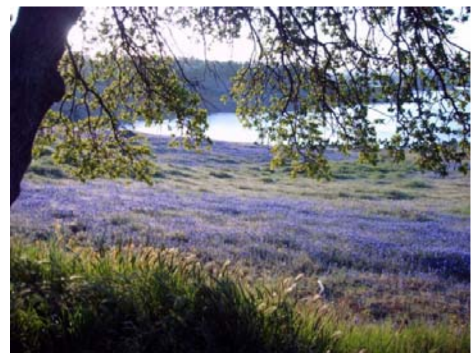
STURGEON
STUDY REPORT
DON PEDRO PROJECT
FERC NO. 2299





Prepared for:
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Sturgeon
Study Report

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List of Acronyms

ac	acres
ACEC	Area of Critical Environmental Concern
AF	acre-feet
ACOE	U.S. Army Corps of Engineers
ADA	Americans with Disabilities Act
ALJ	Administrative Law Judge
APE	Area of Potential Effect
ARMR	Archaeological Resource Management Report
BA	Biological Assessment
BDCP	Bay-Delta Conservation Plan
BLM	U.S. Department of the Interior, Bureau of Land Management
BLM-S	Bureau of Land Management – Sensitive Species
BMI	Benthic macroinvertebrates
BMP	Best Management Practices
BO	Biological Opinion
BRT	Biological Review Team
CalEPPC	California Exotic Pest Plant Council
CalSPA	California Sports Fisherman Association
CAS	California Academy of Sciences
CCC	Criterion Continuous Concentrations
CCIC	Central California Information Center
CCSF	City and County of San Francisco
CCVHJV	California Central Valley Habitat Joint Venture
CD	Compact Disc
CDBW	California Department of Boating and Waterways
CDEC	California Data Exchange Center
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game (as of January 2013, Department of Fish and Wildlife)
CDMG	California Division of Mines and Geology
CDOF	California Department of Finance

CDPH........................California Department of Public Health
CDPR........................California Department of Parks and Recreation
CDSOD.....................California Division of Safety of Dams
CDWR.......................California Department of Water Resources
CE ....California Endangered Species
CEII..........................Critical Energy Infrastructure Information
CEQA........................California Environmental Quality Act
CESA ....California Endangered Species Act
CFR ....Code of Federal Regulations
cfs.............................cubic feet per second
CGS ....California Geological Survey
CMAP ....California Monitoring and Assessment Program
CMC..........................Criterion Maximum Concentrations
CNDDB.....................California Natural Diversity Database
CNPS.........................California Native Plant Society
CORP ....California Outdoor Recreation Plan
CPUE ....Catch Per Unit Effort
CRAM.......................California Rapid Assessment Method
CRLF.........................California Red-Legged Frog
CRRF ....California Rivers Restoration Fund
CSAS.........................Central Sierra Audubon Society
CSBP.........................California Stream Bioassessment Procedure
CT ....California Threatened Species
CTR ....California Toxics Rule
CTS ....California Tiger Salamander
CVRWQCB ....Central Valley Regional Water Quality Control Board
CWA ....Clean Water Act
CWHR.......................California Wildlife Habitat Relationship
Districts.....................Turlock Irrigation District and Modesto Irrigation District
DLA ....Draft License Application
DPRA........................Don Pedro Recreation Agency
DPS ....Distinct Population Segment
EA ....Environmental Assessment

EC ....Electrical Conductivity
EFH ....Essential Fish Habitat
EIR ....Environmental Impact Report
EIS..............................Environmental Impact Statement
EPA ............................U.S. Environmental Protection Agency
ESA ....Federal Endangered Species Act
ESRCD.......................East Stanislaus Resource Conservation District
ESU ....Evolutionary Significant Unit
EWUA........................Effective Weighted Useable Area
FERC..........................Federal Energy Regulatory Commission
FFS ....Foothills Fault System
FL ....Fork length
FMU ....Fire Management Unit
FOT ....Friends of the Tuolumne
FPC ....Federal Power Commission
ft/mi............................feet per mile
FWCA ....Fish and Wildlife Coordination Act
FYLF..........................Foothill Yellow-Legged Frog
g..................................grams
GIS ....Geographic Information System
GLO ....General Land Office
GPS ....Global Positioning System
HCP............................Habitat Conservation Plan
HHWP........................Hetch Hetchy Water and Power
HORB ....Head of Old River Barrier
HPMP.........................Historic Properties Management Plan
ILP..............................Integrated Licensing Process
ISR ....Initial Study Report
ITA ....Indian Trust Assets
kV...............................kilovolt
m ....meters
M&I............................Municipal and Industrial
MCL ....Maximum Contaminant Level

