Aeromonas* spp, *Pseudomonas* ssp	all finfish	+	+
		Bacterial Gill Disease / BGD	*Flavobacterium branchiophilum*	salmonids	+	+
		Columnaris	*Flavobacterium columnare*	all freshwater fish	+	+
		Coldwater Disease / CWD	*Flavobacterium psychrophilum*	salmonids	+	+
		Enteric redmouth / ERM	*Yersinia ruckeri*	salmonids	+	+
		Furunculosis	*Aeromonas salmonicida*	all finfish	-	+
		Bacterial Kidney Disease / BKD	*Renibacterium salmoninarum*	salmonids	+	+
		Salmon Rickettsiosis[1]	*Piscirickettsia salmonis*	salmonids	-	+
Virus		Infectious Hematopoetic Necrosis Virus / IHNV	*Novirhabdovirus* sp.	Salmonids	+	+
		Infectious Pancreatic Necrosis Virus / IPNV[2]	Birnavirus family	Salmonids	-	-
Parasites	Metazoan	Ceratomyxosis	*Ceratomyxa shasta*	Salmonids	+	+
		Parvicapsula	*Parvicapsula minibiconis*	Salmonids	-	+
		Proliferative Kidney Disease / PKD	*Tetracapsuloides bryosalmonae*	Salmonids	+	+
		Blood Fluke	*Sanguinicola*	Salmonids	+	+
		Gyrodactyliasis (Skin and Gill Fluke)	*Gyrodactylus* sp.	all finfish	+	+
		Copepods	*Salmincola californiesis*	Salmonids	+	+
Parasites cont.		Trematodes	*Cryptocotyle lingua* and *Diplostomum spathaceum*	Salmonids	-	+

					Presence in California	
		Common/Acronym Name	**Scientific Name**	**Host**	**+/- Hatcheries**	**+/- Wild Fish**
		Cestodes	*Eubothrium* spp., *Diphyllobothrium* spp.,	Salmonids	-	+
		Nematodes	*Anisakis* spp., *Cystidicola* spp., and *Eustrongylides* sp.	all finfish	-	+
	Protozoan	Ich	*Ichthyophthirius multifilis*	all finfish	+	+
		Chilodonellosis	*Chilodonella* spp.	all finfish	+	+
		Trichodinosis	*Trichodina* spp.	all finfish	+	+
		Ciliates	*Epistylis* spp., *Apiosoma* spp., *Ambiphyra* spp., *Capriniana piscium*	all finfish	+	+
		Costia	*Ichthyobodo necator*	all finfish	+	+
		Cryptobiosis	*Cryptobia* spp	all finfish	+	+
		Tetrahymenosis	*Tetrahymena* sp.	all finfish	+	+
		Hexamitosis	*Spironucleus salmonis*[3]	all finfish	+	+
	Microsporean	Nucleospora	*Nucleospora salmonis*	Salmonids	+	+
		Loma	*Loma* sp.	Salmonids	+	+

[1] In 1998 and 2005, epizootics in juvenile white seabass from Hubbs Seaworld were attributed to the bacterium.

[2] Not detected in over 10 yrs

[3] Formerly known as *Hexamita* sp.

Table 9.2. Disease/Pathogens that could potentially be found in the San Joaquin
CDFG Fish Health Lab 2009, unpublished data.

9.1.7) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation.

Eggs will be incubated using the same source water as the existing trout production hatchery, which has been successfully used for hatching trout and salmon eggs for over 50 years and has been shown to be free of highly virulent pathogens. Because the water originates from the end of a large reservoir (Lake Millerton), siltation has not been problematic. The Interim Facility will use the same non-filtered water. For precautionary measures, the Conservation

Facility will incorporate both solids filtration (sand filters) and UV sterilization during incubation and hatching.

9.2) Rearing:

9.2.1) Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years (1988-99), or for years dependable data are available.

Information for the Conservation Facility is not yet available. Information on survival rates varies considerably in the literature. Survival rates at the Idaho Department of Fish and Wildlife's Lyons Ferry Hatchery of captive reared Tucannon River spring-run Chinook salmon from age 1 to age 5 varied from 3.2 to 16.9% (Gallinat et al., 2009). However, the same program observed significantly lower survival from the offspring of captive reared adults compared to the offspring of naturally reared and conventional hatchery reared adults (Table 9.3). The Conservation Program anticipates survival to be similar what is reported by Pollard and Flagg (2004), that egg-to-smolt survival rates for captive rearing programs are commonly greater that 75% and smolt to adult survival often exceed 50 percent.

	Natural			**Conventional Hatchery**			**Captive Brood**		
Brood Year	**Egg to Parr**	**Parr to Smolt**	**Egg to Smolt**	**Egg to Parr**	**Parr to Smolt**	**Egg to Smolt**	**Egg to Parr**	**Parr to Smolt**	**Egg to Smolt**
2000	13.8	44.9	6.2	95.6	82.8	79.2	29.7	70.7	21.0
2001	6.1	60.1	3.6	95.0	84.0	79.8	69.4	71.9	49.9
2002	6.7	83.8	5.7	89.5	81.6	73.0	28.6	88.7	25.4
2003	9.1	56.2	5.1	89.9	56.3	50.6	53.3	78.9	42.0
2004	6.0	68.3	4.1	91.8	52.4	48.1	45.3	93.9	42.6
2005	5.8	83.1	4.8	93.9	98.7	92.6	35.9	95.8	34.4
2006	---[a]	---[a]	10.7	90.9	94.8	86.2	48.8	98.4	48.0
Mean	7.9	66.1	5.7	92.4	78.6	72.8	44.4	85.5	37.6
S.D.	3.1	15.4	2.3	2.5	17.8	17.2	14.5	11.6	11.1

Table 9.3. Percent survival by life stage of progeny from naturally reared, conventional hatchery reared, and captive reared Tucannon River spring-run Chinook salmon for the 2000-2006 brood years. Data from Gallinat et al., 2009

9.2.2) Density and loading criteria (goals and actual levels).

Three-ft circular tanks (106 gallons; 401 liters) will be used for early feeding and for juvenile segregations. Sixteen-ft circular tanks will be used for rearing fish up to age-2 and 20-

ft tanks will be used for age-2 fish through maturity. During captivity, tank flushing rates will be less than one turnover per hour and the maximum allowable density index will be 0.15 $lb/ft^3/in$ as proposed by Banks (1994) and Ewing and Ewing (1995) for spring-run Chinook salmon.

9.2.3) Fish rearing conditions

The facility will use circular rearing tanks. Circular rearing tanks have been shown to have several advantages over plug flow raceway designs and are the design of choice for many salmon captive rearing programs. The benefits of circular tanks include the following:

- The ability to adjust water velocities to target optimal swimming speeds for salmonids which has been shown in improve growth rates, feed efficiency, oxygen utilization, improved swimming performance and stamina and reduced aggression.
- The ability to self-clean, allowing improved water quality and minimized human to fish contact.
- Improve waste management characteristics.
- The ability to efficiently and evenly add supplemental oxygen.
- Well adapted for water recirculation if needed.

Influent water temperatures typically range between 45 and 55 degree F at the existing trout hatchery. Some temperature control is possible by the adjustment of mixing valves associated with two water supply lines from the dam, which draw water from two depths (high and low). During the summer months, water is drawn closer to the base of the dam to supply cooler water.

Human-fish contact will be minimized and culture tanks will be cleaned no more than once per month, unless required by sanitary conditions. Dissolved oxygen levels will be maintained between 80-100% saturation and not allowed to drop below 70% saturation. Studies indicate the benefits of high dissolved oxygen levels in fish culture (Westers 2001). Both total suspended solids and carbon dioxide levels will be maintained at or below 10 mg/L (Piper et al. 1982, Timmons and Ebeling 2007).

9.2.4) Indicate biweekly or monthly fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available.

Information not yet available.

9.2.5) Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available.

Information not yet available.

Growth rates will be modulated in both the captive rearing program and the smolt

production program by manipulating the feed rate and/or the energy density and protein content of the feed. Growth of captive reared fish will be modulated to minimize precocity and growth during smolt production will be modulated to meet Conservation Facility goals for release size, release timing and strategies for avoiding possible impacts to the wild population.

9.2.6) Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (average program performance).

The Conservation Facility will use high quality slow sinking salmon feed from a reputable fish feed manufacturer. Dietary protein and energy levels may vary in order to modulate fish growth rates according to Conservation Program requirements. Feeding charts will be used to guide the number of feedings and percent of body weight fed per day. Live feeds and other natural feeds will be investigated with the goal of mimicking natural conditions. Feed conversion efficiencies will vary depending on the feed type and feed rate and the age of the fish. Automated feeders will be used and feeding regimes and timing will attempt to mimic natural conditions, particularly for the smolt production program.

9.2.7) Fish health monitoring, disease treatment, and sanitation procedures.

All Conservation Facility fish will be monitored by CDFG pathologists and certified prior to release. Treatment methods prescribed by fish pathologists for disease outbreaks and treatment protocols will be carried out by hatchery staff. Depending on the cause of an outbreak, treatment methods may vary. However, chemical treatments for external pathogens may include the use of salt, $KMnO_4$, formalin or hydrogen peroxide as allowed by the hatchery discharge permit. Bacterial infections could include the use of oxytetracycline, florfenicol or other approved antibiotic. All treatment will follow veterinary guidance and will be used and monitored according to wastewater discharge requirements (NPDES).
Sanitation procedures include:

- All cleaning equipment, lab equipment, transport tanks and nets will be disinfected in iodine-based disinfectant prior to use and separate cleaning instruments will be kept for each culture tank.
- Routine pathology health assessments will be carried out to maintain the health of all hatchery stocks. Fish will be monitored daily for behavior and physical abnormalities. Fish exhibiting abnormal behavior will be screened for pathogens. Sick fish will be promptly examined by the California Department of Fish and Game State Fish Health Lab.
- Feeding practices will be continuously monitored to avoid uneaten feed at the bottom of the rearing tanks and feed will be stored according to manufacturer recommendations to avoid fish health problems related to mycotoxins and rancidity, and feed will be used within the time recommended by the manufacturer.

- Water flushing rate will be maintained at a minimum of one turnover per hour and rotational water velocities will be elevated daily to improve water quality and tank sanitation.
- Sidewall viewing windows will be installed on all large tanks for increased fish health and tank sanitation monitoring.
- Dead or dying fish will be removed promptly from each rearing tank and necropsied. Dying fish will be humanely euthanized immediately after removal from rearing tank.

9.2.8) Smolt development indices (e.g. gill ATPase activity), if applicable.

Smoltification timing will be monitored between the different groups within the Conservation Facility to identify differences associated with origin. Indices used may included gill ATPase, skin reflectance, condition factor, scale loss and behavior.

9.2.9) Indicate the use of "natural" rearing methods as applied in the program.

Section 3 of this HGMP provides a conceptual framework for conservation hatcheries that includes using methods for natural rearing. The methods to be employed include the following:

- *Provide matrix substrates and darkened environments for egg incubation and alevin development.*
- *Promote development of body camouflage coloration in juvenile fish by creating more natural environments in hatchery rearing vessels, for example, overhead cover, and in-stream structures and substrates.*
- *Condition young fish to orient to the bottom rather than the surface of the rearing vessel by using appropriately positioned feed delivery systems.*
- *Exercise young fish by altering water-flow velocities in rearing vessels to enhance their ability to escape predators.*

The use of natural rearing methods is a relatively new phenomenon, as no true conservation hatcheries were in existence prior to 1999 (Flagg and Nash 1999). The Program will institute the techniques that provide the most promise for increasing the reproductive fitness of fish for the Program, as developed and evaluated during rearing trials with fall-run Chinook salmon. Any proposed natural rearing techniques will be reviewed the by the Hatchery Technical Team and submitted to NMFS for approval prior to use on spring-run Chinook. Natural rearing techniques to be evaluated include provision of matrix substrates and darkened environments for proper egg and alevin development, use of overhead cover and in-stream structures and substrates to promote body camouflage coloration in juvenile fish, use feeding systems positions to supply food from the bottom of the rearing vessel, and periodic alteration of water-flow velocities to exercise young fish.

9.2.10) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation.

After natural salmon are re-established in the system, consideration will be given to the size of hatchery fish at time of release and timing of release to minimize the risk of predation and competition with the natural fish. For precautionary measures, the Conservation Facility will incorporate both solids filtration (sand filters) and UV sterilization during incubation and hatching and 80 micron micro drum screen filters for captive rearing. The Conservation Facility will strive to mimic natural rearing conditions in order to avoid, as much as possible, hatchery induced selection. Therefore, efforts will be made to incubate within a substrate (i.e. deep matrix) and in dark conditions. See additional details in HGMP Section 3.

SECTION 10. RELEASE

Describe fish release levels, and release practices applied through the hatchery program.

10.1) Proposed fish release levels. *(Use standardized life stage definitions by species presented in **Attachment 2**. "Location" is watershed planted (e.g. "Elwha River").)*

The proposed fish release levels will be based on the success of the Program to sufficient quantities of fish from the source populations and the success of the captive rearing program. Release levels be determined by the Technical Team and will work to not exceed the carrying capacity of the river system.

Table 10.1 Target hatchery stock levels for fish released to the San Joaquin River as eggs or juveniles in numbers sufficient to produce 100 adults.

	Source	Age	Targeted Hatchery Stock for Release	Anticipated Spawners	
				Females	Males
Year 1-8	Butte Creek	Eggs or Juvenile	106,666 eggs or 1,280 juveniles	16	16
	FRH	Eggs or Juvenile	106,666 eggs or 1,280 juveniles	16	16
	Deer Creek	Eggs or Juvenile	60,000 eggs or 720 juveniles	9	9
	Mill Creek	Eggs or Juvenile	60,000 eggs or 720 juveniles	9	9
	Total Target for Re-Introduction		**333,332 eggs or 4,000 juveniles**	**50 pairs**	

10.2) Specific location(s) of proposed release(s).

Stream, river, or watercourse: San Joaquin River

Release point: The fish will be released from the hatchery in most cases. Additional locations may be necessary based on the condition of the river and the results of the migration and predation studies outlined in HGMP Section 12. Additional potential release sites are presented in Table 10.2, below.

Potential Release Location	Latitude (DMS)	Longitude (DMS)	River Mile
Hatchery location	36°59'11.57"N	119°43'2.11"W	266-267
Lost Lake Park	36°58'14.16"N	119°44'21.19"W	264-265
Ball Ranch Access Point	36°56'38.09"N	119°44'18.74"W	262-263
Willow Ecological Reserve	36°55'48.92"N	119°45'2.27"W	260-261
Fort Washington Access Point	36°52'34.97"N	119°47'14.28"W	255-256
Vulcan Access Point	36°54'33.52"N	119°46'20.93"W	257-259
Sycamore Island	36°51'18.94"N	119°50'13.34"W	251-252
Scout Island	36°51'31.47"N	119°50'20.98"W	250-251
HWY 99 Bridge Crossing	36°50'35.05"N	119°55'55.42"W	243-244
Millburn Unit	36°51'22.68"N	119°52'46.24"W	247-248
Bifurcation Structure Access Point	36°46'26.48"N	120°17'4.08"W	215-217
Mendota Pool Access Point	36°47'34.23"N	120°22'18.88"W	204-205
Sacramento Dam	36°58'55.80"N	120°30'3.67"W	182-183
Firebaugh (bridge)	36°51'30.00"N	120°26'56.00"W	195-196
San Luis Wildlife Area	37°14'10.00"N	120°48'53.00"W	141-145
HWY 165 Bridge	37°17'43.31"N	120°51'4.25"W	132-133
HWY 140 Bridge	37°18'36.00"N	120°55'50.00"W	124-125
Hills Ferry Barrier	37°20'50.84"N	120°58'32.84"W	118-119

Major watershed: San Joaquin River
Basin or Region: Middle San Joaquin-Lower Chowchilla Watershed, USGS Unit: 18040001.

10.3) Actual numbers and sizes of fish released by age class through the program.

There have been no releases over the past 12 years.

10.4) Actual dates of release and description of release protocols.

There have been no releases over the past 5 years.

10.5) Fish transportation procedures, if applicable.

Transportation procedures for the purpose of fish releases will vary depending on life stage to be released. Eggs will be place in a specialized Styrofoam shipping container, and will be cooled and kept moist using non-chlorinated ice and transported in a dark environment. Upon arrival at the release site, eggs will be rehydrated and tempered to the receiving water by increasing the egg temperature 1 ºC per hour until matching the receiving water temperature.

Juvenile and adult fish will transported to the release site using the following general guidelines (Carmichael et al. 2001):

1. Reduce the number of stressors
2. Reduce the severity of stressors
3. Minimize the duration of stressors
4. Minimize plasma ion disturbances
5. Minimize increases in metabolic rate

Fish will be transported from the Conservation Facility using a 500-gallon transport tank at a maximum loading rate of 0.28 kilograms of fish/liter of water. The tank will be filled with Conservation Facility water immediately prior to transport. The transport water will be oxygenated using compressed oxygen cylinders with oxygen stones and impellor driven aerators. Dissolved oxygen levels will be monitored and maintained near saturation during transport. Transport water will be supplemented with sodium chloride to provide a physiologically isotonic concentration to minimize ionic disturbances. When possible, fish will be move in and out of the transport tank using a water-filled vessel and without netting to minimize stress and loss of slime. Release site will be near the Conservation Facility and predicted spawning ground; however, releases may occur much farther downstream to avoid migratory hazards and transport time may be as long as 2 hours if necessary. Water will be tempered to two degrees Celsius of the river location receiving the fish before transferring fish. When possible, releases will occur at night to minimize predation.

10.6) Acclimation procedures (*methods applied and length of time*).

The Program's 10(a)1(A) permit application reviews several methods for reintroducing eggs and juveniles to the San Joaquin River; please see that document for a detailed discussion of the acclimation procedures. For eggs, the document reviews streamside incubators, in-river incubation using an instream incubation box, and in-river incubation using egg injection into the gravel. For juveniles, it reviews direct releases of collected juveniles from the source population and temporary holding in cages for imprinting and acclimation. Acclimation ponds may also be used.

Ultimately, the acclimation procedures used for reintroduction will be adaptively managed depending on the results of the research and monitoring outlined in HGMP Sections 11 and 12. The initial methodologies will be selected based on the results of the Fall-run Chinook Experimental Captive Rearing Study, the Juvenile Chinook Predation Study, the Salmon Egg Survival Study, and the Juvenile Chinook Salmon Migration Survival Study. The results of these studies will be presented in the annual reports from the Conservation Facility, with recommendations on preferred reintroduction methods for the spring-run Chinook salmon.

10.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.

All captive reared broodstock will be genotyped for PBT (See HGMP Section 12 for more details) and tagged using an intraperitoneal, passive integrated transponder (PIT) tag after reaching a minimum length of 85 mm. PIT tags will be used for monitoring individual fish

throughout captivity. Immediately prior to spawning, fish will be disk tagged (intramuscularly) for easy visually identification.

All Conservation Facility juveniles will be adipose fin clipped and coded-wire or PIT tagged prior to release. Additional fin clips will be taken for genetic analysis. This management approach may be modified depending on the findings of a Hatchery Scientific Review Group that is analyzing hatchery practices in California and will soon provide recommendations on this action.

10.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels.

In order to accommodate for anticipated mortality, sufficient numbers of donor fish will be collected which may result in numbers beyond what is needed for rearing to maturity. Typically at the yearling stage, excess fish will be released to the San Joaquin River for reintroduction and possibly research. Depending on the life stage age at release, research fish will be monitored for, among other things, false migration pathways, predation susceptibility, and spawning behavior. When a surplus is noted, the hatchery advisory committee will discuss the possible alternatives and make a recommendation to NMFS regarding disposition of any excess eggs, fingerlings, or smolts.

10.9) Fish health certification procedures applied pre-release.

Diagnostic procedures for pathogen detection will follow American Fisheries Society professional standards as described in the American Fisheries Society Bluebook (AFS-FHS 2007).

If disease is identified, appropriate treatments will be prescribed by a CDFG Fish Pathologist as appropriate, and follow-up examinations will be performed as necessary.

All Conservation Facility fish will be monitored by CDFG pathologists prior to release. Treatment methods prescribed by fish pathologists for disease outbreaks and treatment protocols will be carried out by hatchery staff. Depending on the cause of an outbreak, treatment methods may vary.

State statute and code provide authority to the Department to curtail or minimize the impact of diseases on fish within California. Implementation of this authority is achieved through; 1) inspecting wild fish and aquatic species captured for transport to a different location; 2) and inspecting wild fish and aquatic species to acquire information, useful for fishery management decisions, on the geographical distribution of pathogens; and 3) recommending therapies and corrective measures, or stock destruction to minimize disease impacts. Regulations granting authority to protect the state's resources from fish diseases and parasites are contained in the Fish and Game Code, and the California Code of Regulations, Title 14 (Title 14). Title 14 states the procedures for aquaculture disease control. These regulations are applied to protect aquaculture and the watersheds or geographic areas the Department determines could be threatened. General conditions deals with procedural guidelines. These guidelines involve:

- inspections and examinations, and how they are to be conducted;
- who is notified if a listed disease is identified;
- what to do upon confirmation of any listed disease;
- methods of disposal, and disinfection of equipment and facilities;
- certification, by a fish pathologist, prior to shipment from outside of the United States;
- disease research and who is contacted prior to the causative agent being brought to the facility.

Disease categories are broken down into four groups by level of threat. These categories are: significant diseases, serious diseases, catastrophic diseases, and "Q" diseases (a disease for which there is so little information, permanent classification cannot be given). Each group has a list of diseases, and procedures to follow for each disease. Also contained in the regulations is a list of aquatic diseases and their host organisms.

10.10) Emergency release procedures in response to flooding or water system failure.

The Conservation Facility will be integrated into the Emergency Action Plan of San Joaquin River Fish Hatchery and the Friant Fishwater Release Hydroelectric Project (FERC Project No 11068-CA). The Conservation Facility will be designed to minimize unintended releases to the San Joaquin River during flood events by installing screens on tanks. In the event that an emergency release is necessary due to flooding or other reason, fish will be crowded into the volitional release channel for release, or be loaded into fish transport tanks, transported to the river at an appropriate location and released according to State and Federal rules and requirements.

10.11) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases.

As noted in HGMP Section 3, the spring-run Chinook salmon in the experimental population will interact with listed fish during outmigration, rearing in the Delta, in the ocean, and via straying as adults. The reintroduced fish are likely to interact with other listed salmonid populations, including the endangered winter-run Chinook salmon, and the threatened Central Valley steelhead.

Negative interactions may include induced behavioral changes in wild fish, competition for limited resources, depensatory predation, disease transfers, and interbreeding (Reisenbichler et al. 2004). The fish release methods can influence all of these potential interactions.

Disease transfers will be addressed under the certification procedures identified in HGMP Section 10.9, above.

Induced behavioral changes in wild fish, competition for limited resources and depensatory predation are all aggravated by large releases of naïve fish. Initially, releases from the Conservation Facility will be small and should present limited risk in these areas. As release sizes increase, allocation of reintroduced fish between egg release and juvenile releases should

spread out the period over which juveniles are entering the system, reducing the risk to listed species. Further, with the juveniles raised in-hatchery, volitional release should allow for a gradual introduction of the juveniles into the system, further reducing the risk to listed species. Reintroductions will be adaptively managed to minimize impacts on other listed species.

SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

This section describes how "Performance Indicators" listed in Section 1.10 will be monitored. Results of "Performance Indicator" monitoring will be evaluated annually and used to adaptively manage the Conservation Facility program, as needed, to meet "Performance Standards".

11.1) Monitoring and evaluation of "Performance Indicators" presented in Section 1.10.

As noted in HGMP Section 1.9, above, some indicators are already measured and will continue to be measured as part of other ongoing programs. Data from the ongoing monitoring efforts will be gathered by the Hatchery and Monitoring Technical Team and will be included in the Annual Reports, but the funding for these ongoing efforts is not included in the HGMP budget. This includes Indicators:

1.A.i. – ii., 1.B.ii. – iii., 1.C.ii., 1.D.ii., 1.F.i – ii., 4.A.ii., 6.C.iii.

11.1.1) Describe plans and methods proposed to collect data necessary to respond to each "Performance Indicator" identified for the program.

The Conservation Program Annual Report will document the result of this monitoring effort. The report itself will provide details on Conservation Facility Operations, and the report will include both a Genetics appendix and an Instream Monitoring appendix. An outline for the yearly report and appendices is presented in Appendix 5. The following yearly monitoring activities will form the basis for the report. These programs address specific indicators listed in HGMP Section 1.10; the particular indicators addressed are listed after each section. Some monitoring activities are already ongoing and are not managed by Conservation Facility; these are also identified below.

11.1.1.a) Conservation Facility Operations Monitoring

Monitoring: Monitoring and reporting of broodstock collection methods and results. Estimates of impacts to source populations, in terms of adults taken. Will include reports of any mortality or observed stress on fish.

Indicators: 1.D.i., 1.D.iii, 1.E.i. – ii., 1.G.i. – 1.G.v., 6.C.i. – iv.

Monitoring: Release practices are documented, including location of releases, number of fish of each stage released, and physical marks applied to fish. Marking and genetic parental based tagging should allow differentiation of the reintroduced spring-run fish from other Central Valley salmon runs. Genetic analysis is used to examine success of different reintroduction methods. Experimental releases employing different release strategies are documented and results feed

back into release decisions for future years. Adult returns are compared to release method and location. The effects of marking and tagging of fish on fish stress level will be investigated.

Indicators: 1.C.i, 1.C.iii., 2.B.i., 3.B.i – ii., 3.C.ii. – vii., 3.D.i. – v., 4.A.i., 4.A.iii, 5.C.ii., 6.A.i. – iv.

Monitoring: Public visits to the Conservation Facility will be logged and total number of visitors will be reported annually. Public outreach activities at the Conservation Facility and in other venues will be logged and reported annually. Recommendations for improving public outreach will be developed annually, and implementation of prior year's recommendations will be monitored and reported.

Indicators: 9.A.i. – 9.B.ii.

Monitoring: Fish health policy compliance will be monitored, and any observed disease outbreaks during inspections will be reported. Rearing survival rates will be calculated and compared to other hatcheries that rear spring-run Chinook salmon. In-river population will be monitored for disease occurrence using both visualization and diagnostic assays. Fish carcass disposition procedures and compliance with procedures will be reported, including compliance with disease control regulations or guidelines.

Indicators: 5.A.i. – 5.A.vii., 5.B.i. – iii.

Monitoring: Rearing practices will be monitored and reported. Juvenile densities will be reported. Adherence of hatchery operations and conditions to recommended natural hatchery rearing practices (per HGMP Section 3) will be reported.

Indicators: 2.C.i.

Monitoring: Water use and source will be described annually. Water quality information, both for source and outflow, will be reported, as will compliance with water quality permits. Daily temperature of river water, Conservation Facility tanks, and water supply will be reported. Visits/inspections will be reported.

Indicators: 8.C.i. – 8.D.iv.

Monitoring: Conservation Facility permitting and compliance with the HGMP, including monitoring and reporting requirements, is evaluated annually. Hatchery and monitoring technical teams meet biannually to review the annual report and make recommendations for changes to the hatchery practices or to the HGMP. Data and annual reports are publicly available online and are distributed to all participants.

Indicators: 8.A.i. – B.ii., 8.E.i. – iii.

11.1.1.b) Genetics Monitoring

Monitoring: Continued genetic monitoring of the selected source populations. This may be part of ongoing monitoring of those populations outside the Conservation Facility program for the FR, although additional genetic monitoring may need to be undertaken on the Butte, Deer, and Mill Creeks.

Indicators: 1.D.ii

Monitoring: Genetic analysis of the broodstock population and the naturalizing experimental population from initial returns through the end of the recovery program. This will document the matings used in the hatchery and the in-hatchery success of these matings. This will include analysis of all reintroduction methods employed to determine relative success of each method. This should include parentage analysis and an estimate of the success of each of the three source populations, both independently and based on percentage of the admixture in mixed offspring-run. If these studies reveal unexpected differentials in rates of establishment, either by differential survival of family-groups within sources or differential survival of broodstock source, recommendations should be made for changes in broodstock collection or mating practices. Introgression between spring-run and fall run populations in the San Joaquin River will also be reported, to the extent practicable given existing introgression in Feather River fish.

Indicators: 1.B.i., 2.A.i. – iii., 2.B.i., 4.B.i. – iii., 4.C.iii., 6.B.i., 7.A.i

11.1.1.c) Instream Monitoring

Monitoring: Escapement estimates will be developed for the returning adults beginning in 2015. Monitoring will include snorkel surveys, redd surveys, and carcass surveys. The returning fish should be analyzed to determine their origin (strays vs. planted fish and spring-run vs. fall run). Spawner to recruitment ratios will be calculated for San Joaquin River fish. San Joaquin River escapement estimates will be the basis for Conservation Facility production goals after the restoration period ends. Outmigrant monitoring will record number and origin of outmigrants.

Indicators: 3.A.i. – v., 3.C.ii – 3.C.ix, 3.D.iv., 4.A.iii, 4.C.ii. – iii., 6.A.i – 6.A.iii, 6.B.i., 7.A.i. – ii., 7.B.i – 7.B.iv.

Monitoring: Restoration of in-river habitat will be monitored and compared to baseline conditions. Estimates will be made annually of river carrying capacity, including spawning, freshwater rearing, migration corridor, and estuarine and near shore rearing, which will guide the release numbers. Monitoring will include differentiation of spring-run and fall run habitat.

Indicators: 3.C.i – 3.C.vii.

Long term monitoring of the natural population: Life history characteristics of the natural population are monitored for adaptation to the local environment. Includes monitoring over successive generations of:

- Juvenile dispersal/outmigration timing

- Juvenile size at smoltification and outmigration, and outmigration age composition
- Adult return timing
- Adult return age and sex composition
- Adult size at return
- Spawn timing and distribution
- Fry emergence timing
- Juvenile rearing densities, distribution, and behaviors
- Juvenile growth rate, condition factors, and survivals at several growth stages prior to final release
- Adult physical characteristics (length, weight, condition factors)
- Fecundity and egg size
- Spawning behavior and success
- Diet (food availability in natural environment)
- Incidence of disease in the natural environment

The monitoring framework will include static sites for collecting biological data and a genetic sample (e.g., fin clip) to allow genetic identification of individuals and their biological status (e.g.: growth, weight, condition factor) for both outmigrating juvenile and returning adult spring-run Chinook salmon.

Indicators: 4.B.i. – 4.B.iii., 5.C.i.

Monitoring: Fish barrier deployment and efficacy information will be gathered each year, including date of erection of barrier, date of barrier removal, and estimate of numbers and origin of fish that successfully evade the barrier and move upstream.

Indicators: 4.C.i. – 4.C.ii., 6.A.ii

11.1.2) Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Staffing requirements for monitoring are detailed in HGMP Section 1, above. Funding for operational funding for monitoring and evaluation is currently being negotiated by CDFG and Reclamation.

11.2) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from monitoring and evaluation activities.

Monitoring and evaluation activities will be conducted in close cooperation with the Program's Technical Team and will be conducted in order to minimize stress and mortality to listed fish. In the event that activities are found to increase stress and mortality, findings will be presented to the Technical Team and appropriate measures will be taken to reduce the impacts of activities.

SECTION 12. RESEARCH

12.1) Objective or purpose.

The Conservation Facility program includes several planned studies, and additional studies may be developed. The following list includes planned studies, although some of the studies may not be completed due to funding or time constraints. Any additional studies would be reviewed by the technical teams and NMFS before being added to an amended HGMP Section 12. Conservation needs will be given priority over research needs. The discussion below is divided by project for the planned studies.

12.1.1) Fall-run Chinook Experimental Captive Rearing Study

12.1.1.a) Objective: This study will test captive rearing culture practices on fall-run Chinook, a non-ESA listed species, prior to working with the listed spring-run Chinook salmon.

12.1.1.b) Benefit: This project will benefit the spring-run population by identifying problem areas in the culture system and practices prior to rearing the listed species. This should reduce the take to the listed populations later in the Conservation Facility process.

12.1.1.c) Broad Significance: The project provides a model for avoiding or minimizing impacts to listed and sensitive species in California while undertaking research or reintroduction with those species.

12.1.1.d) Techniques: Year 1. Receive 500-1500 eyed fall-run Chinook salmon eggs from Merced River Hatchery during the fall of 2010. Of these, 500-1000 will be transferred to UC Davis for experimental use in the temperature study described below and 500 will be transferred to the Interim Facility for experimental rearing. Fish will be reared until ready to spawn and will then be spawned. Spawned, eyed eggs will likely be returned to Merced River Hatchery for hatching. Rearing conditions will mimic conditions for rearing spring-run Chinook salmon that will be acquired in the fall/winter of 2012/2013. Investigations will include growth rate modulation, feed source, feed quantity and timing, disease monitoring and treatment, sterilization of source water, use of ultrasound monitoring for gonadal development, use of tags (VI and PIT) and marks, possible genetic analysis, development of appropriate breeding matrixes to prepare for the mechanics of breeding under a matrix approach, and other procedures associated with captive rearing. All chemical use including disease treatments will be conducted in accordance to NPDES and State Fish Health regulations.

Year 2. The Conservation Facility will collect 1000 wild fall-run Chinook salmon eggs or salmon smolts from the Merced River using redd pumping during the fall of 2011 in order to mimic collection procedures to be used in the collection of spring-run Chinook salmon during the fall/winter of 2012/2013. Of these, 500 will be transferred to UC Davis for experimental use and 500 will be transferred to the Interim Facility for experimental rearing. Fish will be reared to adulthood

and spawned. Spawned eyed eggs will be returned to Merced River Hatchery for hatching unless determined otherwise. Rearing conditions will mimic conditions for rearing spring-run Chinook salmon that will be acquired in the fall/winter of 2012/2013. Investigations will include growth rate modulation; feed source, quantity and timing; disease monitoring and treatment; sterilization of source water; use of ultrasound monitoring for gonadal development; use of tags (VI and PIT) and marks; possible genetic analysis; development of appropriate breeding matrixes to prepare for the mechanics of breeding under a matrix approach; and other procedures associated with captive rearing. All chemical use including disease treatments will be conducted in accordance to NPDES and State Fish Health regulations.

12.1.1.e) Alternative methods to achieve project objectives: If the pilot captive rearing system is not ready to receive eggs by the fall of 2010, other facilities will be investigated or the project will be delayed an additional year.

12.1.1.f) Level of take of listed fish: The project should have no negative impact on listed species.

12.1.1.g) Risk aversion measures: While there is no anticipated impact to listed species, researchers will observe for possible impacts to listed species and address them accordingly.

12.1.1.h) Initiation date and Principal Investigator: 2010, CDFG

12.1.2) Potential Natural Recolonization Study

12.1.2.a) Objective: This study will characterize the genetic makeup and life history diversity of the Chinook salmon populations in the lower San Joaquin River and its tributaries.

12.1.2.b) Benefit: Information about potential natural recolonizers is vital to determining how best to integrate natural recolonization with hatchery-driven recolonization. This study will provide information about the origin, run-size, run-timing, and straying rate of natural populations located in close proximity to the Restoration Area and will make recommendations about how to include these fish in the reintroduction effort.

12.1.2.c) Broad Significance: This information will provide a better characterization of the Central Valley Chinook population as a whole and will provide additional demographic and genetic information about Chinook salmon populations at the extreme Southern end of their range.

12.1.2.d) Techniques: The analysis will center on single nucleotide polymorphisms (SNPs), which are used broadly in the characterization of Chinook salmon populations. Initial analysis will rely on Chinook salmon tissue from the tissue bank collected over the last several years, and additional analysis may include tissue from more targeted collections in the lower San Joaquin River and its tributaries. For example, PBT of the adult over summering Salmon on the San Joaquin River coupled with floy tagging and otolith studies of the same fish

to determine their rivers of origin and subsequent genetic analysis of yearling outmigrants will allow assessment of hatchery vs. wild origin, river of origin, and the expression of the spring-run phenotype in these fish.

12.1.2.e) Alternative methods to achieve project objectives: None.

12.1.2.f) Level of take of listed fish: Initially, no take is involved, because the study uses previously collected tissues. If targeted collection occurs, the level of take of listed fish is unknown, because the identity of the salmon in these areas is undetermined. However, NMFS does not recognize the presence of any spring-run population on the San Joaquin River in their ESA listing. Collection is non-lethal and involves fin clip, so even if fish are present, any take should be nonlethal.

12.1.2.g) Risk aversion measures: For the initial phase, no risk aversion measures are needed. In the longer term, tissue sampling protocols will minimize risk to the sampled fish.

12.1.2.h) Initiation date and Principal Investigator: 2010, UC Davis, Reclamation

12.1.3) Temperature Tolerance Study

12.1.3.a) Objective: This study will first test thermal tolerance of Fall-run Chinook salmon in a controlled laboratory environment to evaluate gene expression under a minimum of three different thermal regimes. Experimentation using fall-run fish will allow for investigation using non-ESA-listed species prior to working with listed (spring-run) species. Pending availability of fish, a similar experiment may be repeated with spring-run fish after 2012, using the candidate genes or the approach identified in the fall-run study.

12.1.3.b) Benefit: Thermal tolerance is well-studied in Chinook salmon and an important variable for fitness at various life stages. It is therefore a key factor to consider in a successful reintroduction program. This is particularly critical for the reintroduction of Chinook salmon to the San Joaquin River system, the southernmost limit of the species' native range; great potential exists for climate change impacts to be felt early and severely in this portion of the range. Higher temperatures are known to directly affect salmonid growth and mortality, and to indirectly affect other variables such as susceptibility to disease or fish behavior (e.g., habitat selection, swimming performance, relationship to prey-predator community structure), all of which likely have some degree of genetic basis and heritability. Obtaining a gene expression profile of fall-run Chinook under variable thermal regimes will lend to our understanding of the genetic basis of thermal tolerance in this run and possibly in other genetically similar runs such as spring-run Chinook salmon.

12.1.3.c) Broad Significance: Obtaining a gene expression profile of fall-run Chinook under variable thermal regimes may lend to our understanding of the genetic basis of thermal tolerance in other genetically similar runs such as spring-

run Chinook salmon. Furthermore, this information will be useful in understanding the mechanisms of response to heat shock and possibly also in monitoring and predicting changes in wild populations facing thermal stress.

12.1.3.d) Techniques: Fifty fertilized eggs will be collected from 10-20 different single pair fall-run Chinook matings (so that multiple families are represented in each temperature treatment) performed at Merced River hatchery as crosses are made. Fin clips from parents will also be taken at that time. Total egg take will be 500-1000 eggs. All rearing and experimentation will be performed at CABA facility, UC Davis. Eggs will be acclimated at a common temperature prior to initiation of experiments.

During the experimental phase, 200 eggs will be held at each of four temperatures for the experimental timeframe; sampling may occur at eyed stage and several other stages to be determined. Temperature will be controlled through the use of Living Stream Systems (CDFG). Families will be separated, but will experience the same temperature conditions. Tissue will be collected from 10 individuals from each temperature treatment at relevant time points for use in gene expression analysis, allowing for a total of 5 to 10 replicates per treatment. This may include the use of either microarray or RNAseq techniques, to be decided at a future date.

All experimental activity will be conducted under an approved UC Davis Animal Care and Use protocol.

12.1.3.e) Alternative methods to achieve project objectives: None

12.1.3.f) Level of take of listed fish: None

12.1.3.g) Risk aversion measures: None required

12.1.3.h) Initiation date and Principal Investigator: 2010, UC Davis

12.1.4) Juvenile Chinook Predation Study

12.1.4.a) Objective: Determine predation risk to reintroduced fish at various captured mine pit habitats on the San Joaquin River.

12.1.4.b) Benefit: The results of this study will allow prioritization of mine pits for restoration to improve survival of juvenile salmon and allow for selection of the most appropriate release locations of reintroduced fish based on predation hot-spots. The study is necessary to better understand how the predators in the San Joaquin River may impact the reintroduced salmon.

12.1.4.c) Broad Significance: The research will contribute to the information on warm water predators and impacts on Chinook salmon in a reintroduction setting.

12.1.4.d) Techniques: Fish reared at the Conservation Facility will be released above captured mine pits, predators will be sampled in mine pits after release, and then gastric lavage will be used to determine predation rates. Recapture efforts for juvenile salmonids downstream of the mine pits will also provide information on juvenile salmonid survival through the habitat. Fish will be marked to distinguish each release group (CWT, visible implant elastomer, etc), and PBT

will allow comparison of survival by family group. Acoustic technology may be used to monitor the fish.

12.1.4.e) Alternative methods to achieve project objectives: None.

12.1.4.f) Level of take of listed fish: The study involves release of 500 juveniles fall-run Chinook salmon above each of 5 selected known or suspected predator habitats, totaling 2500 fish. There should be no take of listed fish, unless spring-run fish are straying into the lower San Joaquin River, in which case they may be captured and fin-clipped with the released fish below the predation zones.

12.1.4.g) Risk aversion measures: This study can be accomplished using fall run fish only. No listed spring-run Chinook salmon should be in the system when this study is conducted.

12.1.4.h) Initiation date and Principal Investigator: 2011, CDFG, USFWS

12.1.5) Positioning Central Valley Chinook SNPs onto the genetic map for Chinook salmon

12.1.5.a) Objective: Position 96 SNP markers used for genetic diversity studies of Central Valley salmon onto the Chinook salmon genetic map.

12.1.5.b) Benefit: Determining the relative position of markers on the genetic map ensures adequate coverage of the genome for accurate genetic diversity estimates.

12.1.5.c) Broad Significance: Positioning markers onto the genetic map is one of the first steps for mapping quantitative trait loci (QTL). QTL contribute to variation in heritable traits that may affect reintroduction success, such as adaptation, disease, and domestication.

12.1.5.d) Techniques: The parents and progeny of several fall-run Chinook families will be genotyped for 96 SNP markers and many (~40 – 50) microsatellite markers. Linkage mapping software will determine the relative positions of all markers.

12.1.5.e) Alternative methods to achieve project objectives: None.

12.1.5.f) Level of take of listed fish: None. Only fall-run tissue will be used and all samples have already been collected.

12.1.5.g) Risk aversion measures: None required.

12.1.5.h) Initiation date and Principal Investigator: 2010, UC Davis

12.1.6) Juvenile Chinook Acoustic Telemetry Study (fall-run)

12.1.6.a) Objective: This study will characterize migration of juvenile fall-run Chinook salmon through the restoration area.

12.1.6.b) Benefit: The characterization of migration of juvenile Chinook salmon through the restoration area will allow the Conservation Facility to pinpoint problem areas and address those problems through additional restoration or alternative methods of reintroduction.

12.1.6.c) Broad Significance: This project will characterize movement of juvenile

Chinook salmon and allow for the assessment of survival through the restoration area. It will determine areas of loss, migration delay, habitat use, passage impediments, etc. Beyond this reintroduction, the research should provide information about habitat suitability and survivability for juvenile salmonids in a rewatered stream section. Data will be comparable to that gathered from the array of acoustic receivers in the Sacramento-San Joaquin Delta, so data can be compared to other populations of juvenile salmonids in the Central Valley

12.1.6.d) Techniques: Juvenile fall-run Chinook salmon reared at the Conservation Facility or at UC Davis will be implanted with acoustic tags and released in reach 1 of the restoration area. Stationary telemetry receivers will be placed throughout the passable portions of the restoration area to track movement of juveniles past receivers. Mobile tracking will also be conducted to determine habitat use between stationary receivers.

12.1.6.e) Alternative methods to achieve project objectives: None.

12.1.6.f) Level of take of listed fish: Study will consist of 100 acoustically tagged fish released with an escort group of 1000 fish, but all of the fish will be fall-run. No listed fish should be taken.

12.1.6.g) Risk aversion measures: None required.

12.1.6.h) Initiation date and Principal Investigator: 2011, USFWS

12.1.7) Broodstock Genetic Diversity Study

12.1.7.a) Objective: This study will examine the genetic diversity in the broodstock fish taken from each of the three potential source populations. Based on prior, ongoing, and, as needed, additional SNP work to characterize the source populations, the study will determine how well the diversity in the wild source population is reflected in the broodstock and will make recommendations for adaptively managing the broodstock collection to better capture the wild populations' diversity.

12.1.7.b) Benefit: The study will ensure adequate diversity in the broodstock to avoid bottlenecks and inbreeding in the experimental population.

12.1.7.c) Broad Significance: The study will provide empirical data on the population size necessary to adequately capture a wild population's genetic diversity, which should benefit reintroduction efforts for other salmonids.

12.1.7.d) Techniques: The analysis will center on single nucleotide polymorphisms (SNPs), which are used broadly in the characterization of Chinook salmon populations. Initial analysis will rely on Chinook salmon tissues collected ancillary to the PBT. Additional analysis, if needed, may include tissue from more targeted collections in the source populations.

12.1.7.e) Alternative methods to achieve project objectives: None.

12.1.7.f) Level of take of listed fish: None beyond normal hatchery operations for the broodstock. If necessary, some nonlethal take will result from the collection

of additional fin clips from the source populations, although the level of collection is unknown at this time.

12.1.7.g) Risk aversion measures: None required.

12.1.7.h) Initiation date and Principal Investigator: 2012, UC Davis or other

12.1.8) Epigenetics Study: Comparison of Genetic Diversity and Methylation Diversity of spring-run broodstock

12.1.8.a) Objective: This study will evaluate spring-run Chinook salmon broodstock for genetic diversity using neutral markers (microsatellites, SNPs, AFLPs) and compare observed variation to methylation diversity as detected using methylation-sensitive amplified fragment polymorphism (msAFLP) markers. In the Restoration Area, the relationship of these two diversity indices, both independently and in combination, with survival and reproductive success will be assessed to determine if increased diversity is associated with higher fitness.

12.1.8.b) Benefit: Knowledge of the predictive power of genetic and epigenetic diversity for reintroduction success may enable more informed decision making regarding broodstock source selection in the future.

12.1.8.c) Broad Significance: Epigenetic diversity can accumulate from both natural selection and environmental change and is believed to be an important component of phenotypic plasticity. Recent research has suggested that natural populations with little genetic diversity can have large epigenetic diversity in different environments. The potential ability of some populations to adapt more quickly to the likely stochastic environment of the Restoration Area may lead to differential rates of survival and reproductive fitness. Although the overall genetic diversity of the source populations is low, an examination of source population epigenetic diversity will provide a more complete picture of overall diversity that can enable adaptation. This study may have broad implications towards increasing our understanding of how genetic and epigenetic factors interact in a natural stochastic system.

12.1.8.d) Techniques: Fin clip samples used for PBT will also be used for this study. Genomic DNA will be digested with methylation-specific restriction enzymes to detect individual differences in methylation patterns. Epigenetic and genetic population diversity indices will be compared and correlated to fitness using results from PBT.

12.1.8.e) Alternative methods to achieve project objectives: None.

12.1.8.f) Level of take of listed fish: No additional take beyond normal hatchery operations for adults. For juveniles, sampling will opportunistic based on sampling for other studies, so there should be no additional incremental take.

12.1.8.g) Risk aversion measures: A minimal number of fish will be collected to adequately sample the genetic and epigenetic diversity of the populations.

Collecting from multiple broodstock populations minimizes the impacts on any one population.

12.1.8.h) Initiation date and Principal Investigator: 2012, UC Davis or other

12.1.9) Spring-run Chinook Salmon Egg Survival Study

12.1.9.a) Objective: The study will determine if direct reintroduction of eggs directly into the river is a feasible approach to successful reintroduction. The study will also allow a comparison of hatching success of source population eggs taken directly from wild redds versus eggs reared at Conservation Facility.

12.1.9.b) Benefit: This study will allow the Conservation Facility managers to better understand the potential for in-river hatching on the San Joaquin, which may reduce hatchery impacts on the reintroduced population.

12.1.9.c) Broad Significance: This study will provide information on egg survival in environmental conditions experienced at the edge of the range for Chinook salmon spawning.

12.1.9.d) Techniques: Eyed eggs reared in the Conservation Facility and eggs mined from source population populations will be placed in egg tubes and buried to varied depths in artificial redds built in Reach 1 of the San Joaquin River in areas appropriate for salmon spawning, based on substrate, flow, depth, and temperature. A control group will be reared in the Conservation Facility, consisting of 5 egg tubes of each origin reared. The experimental groups will consist of egg tubes in 5 locations in the San Joaquin River, with each location including 5 egg tubes of hatchery eyed eggs and 5 egg tubes of donor eggs placed side by side in an artificial redd. Results will be obtained during outmigration and again in the subsequent spawning run based on PBT analysis.

12.1.9.e) Alternative methods to achieve project objectives: None. The unique temperature tolerances of the spring-run fish make substitution of fall-run fish impossible for this study.

12.1.9.f) Level of take of listed fish: 6000 hatchery eyed eggs and 6000 source population eggs.

12.1.9.g) Risk aversion measures: Eggs will be taken from 3 available stocks (Butte, Deer/Mill, and Feather) to minimize impacts to each individual stock, and the use of eggs minimizes impacts to the source populations. Egg take will not exceed levels permitted by NMFS.

12.1.9.h) Initiation date and Principal Investigator: 2012, CDFG

12.1.10) Juvenile Chinook Salmon Migration Survival Study

12.1.10.a) Objective: This study will compare survival between juveniles migrating in the San Joaquin River channel and fish migrating in the bypass system.

12.1.10.b) Benefit: The study will determine the migratory pathway that allows the highest success rate, allowing managers to more accurately target their reintroduction efforts.

12.1.10.c) Broad Significance: The study contributes additional knowledge on salmonid migration characteristics at the southern edge of their range.

12.1.10.d) Techniques: Juvenile fish will come from one of two sources. First, juveniles may be reared to smolt size in the facility, or second, smolts may be collected directly from source populations. Fish will be marked in 2 separate release groups, those released in the river channel and those released at the inlet into the bypass system. Each group should consist of a minimum of 5,000 fish. Results will also be obtaining during outmigration and again in the subsequent spawning run based on PBT analysis and potentially acoustic studies.

12.1.10.e) Alternative methods to achieve project objectives: This could be done with all fall-run fish or with the Feather River hatchery stock to minimize impact to wild stocks. However, using the fish that will also form the broodstock for the reintroduction will provide the most accurate results.

12.1.10.f) Level of take of listed fish: A total of 10,000 juveniles are needed for this study. Potential source fish include fall run fish from the Merced River, spring-run juveniles from the source populations, and hatchery-reared juveniles from the spring-run broodstock. The level of take will depend on which option is selected.

12.1.10.g) Risk aversion: Fish may be taken from a combination of above stocks to reduce impact to any one stock. The use of hatchery-reared juveniles would minimize the impacts to the source populations.

12.1.10.h) Initiation date and Principal Investigator: 2015, CDFG, USFWS

Year	Research Project	Facility	Funding	Broodstock Collection	Broodstock available for use
2010		Small-scale Interim Facility initiated.	No capital funds. Operational funds only (includes monitoring funds).	None collected.	None.
2011		Interim Facility in use. Pending funding approval, Conservation Facility construction planning begins.	Capital funds available when state budget is approved, if included. Operational funding continues.	None collected.	None.
2012		Interim Facility in use. Begin construction.	Capital/operational funding continues.	Collection begins after Apr. 30, 2012. Collect 300 fish, a mix from brood year (BY) 2011 or 2012 (i.e. eggs or juveniles), sufficient to produce 100 adults at an equal sex ratio.	None. Additional eggs and fish will be collected for direct placement into the river. Some of these may be brought into the hatchery for acclimation before going to river. Any extra fish and eggs may be released as yearlings.
2013		Interim Facility should have capacity for juveniles identified in Broodstock Collection column. Construction continues.	Capital/operational funding continues.	Collect 300 BY 2012 or 2013 eggs/juveniles to produce 100 adults at an equal sex ratio. Continue rearing fish collected in 2012.	None. Jacks (Age 2 from BY 2011) may be available. If so, their milt will be frozen for later use. Jacks will generally be ripe at age 2 and will be incorporated in the spawning process.
2014		Interim Facility in use, but will be integrated into the Conservation Facility as it comes on line.	Capital funding completed in 2014. Operational funding continues through life of program.	Full-scale collection. Collect eggs and juveniles per the Lindley report on broodstock availability and Conservation Facility capacity. Continue rearing fish collected in 2012 and 2013.	Most BY 2011, collected in 2012, will be ready for spawning.

Year	Research Project	Facility	Funding	Broodstock Collection	Broodstock available for use
2015		Interim Facility retired. Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2012, 2013, and 2014. May be returns from egg boxes, which may be integrated into the hatchery mating matrix.	BY 2011, 2012, and jacks from 2013 and precocious males from 2014.
2016		Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2012, 2013, 2014, and 2015. May be returns from egg boxes.	BY 2011, 2012, 2013, and additional precocious males.
2017		Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2013, 2014, 2015, and 2016. First significant returns, from fish produced in 2014, and some of these adults may be collected for use as broodstock.	BY 2012, 2013, 2014, and additional precocious males.
2018		Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2014, 2015, 2016, and 2017.	BY 2013, 2014, 2015, and additional precocious males.
2019		Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2015, 2016, 2017, and 2018. First returns from the full-scale hatchery production (2016) expected in 2019.	BY 2014, 2015, 2016, and additional precocious males.
2020		Conservation Facility online.	Operational funding.	Last year of full-scale collections (8 years total, 2 generations). Collect as above. Continue rearing fish collected in 2016, 2017, 2018,	BY 2015, 2016, 2017, and additional precocious males.

Year	Research Project	Facility	Funding	Broodstock Collection	Broodstock available for use
				and 2019.	
2021		Conservation Facility online. Begin ramping down hatchery operations.	Operational funding.	Continue rearing fish collected in 2017, 2018, 2019, and 2020.	BY 2016, 2017, 2018, and additional precocious males.
2022		Conservation Facility online.	Operational funding.	Continue rearing fish collected in 2018, 2019, and 2020.	BY 2017, 2018, 2019, and additional precocious males.
2023		Conservation Facility online.	Operational funding.	Continue rearing fish collected in 2019 and 2020.	BY 2018, 2019, 2020.
2024		Conservation Facility online.	Operational funding.	Continue rearing fish collected in 2020.	BY 2019, 2020
2025		Conservation Facility use by Program ends.	Operational funding ends.	Probably no broodstock in hatchery, although may continue spawning naturalized adults as necessary to meet production targets.	BY 2020

12.2) Cooperating and funding agencies.

CDFG is providing some research funding until 2012. Long term funding has not been secured, but will likely be from both state (CDFG) and federal (USBR, NMFS) agencies for long-term research.

12.3) Principal investigator or project supervisor and staff.

The Conservation Facility research projects will be undertaken by several different Principal investigators, who are identified above if known at this time; the Conservation Facility hatchery supervisor will coordinate the research effort and will advise NMFS of changes, additional Principal investigators, or additional research via letter.

12.4) Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2.

The stocks affected by the research will include those described in HGMP Section 2, the experimental stock reintroduced on the San Joaquin, and stray salmon returning to the San Joaquin River and other nearby rivers. The take on stray salmon and salmon in nearby rivers will be nonlethal tissue sampling, and these salmon are not well characterized and appear to be ephemeral populations. Their status and identity are unknown. The Stock Selection Strategy discusses these small, ephemeral stocks in more detail, although additional research is necessary to better understand these stocks.

12.5) Techniques: include capture methods, drugs, samples collected, tags applied.

Techniques will vary by project; to the extent the techniques have been identified, they are discussed in HGMP Section 12.1, above.

12.6) Dates or time period in which research activity occurs.

Research with non-listed populations will begin in 2010. Any research impacting listed populations will not begin until permits are secured. Research will continue as allowed under those permits through the end of the Conservation Facility program.

12.7) Care and maintenance of live fish or eggs, holding duration, transport methods.

See HGMP Sections 7 and 9, above.

12.8-.10) Expected type and effects of take and potential for injury or mortality.

Most of the planned studies will be conducted with non-listed fall-run fish, and any take associated from those studies would occur during in-river monitoring. Moreover, those studies conducted prior to the reintroduction of spring-run Chinook salmon in 2012 are unlikely to have any impact on listed species in the Restoration Area, and any fall-run Chinook salmon that leave the Restoration Area would be unlikely to have impacts on the listed species in the Delta or beyond, given that there are fall-run Chinook salmon already present in those systems. Those studies that continue after reintroduction begins may impact spring-run Chinook salmon through monitoring; any take would be incidental to data collection on the fall-run fish and collection is generally non-lethal. Fin clips will be taken from all handled fish, when possible.

All spring-run Chinook salmon raised in the hatchery, and as many naturally-produced fish as possible in the Restoration Area, will be adipose fin clipped, both as an identifying mark (for hatchery fish) and to allow PBT. Fin clipping is generally not lethal, although a small number of fish may die during the process.

Outside of the Restoration Area, some additional tissue samples may be required from the San Joaquin tributaries and the potential source populations. If necessary, some nonlethal take will result from the collection of additional fin clips, although the level of collection is unknown

at this time and will depend on data needs. For most of these fin clips, sampling will be opportunistically based on ongoing work in those systems, with little need for additional handling.

Finally, three studies may involve lethal take of spring-run Chinook salmon, if permitted. First, the temperature study will require 500-1000 eggs, and up to 400 of the fish produced from those eggs will be subjected to lethal take as part of the study, although the actual number will likely be much lower. Any remaining fish will be returned to the hatchery. The spring-run Chinook salmon egg survival study, involving a total of 12,000 eggs, and the migration study, utilizing an undetermined number of spring-run Chinook juveniles, will undoubtedly result in some mortality due to the river conditions, but the level of take will not be known until the experiments are completed.

12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

As available, information on take associated with each study is listed above. Unlisted fall-run Chinook salmon will be taken as part of these studies. Studies beginning in Fall 2010 will require a total of 2,500 to 3,000 eggs, with an additional 5,900 eggs required in 2011. Egg totals may be lower, if individuals raised for one study can be used for other projects. For example, some portion of the eggs for the temperature study may not be required and can instead be used for the telemetry study. In total, these eggs could be provided by 3-4 female hatchery salmon, so population-level impacts will be minimal.

Many of the studies will involve mortality at a undetermined level; the telemetry study, the in-river egg survival study, and the predation study all evaluate the conditions in the Restoration Area, and determining the mortality level is part of those studies. The temperature study will result in mortality to some portion of the eggs/young fish involved in that study, although the level of mortality will not be known until the experiment is completed.

12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed fish as a result of the proposed research activities.

As available, information on take associated with each study is listed above.

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Appendix 1. Conservation Facility Operations Summary

Year	Facility	Funding	Broodstock Collection	Broodstock available for use	Permitting	Production
2010	Small-scale Interim Facility initiated.	No capital funds. Operational funds only (includes monitoring funds).	None collected.	None.	Prep/review 10(a)1(A), 10(j) designation, 4(d) regulations.	No spring-run. Some experimental unlisted fall-run production. Possibly. We may be limited to early life stages
2011	Interim Facility in use. Pending funding approval, Conservation Facility construction planning begins.	Capital funds available when state budget is approved, if included. Operational funding continues.	None collected	None.	NMFS reviewing the above.	No spring-run. Some experimental unlisted fall-run production.
2012	Interim Facility in use. Begin construction.	Capital/operational funding continues.	Collection begins after Apr. 30, 2012. Collect 300 fish, a mix from brood year (BY) 2011 or 2012 (i.e. eggs or juveniles), sufficient to produce 100-200 adults at an equal sex ratio.	None. Additional eggs and fish will be collected for direct placement into the river. Some of these may be brought into the hatchery for acclimation before going to river. Any extra fish and eggs may be released as yearlings.	Decisions on permits will be made by Apr. 30, 2012, per the settlement agreement.	None. Eggs may be placed directly into the river, pending permitting.

Year	Facility	Funding	Broodstock Collection	Broodstock available for use	Permitting	Production
2013	Interim Facility should have capacity for juveniles identified in Broodstock Collection column. Construction continues.	Capital/operational funding continues.	Collect 300 BY 2012 or 2013 eggs/juveniles to produce 100-200 adults at an equal sex ratio. Continue rearing fish collected in 2012.	None. Jacks (Age 2 from BY 2011) may be available. If so, their milt will be frozen for later use. Jacks will generally be ripe at age 2 and will be incorporated in the spawning process.	All permits should be issued in 2012.	None. Eggs may be placed directly into nest boxes, pending permitting.
2014	Interim Facility in use, but will be integrated into the Conservation Facility as it comes on line.	Capital funding completed in 2014. Operational funding continues through life of program.	Full-scale collection. Collect eggs and juveniles per the Lindley report on broodstock availability and Conservation Facility capacity. Continue rearing fish collected in 2012 and 2013.	Some BY 2011, collected in 2012, will be ready for spawning.	Permits in hand.	Up to 62,500 smolts (50 females, 2500 eggs per female, 50% survival. Actual production will depend on the number of fish that are sexually mature in 2014.
2015	Interim Facility retired. Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2012, 2013, and 2014. May be returns from egg boxes, which may be integrated into the hatchery mating matrix.	BY 2011, 2012, and jacks from 2013 and precocious males from 2014.	Permits in hand.	62,500 smolts (50 females, 2500 eggs per female, 50% survival.
2016	Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2012, 2013, 2014, and 2015. May be returns from egg boxes.	BY 2011, 2012, 2013, and additional precocious males.	Permits in hand.	62,500 smolts (50 females, 2500 eggs per female, 50% survival.

Year	Facility	Funding	Broodstock Collection	Broodstock available for use	Permitting	Production
2017	Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2013, 2014, 2015, and 2016. First significant returns, from fish produced in 2014, and some of these adults may be collected for use as broodstock.	BY 2012, 2013, 2014, and additional precocious males.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2018	Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2014, 2015, 2016, and 2017.	BY 2013, 2014, 2015, and additional precocious males.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2019	Conservation Facility online.	Operational funding.	Collect as above. Continue rearing fish collected in 2015, 2016, 2017, and 2018. First returns from the full-scale hatchery production (2016) expected in 2019.	BY 2014, 2015, 2016, and additional precocious males.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2020	Conservation Facility online.	Operational funding.	Last year of full-scale collections (8 years total, 2 generations). Collect as above. Continue rearing fish collected in 2016, 2017, 2018, and 2019.	BY 2015, 2016, 2017, and additional precocious males.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2021	Conservation Facility online. Begin ramping down hatchery operations.	Operational funding.	Continue rearing fish collected in 2017, 2018, 2019, and 2020.	BY 2016, 2017, 2018, and additional precocious males.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.

Year	Facility	Funding	Broodstock Collection	Broodstock available for use	Permitting	Production
2022	Conservation Facility online.	Operational funding.	Continue rearing fish collected in 2018, 2019, and 2020.	BY 2017, 2018, 2019, and additional precocious males.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2023	Conservation Facility online.	Operational funding.	Continue rearing fish collected in 2019 and 2020.	BY 2018, 2019, 2020.	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2024	Conservation Facility online.	Operational funding.	Continue rearing fish collected in 2020.	BY 2019, 2020	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.
2025	Conservation Facility use by Program ends.	Operational funding ends.	Probably no broodstock in hatchery, although may continue spawning naturalized adults as necessary to meet production targets.	BY 2020	Permits in hand.	Between 44,000 and 1,575,000 spring-run Chinook salmon juveniles (egg number would be higher). May need to reduce to allow for natural production.

Appendix 2. Definition of Terms Referenced in the HGMP Template

Augmentation - The use of artificial production to increase harvestable numbers of fish in areas where the natural freshwater production capacity is limited, but the capacity of other salmonid habitat areas will support increased production. Also referred to as "fishery enhancement".

Broodstock

Critical population threshold - An abundance level for an independent Pacific salmonid population below which: depensatory processes are likely to reduce it below replacement; short-term effects of inbreeding depression or loss of rare alleles cannot be avoided; and productivity variation due to demographic stochasticity becomes a substantial source of risk.

Direct take - The intentional take of a listed species. Direct takes may be authorized under the ESA for the purpose of propagation to enhance the species or research.

Evolutionarily Significant Unit (ESU) - NMFS definition of a distinct population segment (the smallest biological unit that will be considered to be a species under the Endangered Species Act). A population will be/is considered to be an ESU if 1) it is substantially reproductively isolated from other conspecific population units, and 2) it represents an important component in the evolutionary legacy of the species.

Harvest project - Projects designed for the production of fish that are primarily intended to be caught in fisheries.

Hatchery fish - A fish that has spent some part of its life-cycle in an artificial environment and whose parents were spawned in an artificial environment.

Hatchery population - A population that depends on spawning, incubation, hatching or rearing in a hatchery or other artificial propagation facility.

Hazard - Hazards are undesirable events that a hatchery program is attempting to avoid.

Incidental take - The unintentional take of a listed species as a result of the conduct of an otherwise lawful activity.

Integrated harvest program - Project in which artificially propagated fish produced primarily for harvest are intended to spawn in the wild and are fully reproductively integrated with a particular natural population.

Integrated recovery program - An artificial propagation project primarily designed to aid in the recovery, conservation or reintroduction of particular natural population(s), and fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population(s). Sometimes referred to as "supplementation".

Isolated harvest program - Project in which artificially propagated fish produced primarily for harvest are not intended to spawn in the wild or be genetically integrated with any specific natural population.

Isolated recovery program - An artificial propagation project primarily designed to aid in the recovery, conservation or reintroduction of particular natural population(s), but the fish produced are not intended to spawn in the wild or be genetically integrated with any specific natural population.

Mitigation - The use of artificial propagation to produce fish to replace or compensate for loss of fish or fish production capacity resulting from the permanent blockage or alteration of habitat by human activities.

Natural fish - A fish that has spent essentially all of its life-cycle in the wild and whose parents spawned in the wild. Synonymous with *natural origin recruit (NOR).*

Natural origin recruit (NOR) - See *natural fish* .

Natural population - A population that is sustained by natural spawning and rearing in the natural habitat.

Population - A group of historically interbreeding salmonids of the same species of hatchery, natural, or unknown parentage that have developed a unique gene pool, that breed in approximately the same place and time, and whose progeny tend to return and breed in approximately the same place and time. They often, but not always, can be separated from another population by genotypic or demographic characteristics. This term is synonymous with stock.

Preservation (Conservation) - The use of artificial propagation to conserve genetic resources of a fish population at extremely low population abundance, and potential for extinction, using methods such as captive propagation and cryopreservation.

Research - The study of critical uncertainties regarding the application and effectiveness of artificial propagation for augmentation, mitigation, conservation, and restoration purposes, and identification of how to effectively use artificial propagation to address those purposes.

Restoration - The use of artificial propagation to hasten rebuilding or reintroduction of a fish population to harvestable levels in areas where there is low, or no natural production, but potential for increase or reintroduction exists because sufficient habitat for sustainable natural production exists or is being restored.

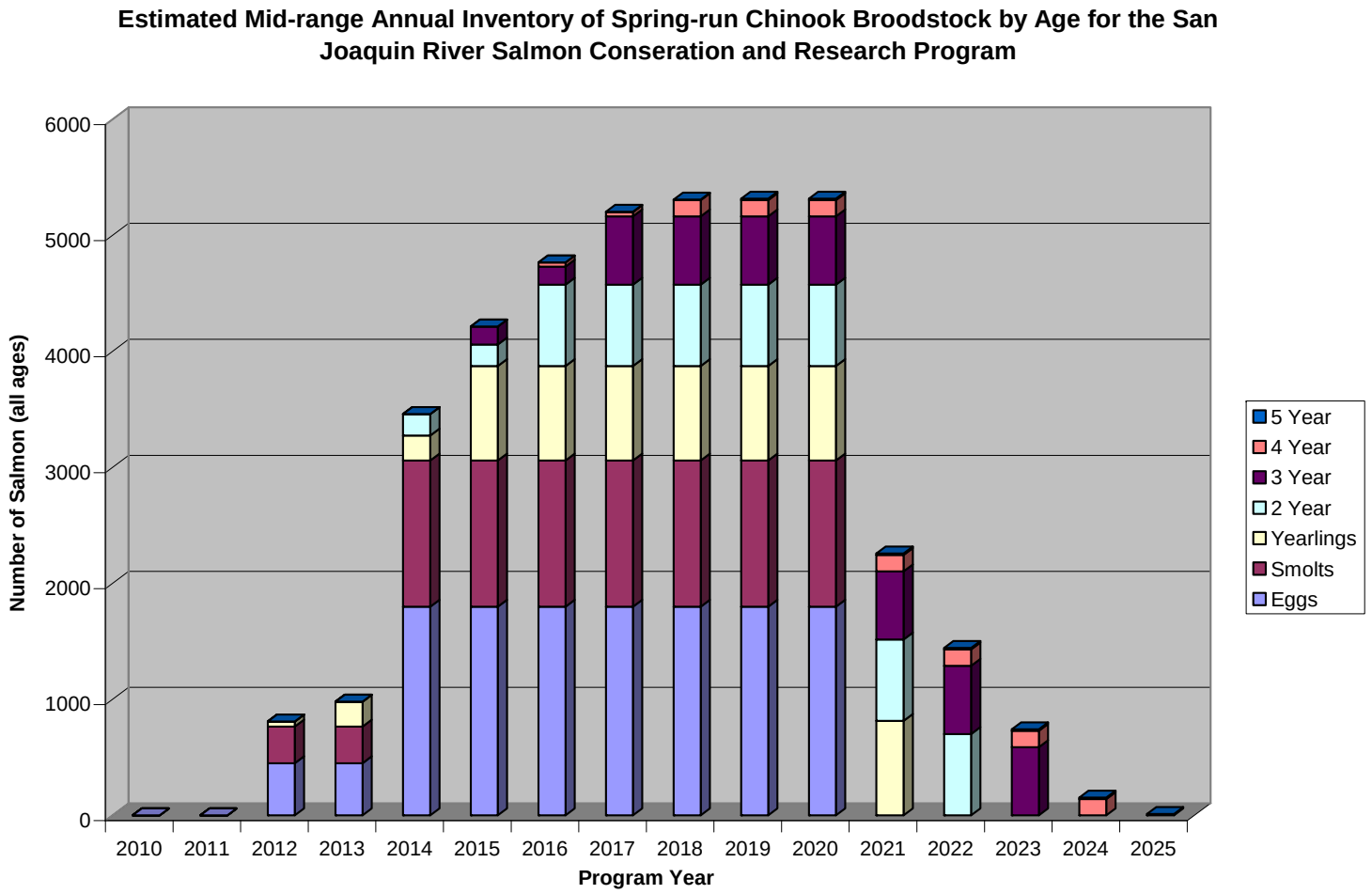
Stock - (see “Population”).

Source population

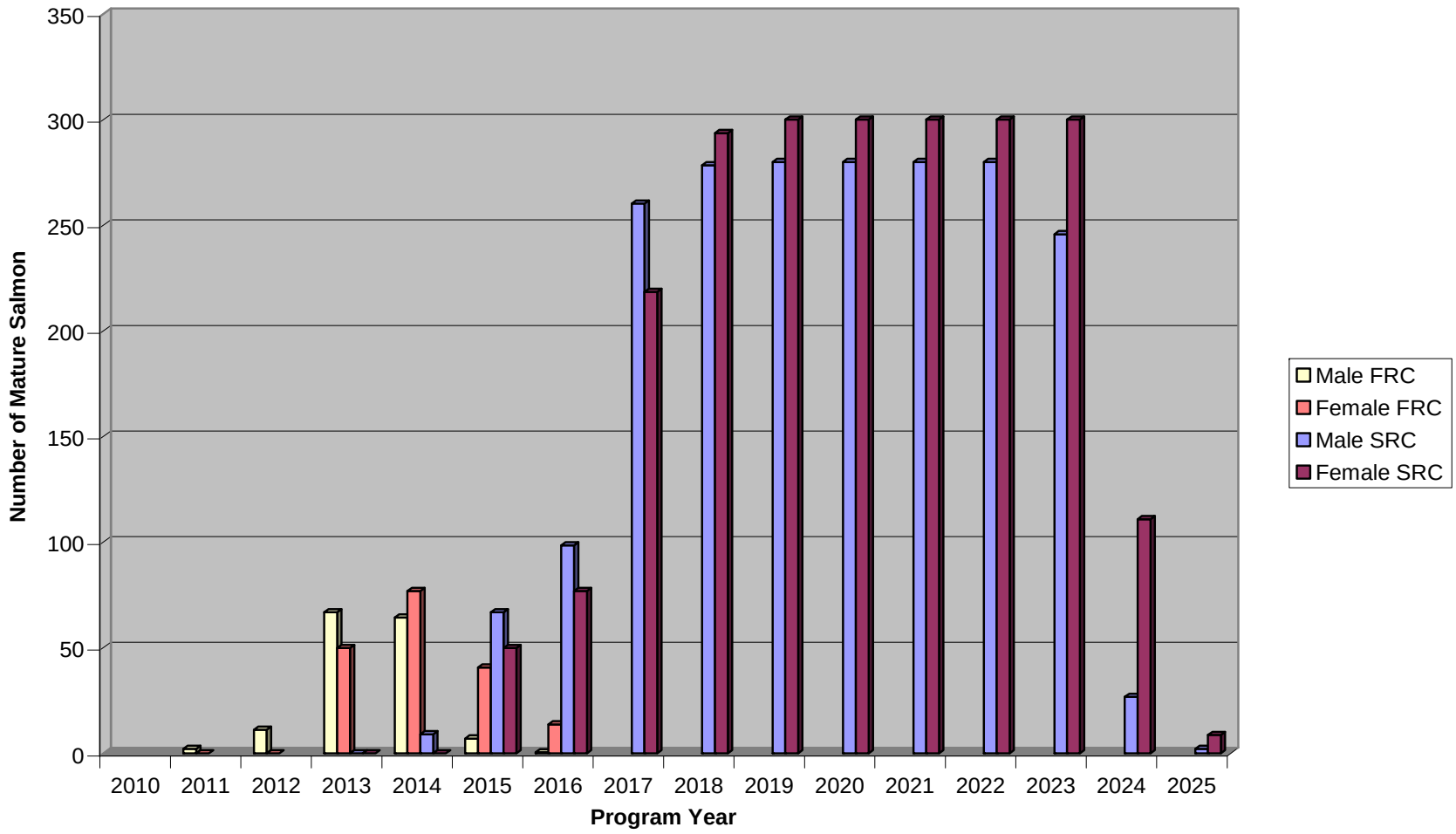
Take - To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

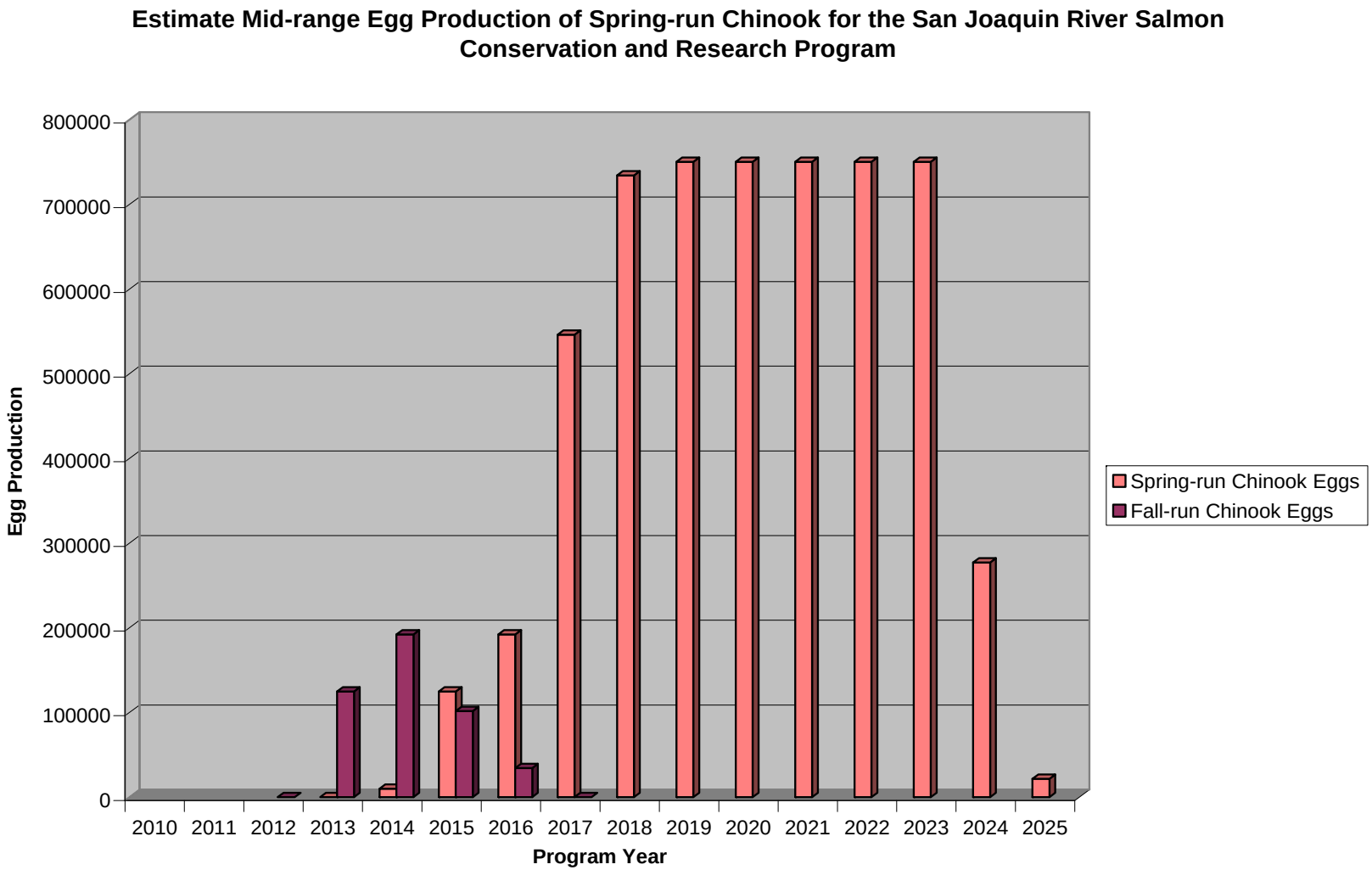
Viable population threshold - An abundance level above which an independent Pacific salmonid population has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame.

Appendix 3. Conservation Facility Mid-range Annual Inventory Projections



Estimated Mid-range Fall- and Spring-run Chinook Mature Adults for the San Joaquin Salmon Conservation and Research Program




Estimate Mid-range Egg Production of Spring-run Chinook for the San Joaquin River Salmon Conservation and Research Program
Egg Production
800000
700000
600000
500000
400000
300000
200000
100000
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Program Year
Spring-run Chinook Eggs
Fall-run Chinook Eggs

Appendix 4. Temperature Data for Source Watersheds and the Restoration Area

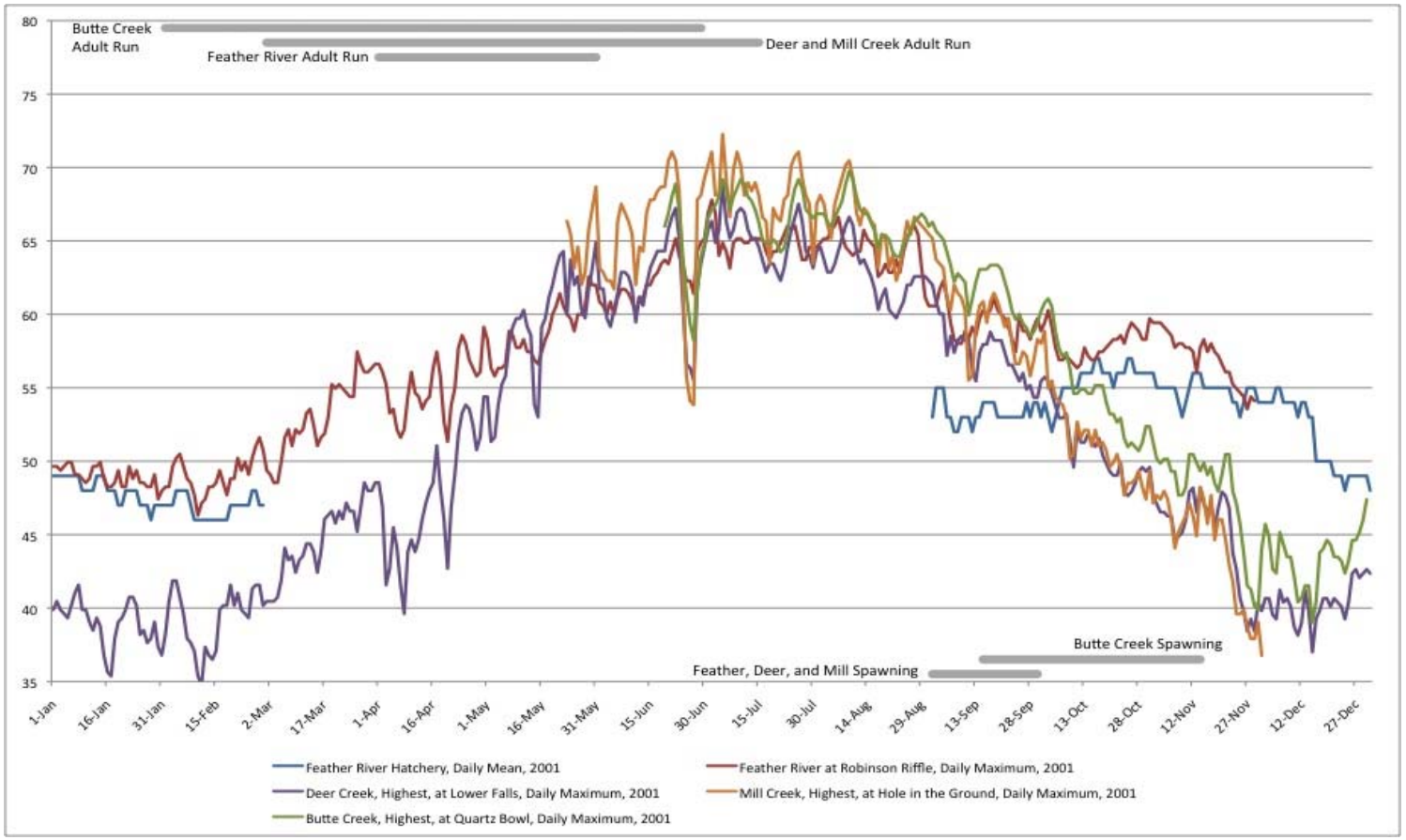


Figure App. 4.A. Higher elevation water temperatures data for source stock

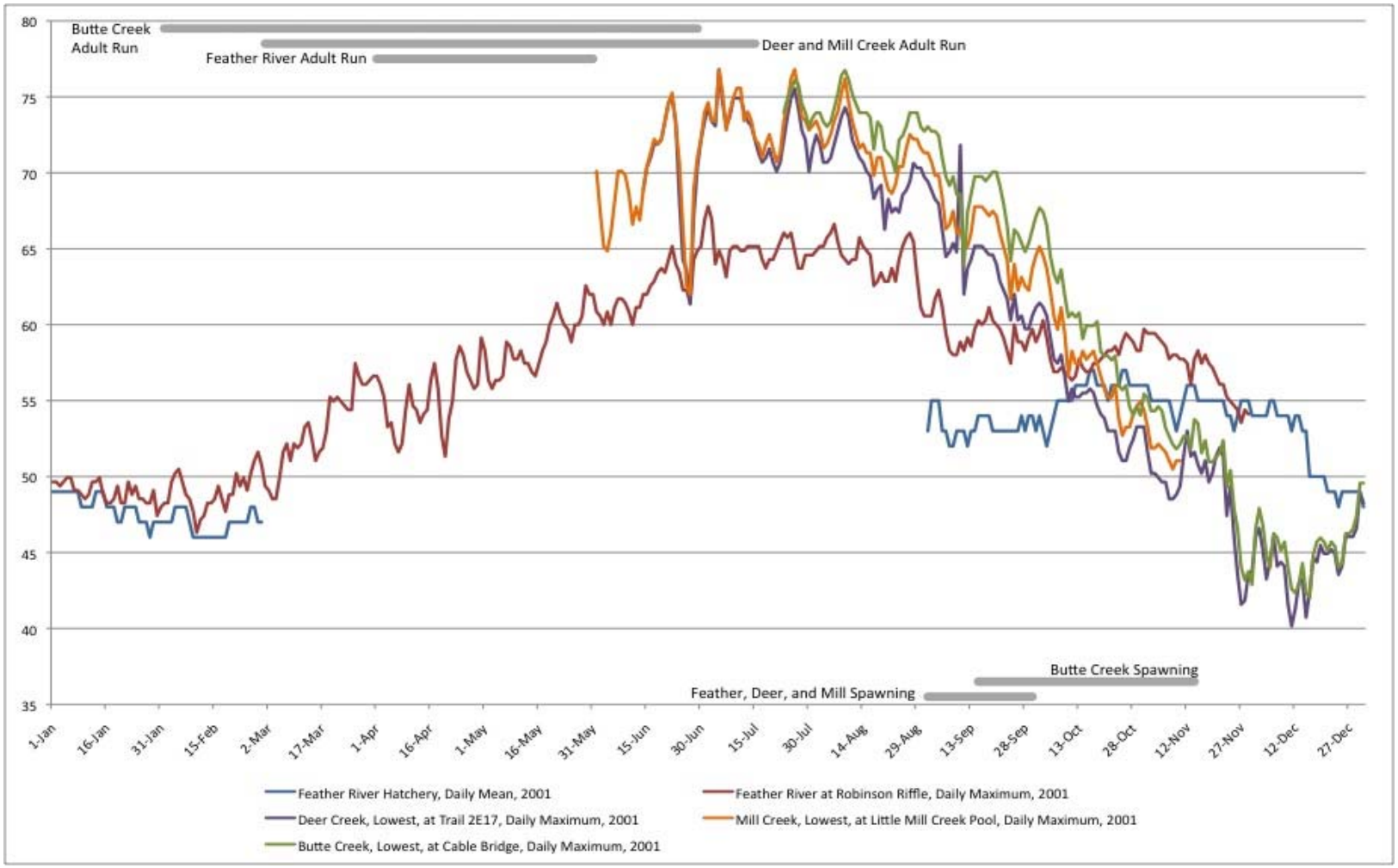


Figure App. 4.B. Lower elevation water temperature data for source stock populations.

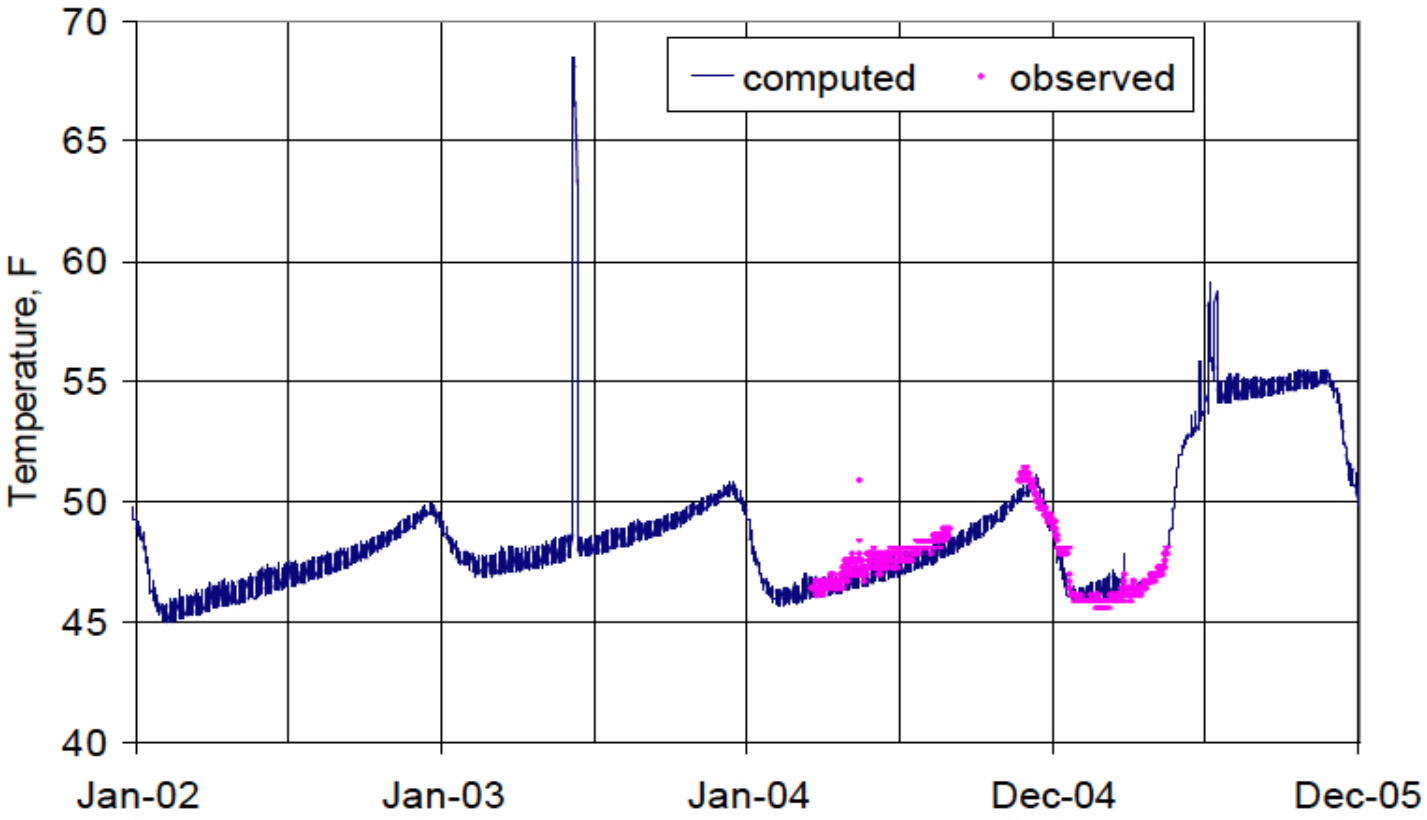


Figure App. 4.C. Computed and observed temperatures at Friant Dam (0.1 miles D/S). Originally Figure 3-13 in Resource Management Associates, Inc. (2007).

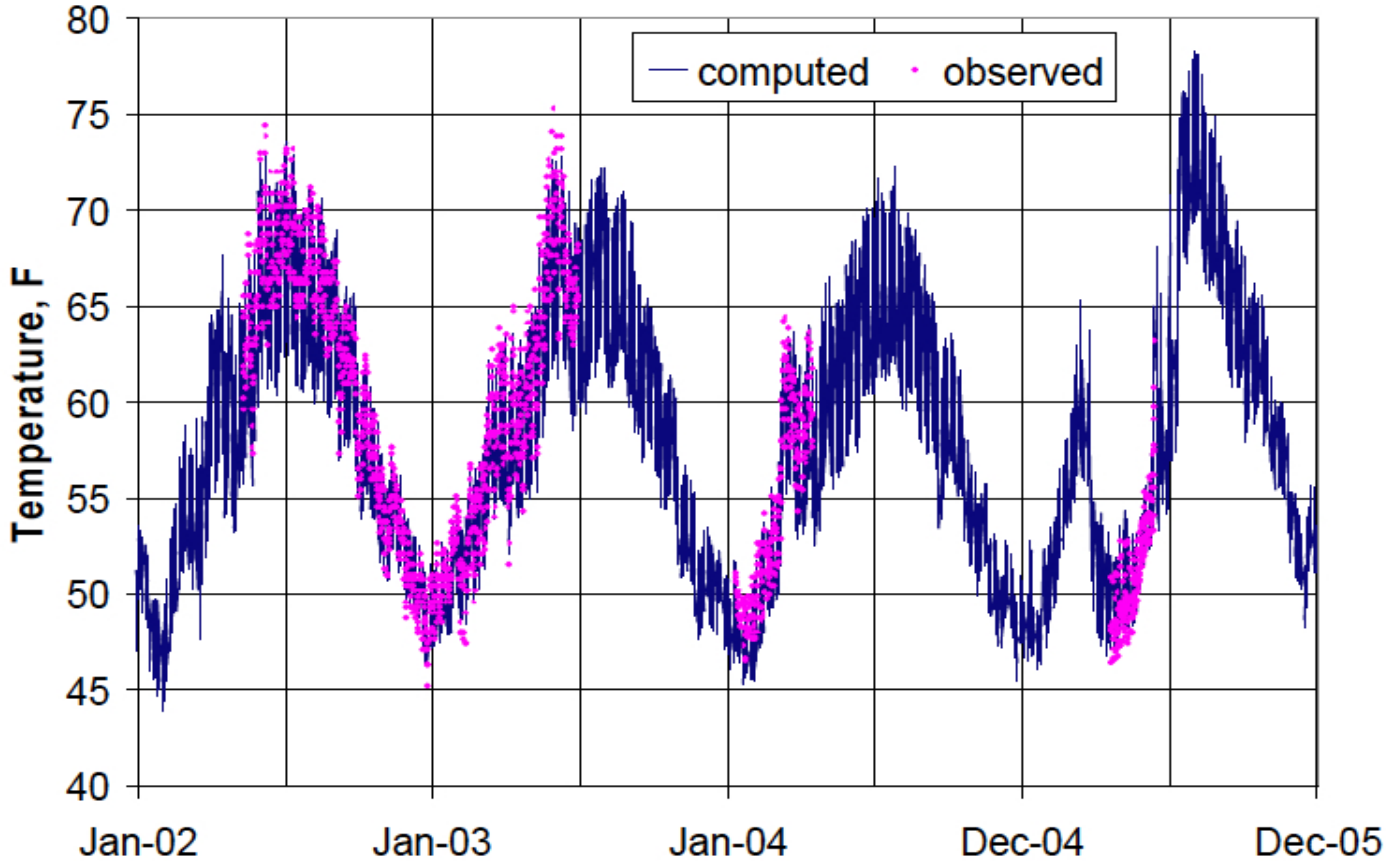


Figure App. 4.D. Computed and observed temperatures at Sportsman Club (12 miles D/S). Originally Figure 3-18 in Resource Management Associates, Inc. (2007).

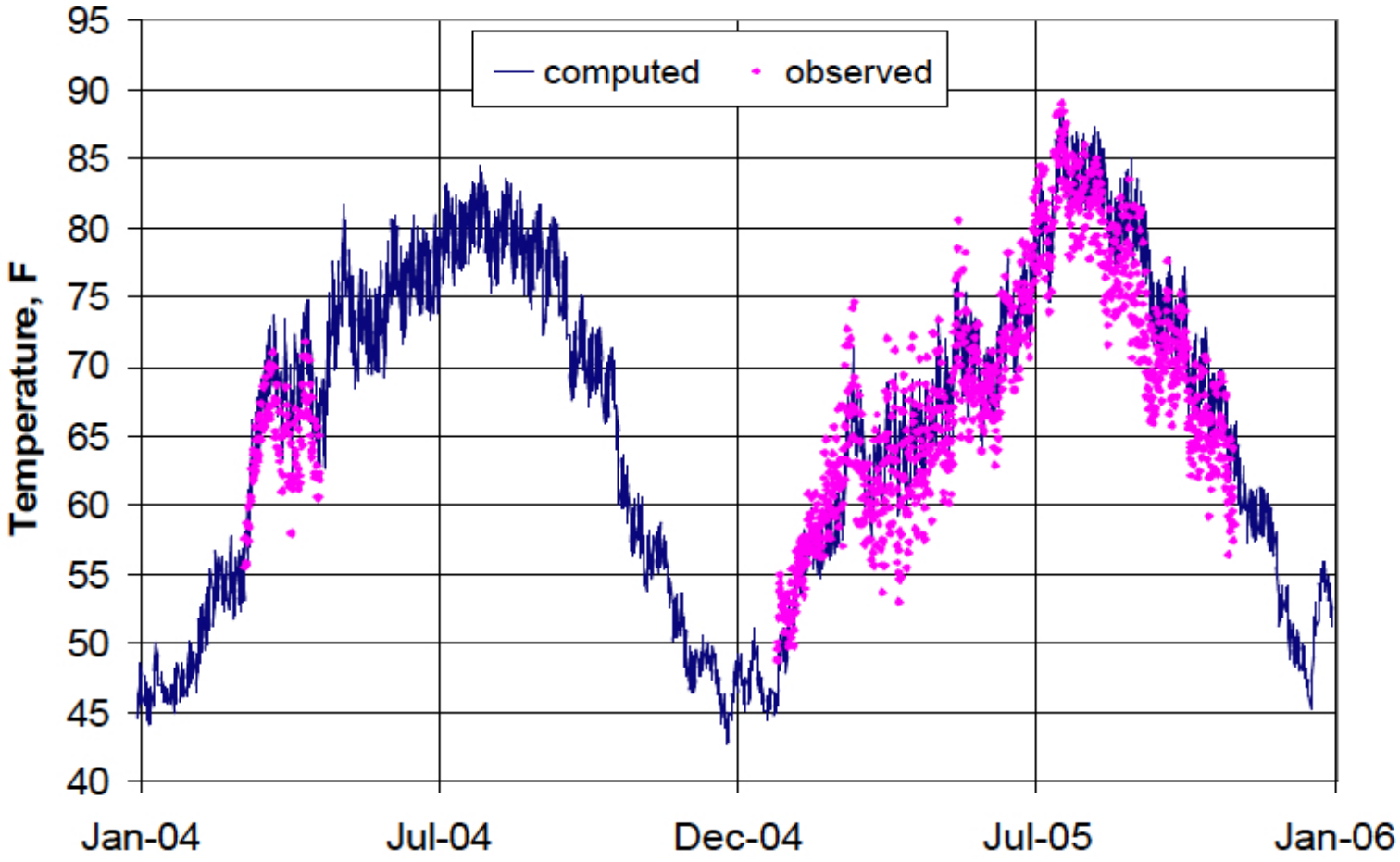


Figure App. 4.E. Computed and observed temperatures at Sack Dam (85 miles D/S). Originally Figure 3-26 in Resource Management Associates, Inc. (2007).

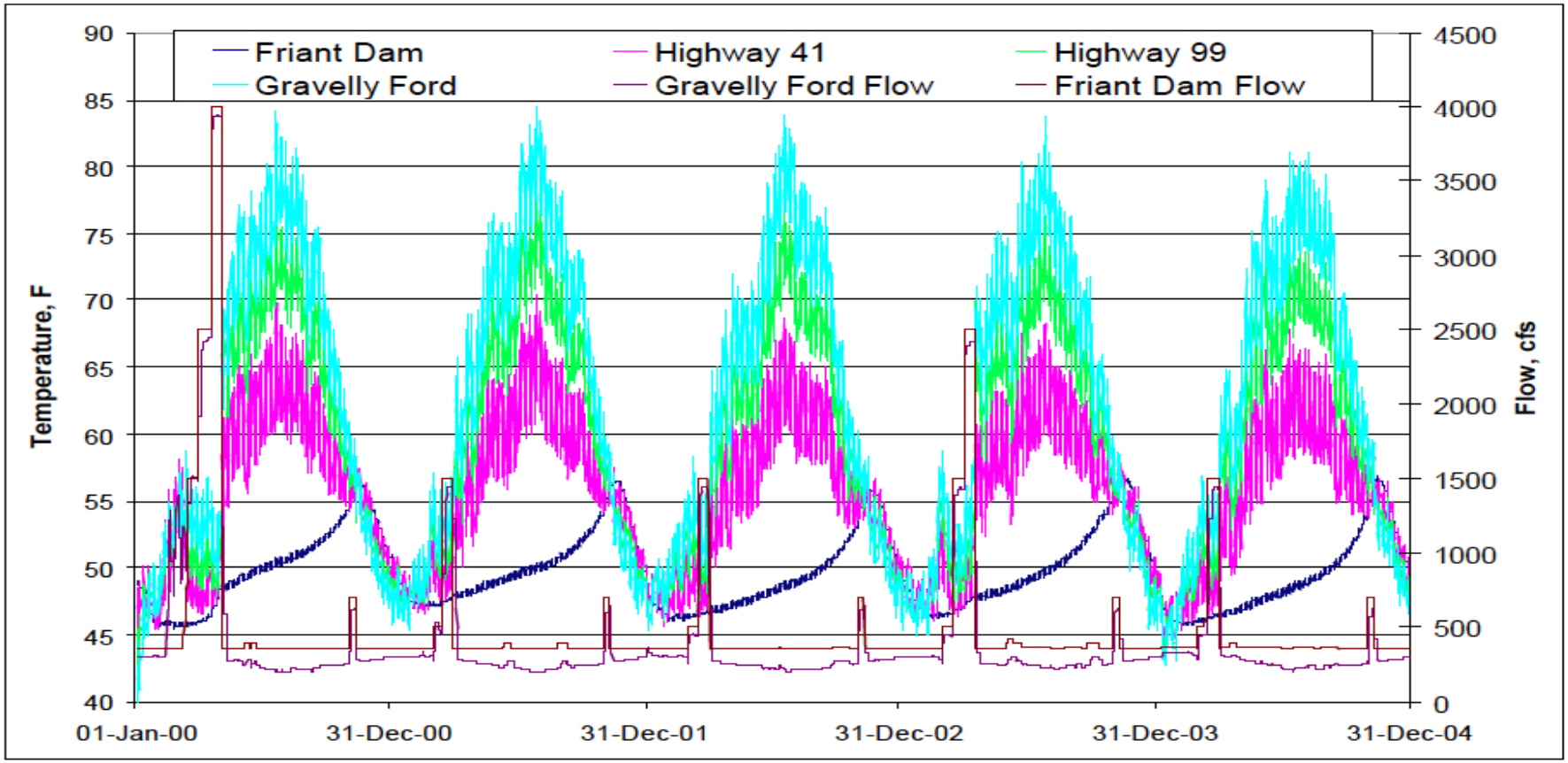


Figure App. 4.F. Kondolf Hydrographs - Computed Temperatures and Flow during 2000 through 2004, if water management in those years had been under settlement conditions. Locations are in Reach 1, approximately 1/8, 14, 23 and 39 miles below Friant Dam. Originally Figure 4-1 in Resource Management Associates, Inc. (2007).

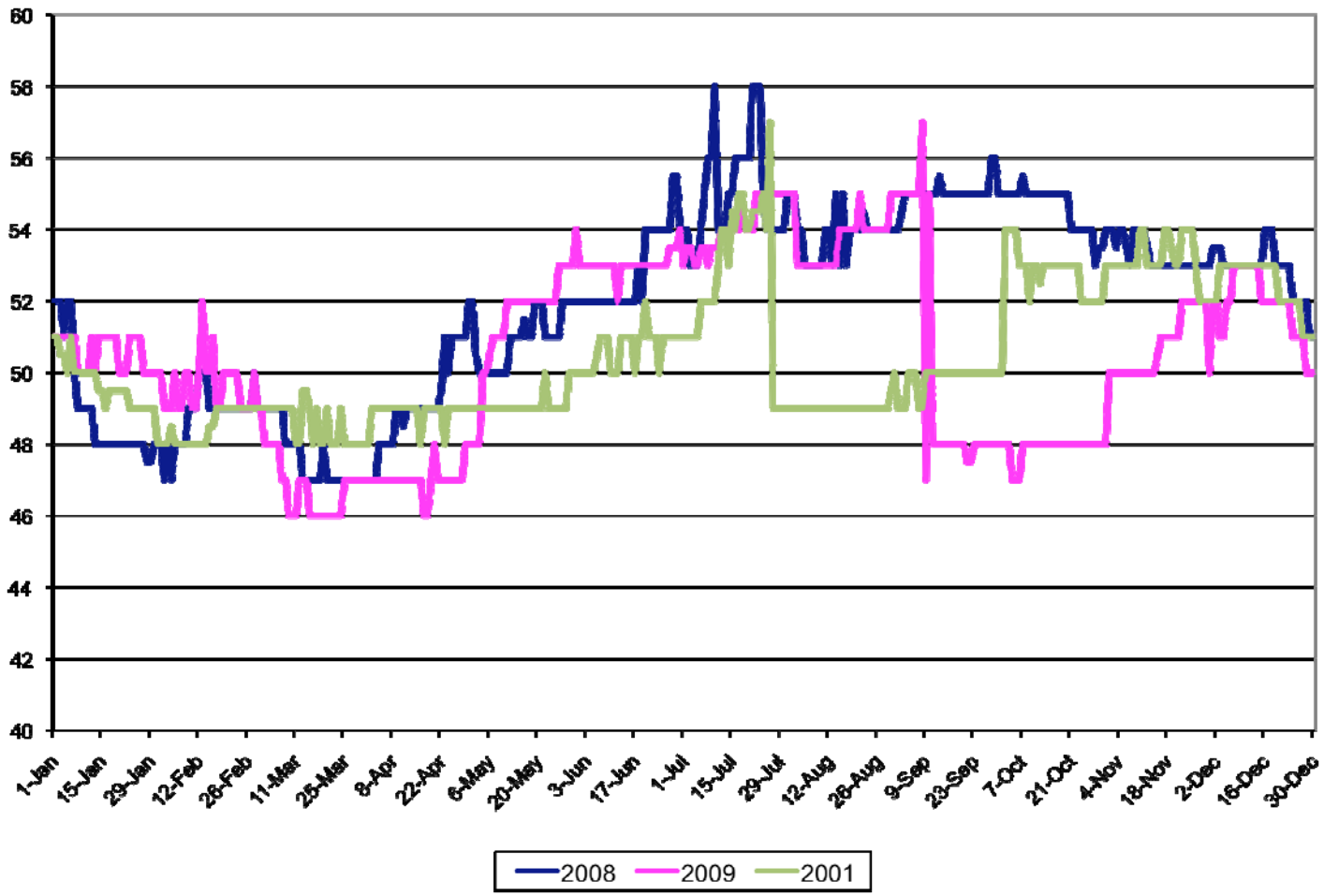


Figure App. 4.G. Observed temperatures at the San Joaquin Fish Hatchery in 2001, 2008, and 2009.

Appendix 5. Sample Hatchery Annual Report Outline.

Hatchery annual reports are published by the Department of Fish and Game as Fisheries Branch Administrative Reports. See Inland Fisheries - Informational Leaflet No. 44 INSTRUCTIONS TO AUTHORS OF INLAND FISHERIES ADMINISTRATIVE REPORTS. The following outline is based in part on the outline present in the draft Feather River HGMP, Appendix F.

1. INTRODUCTION
- **1.1)** Describe the hatchery location.
- **1.2)** Describe the hatchery goals and objectives.
- **1.3)** Describe the hatchery facilities, any changes since the prior years, and any plans for changes in the coming year.
- **1.4)** List the operator, owner, and contractor as appropriate
- **1.5)** List funding sources and funding allocated or identified for the following year for hatchery operations, capital improvement, and monitoring.
- **1.6)** Include period covered by this report (mm/dd/year through mm/dd/year).

2. PUBLIC RELATIONS
- **2.1)** Summary
  - **2.1.1)** List number of visitors and method of counts
  - **2.1.2)** Website hits
- **2.2)** Describe all hatchery data (including annual reports, genetics information, instream monitoring data, etc) posted online for public use
  - **2.2.1)** Note any information not posted and reason information was not posted.
- **2.3)** Describe any other related public relations information
- **2.4)** Recommend changes or additional activities for the following year that could improve public relations.

3. BROODSTOCK COLLECTION/REARING
- **3.1)** Report broodstock collected from each source population
  - **3.1.1)** Data should include date, location of collection, collection method, any mortalities or other signs of stress, and life stage collected.
  - **3.1.2)** Report risk aversion measures applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during broodstock collection.
- **3.2)** Report any broodstock collection from adults returning to the San Joaquin.
- **3.3)** Background donor information
  - **3.3.1)** Report any information from ongoing population and behavioral monitoring of source populations.
  - **3.3.2)** Evaluate potential impact of broodstock collection on source populations
- **3.4)** Broodstock Rearing
  - **3.4.1)** Describe rearing facilities
  - **3.4.2)** Describe rearing methods, including feeding regimen and method of feeding
  - **3.4.3)** Describe annual growth and maturation of broodstock (and whether size targets have been met)

3.5) Survival
- **3.5.1)** Report survival rates for eggs, fry, parr and/or smolt by brood year
- **3.5.2)** Chinook salmon disease Information
  - **3.5.2.a)** Describe any outbreaks of pathogens or disease in hatchery or wild populations, including efforts made to detect known or suspected problem diseases
  - **3.5.2.b)** Include control information
  - **3.5.2.c)** Describe any medicated feed
  - **3.5.2.d)** Describe any routine treatments

3.6) Recommendations
- **3.6.1)** Recommend any changes to broodstock collection methods or overall collection numbers necessary to improve hatchery performance.
- **3.6.2)** Recommend any changes necessary to comply with permits or to otherwise minimize impacts to source population.
- **3.6.3)** Recommend any changes necessary to improve broodstock survival and fitness for spawning.

4. MATING

4.1) Summary
- **4.1.1)** Report number of eggs produced by broodyear taken or received
- **4.1.2)** Report origin and number of adult fish spawned
- **4.1.3)** List number of fish released by stage and location.

4.2) Sorting and Spawning
- **4.2.1)** Report Spawning Start and end dates
- **4.2.2)** Report weekly and overall total:
  - (a) Number of males, females, jacks, and jills spawned
  - (b) Eggs taken, number of eggs per female, size of eggs per ounce, and fertility rate
- **4.2.3)** Describe methods used to of artificially spawn fish.
- **4.2.4)** Describe spring-run Chinook salmon mating protocols.

4.3) Parental Data Collection
- **4.3.1)** From all spawners:
  - **4.3.1.a)** Record and report fork length, sex, Hallprint tag number, adipose clip status (yes or no), head tag code, fishing hooks/scar status (yes or no), and number of eggs collected (for females)
  - **4.3.1.b)** Collect scales, otoliths and tissues from each fish, record sample ID. Indicate how and where samples were stored. If moved off site, indicate person responsible and new location.
- **4.3.2)** Record portion of broodstock spawned, by broodstock year class and source population.
- **4.3.3)** Record all matings and report fertility by mating.
- **4.3.4)** Prepare graph of length frequency of male and female spring-run Chinook salmon spawned
- **4.3.5)** Disposal of Salmon Carcasses
  - **4.3.5.a)** List pounds, number, and disposal methods(s) for Chinook salmon carcasses

5. REARING

- **5.1)** Incubation and Ponding
  - **5.1.1)** Incubation methods
  - **5.1.2)** Egg density
  - **5.1.3)** Size and dates of ponding
  - **5.1.4)** Rearing facilities
  - **5.1.5)** Describe any natural rearing methods
  - **5.1.6)** Diet and feeding regiment
  - **5.1.7)** Method of feeding.
- **5.2)** Survival
  - **5.2.1)** Report survival rates for eggs, fry, parr and/or smolt by brood year
  - **5.2.2)** Chinook salmon disease information
    - **5.2.2.a)** Describe any outbreaks of pathogens or disease
    - **5.2.2.b)** Include control information
    - **5.2.2.c)** Describe any medicated feed
    - **5.2.2.d)** Describe any routine treatments

6. RELEASE

- **6.1)** Releases
  - **6.1.1.a)** Total fish released, by life stage and location
  - **6.1.1.b)** Release methods employed
  - **6.1.1.c)** Markings applied, including marking rate (should be 100%)
  - **6.1.1.d)** Tags applied, including tagging rate by release location and date
- **6.2)** Experimental Results
  - **6.2.1)** Results of different release strategies in terms of percent survival to life stage
  - **6.2.2)** Recommendations for changes to release methods for future years.

7. WATER

- **7.1)** Water Supply
  - **7.1.1)** Describe the hatchery water source
  - **7.1.2)** Describe any temperature controls
  - **7.1.3)** Report daily minimum and maximum water temperatures
  - **7.1.4)** Report impacts on river flows
  - **7.1.5)** Recommend changes to water use and supply practices.
- **7.2)** Outflows
  - **7.2.1)** Report water monitoring data for outflows.
  - **7.2.2)** Report compliance with water quality permits.
  - **7.2.3)** Recommend changes to effluent processing as necessary.

8. RETURNS

- **8.1)** Marks and tags observed
  - **8.1.1)** Report **weekly** mark and tag data
    - **8.1.1.a)** List total number of fish examined for marks (adipose fin clip status)
    - **8.1.1.b)** Number of marked fish observed
    - **8.1.1.c)** Number of marked fish collected (i.e. heads collected for CWT recovery)
    - **8.1.1.d)** For tags recovered (other than CWT) report:
      - (a) Tag description, tag number, fish fork length, fish sex

8.1.2) For each CWT recovered report (as Appendix Table 2)
8.1.2.a) Brood year, release location, release size, release race, recovery race, recovery fork length, recovery sex, recovery Hallprint tag code

9. OTHER HATCHERY OPERATION INFORMATION
9.1) Report other relevant operational information
9.2) Recommend any additional changes to hatchery operations
9.3) Recommend any changes to the monitoring and reporting process
9.4) Recommend any changes to the HGMP

10. LITERATURE CITED
10.1) Add any Literature Cited references here using the CBE (Council of Biology Editors) Style Manual.

11. APPENDIX A – GENETICS
11.1) BROODSTOCK COLLECTION/REARING
11.1.1) Report results of ongoing genetic monitoring of the source populations
11.1.2) Report genetic analysis of broodstock
11.1.2.a) Compare to diversity of source populations
11.1.3) Recommend changes to broodstock collection or changes to the duration/size of the broodstock program in order to capture the genetic diversity of the source populations.
11.2) MATING
11.2.1) Based on broodstock analysis, develop mating matrix for the broodstock, per HGMP Section 8.
11.3) RELEASE
11.3.1) Review data on survival under various release methods to determine if there is a genetic basis for differential survival.
11.4) RETURNS
11.4.1) Determine source of any returning adults.
11.4.2) Conduct parentage analysis and estimate of the success of each of the three source populations, both independently and based on percentage of the admixture in mixed offspring-run, based on adult returns.
11.4.2.a) Recommend changes to broodstock collection and mating practices, as appropriate.
11.4.3) Examine returning adults for evidence of introgression between spring-run and fall run populations.
11.4.3.a) Recommend changes to barrier operation, as appropriate
11.4.3.b) Recommend changes to broodstock collection and mating practices, as appropriate.

12. APPENDIX B – INSTREAM MONITORING
12.1) Restoration
12.1.1) Report restoration efforts undertaken and completed over the previous year.
12.1.2) Estimate river carry capacity by life history stage
12.1.2.a) Spawning
12.1.2.b) Freshwater rearing

12.1.2.c) Migration corridor
12.1.2.d) Estuarine and nearshore rearing habitat and ocean conditions
12.1.3) Recommend release numbers for the following year based on river restoration and carrying capacity.

12.2) Life History Monitoring
12.2.1) Report:
12.2.1.a) Juvenile dispersal/outmigration timing
12.2.1.b) Juvenile size at outmigration, and outmigration age composition
12.2.1.c) Adult return timing
12.2.1.d) Adult return age and sex composition
12.2.1.e) Adult size at return
12.2.1.f) Spawn timing and distribution
12.2.1.g) Fry emergence timing
12.2.1.h) Juvenile rearing densities, distribution, and behaviors
12.2.1.i) Juvenile growth rate, condition factors, and survivals at several growth stages prior to final release
12.2.1.j) Diet composition and availability
12.2.1.k) Adult physical characteristics (length, weight, condition factors)
12.2.1.l) Fecundity and egg size
12.2.1.m) Spawning behavior and success
12.2.2) Report static sites for collecting biological data and a genetic sample (e.g., fin clip) to allow genetic identification of individuals and their biological status (e.g.: growth, weight, condition factor) for both outmigrating juvenile and returning adult spring-run Chinook salmon.
12.2.2.a) Report number of samples taken
12.2.2.b) Report data taken for each individual fish.
12.2.2.c) Note: The monitoring of life history changes may be adapted as the number of fish in the system increases and statistical methods for estimating some of the characteristics of interest are required. Changes to the life history monitoring should be recommended in consultation with the geneticists, on a consensus basis.

12.3) Escapement
12.3.1) Report escapement estimates
12.3.1.a) Report results of snorkel surveys, redd surveys, and carcass surveys.
12.3.1.b) Working with the geneticists, determine origin of returning adults
12.3.1.c) Report spawner:recruit ratios for returns from the San Joaquin.

12.4) Fish barrier
12.4.1) Date of installation
12.4.2) Evaluation of fish barrier efficacy
12.4.3) Recommendations for changes to barrier installation and operation for future.