mg/kg ....milligrams/kilogram

mg/L...........................milligrams per liter

mgd ....million gallons per day

mi ....miles

mi^2 ....square miles

MID............................Modesto Irrigation District

MOU ....Memorandum of Understanding

MSCS.........................Multi-Species Conservation Strategy

msl..............................mean sea level

MVA ....Megavolt Ampere

MW ....megawatt

MWh ....megawatt hour

mya.............................million years ago

NAE ....National Academy of Engineering

NAHC ....Native American Heritage Commission

NAS............................National Academy of Sciences

NAVD 88 ....North American Vertical Datum of 1988

NAWQA ....National Water Quality Assessment

NCCP ....Natural Community Conservation Plan

NEPA ....National Environmental Policy Act

ng/g ....nanograms per gram

NGOs ....Non-Governmental Organizations

NHI ....Natural Heritage Institute

NHPA.........................National Historic Preservation Act

NISC ....National Invasive Species Council

NMFS.........................National Marine Fisheries Service

NOAA ....National Oceanic and Atmospheric Administration

NOI ....Notice of Intent

NPS ............................U.S. Department of the Interior, National Park Service

NRCS ....National Resource Conservation Service

NRHP.........................National Register of Historic Places

NRI.............................Nationwide Rivers Inventory

NTU ....Nephelometric Turbidity Unit

NWI............................National Wetland Inventory
NWIS ....National Water Information System
NWR ....National Wildlife Refuge
NGVD 29 ....National Geodetic Vertical Datum of 1929
O&M ....operation and maintenance
OEHHA......................Office of Environmental Health Hazard Assessment
ORV ....Outstanding Remarkable Value
PAD............................Pre-Application Document
PDO............................Pacific Decadal Oscillation
PEIR...........................Program Environmental Impact Report
PGA............................Peak Ground Acceleration
PHG............................Public Health Goal
PM&E ....Protection, Mitigation and Enhancement
PMF............................Probable Maximum Flood
POAOR ....Public Opinions and Attitudes in Outdoor Recreation
ppb.............................parts per billion
ppm ....parts per million
PSP ....Proposed Study Plan
QA..............................Quality Assurance
QC ....Quality Control
RA ....Recreation Area
RBP ....Rapid Bioassessment Protocol
Reclamation ...............U.S. Department of the Interior, Bureau of Reclamation
RM ....River Mile
RMP ....Resource Management Plan
RP...............................Relicensing Participant
RSP ....Revised Study Plan
RST ....Rotary Screw Trap
RWF...........................Resource-Specific Work Groups
RWG ....Resource Work Group
RWQCB.....................Regional Water Quality Control Board
SC...............................State candidate for listing under CESA
SCD............................State candidate for delisting under CESA

SCE ....State candidate for listing as endangered under CESA

SCT ....State candidate for listing as threatened under CESA

SD1 ....Scoping Document 1

SD2 ....Scoping Document 2

SE...............................State Endangered Species under the CESA

SFP.............................State Fully Protected Species under CESA

SFPUC ....San Francisco Public Utilities Commission

SHPO ....State Historic Preservation Office

SJRA ....San Joaquin River Agreement

SJRGA ....San Joaquin River Group Authority

SJTA ....San Joaquin River Tributaries Authority

SPD ....Study Plan Determination

SRA............................State Recreation Area

SRMA ....Special Recreation Management Area or Sierra Resource Management Area (as per use)

SRMP.........................Sierra Resource Management Plan

SRP ....Special Run Pools

SSC ....State species of special concern

ST...............................California Threatened Species under the CESA

STORET ....Storage and Retrieval

SWAMP.....................Surface Water Ambient Monitoring Program

SWE ....Snow-Water Equivalent

SWRCB......................State Water Resources Control Board

TAC............................Technical Advisory Committee

TAF ....thousand acre-feet

TCP ....Traditional Cultural Properties

TDS ....Total Dissolved Solids

TID.............................Turlock Irrigation District

TL...............................Total length

TMDL ....Total Maximum Daily Load

TOC............................Total Organic Carbon

TRT ....Tuolumne River Trust

TRTAC ....Tuolumne River Technical Advisory Committee

UC ....University of California
USDA.........................U.S. Department of Agriculture
USDOC......................U.S. Department of Commerce
USDOI ......................U.S. Department of the Interior
USFS .........................U.S. Department of Agriculture, Forest Service
USFWS .....................U.S. Department of the Interior, Fish and Wildlife Service
USGS .........................U.S. Department of the Interior, Geological Survey
USR............................Updated Study Report
UTM...........................Universal Transverse Mercator
VAMP ....Vernalis Adaptive Management Plan
VELB ....Valley Elderberry Longhorn Beetle
VRM ....Visual Resource Management
WPT ....Western Pond Turtle
WSA...........................Wilderness Study Area
WSIP ....Water System Improvement Program
WWTP ....Wastewater Treatment Plant
WY ....water year
µS/cm ....microSeimens per centimeter

1.0 INTRODUCTION

1.1 General Description of the Don Pedro Project

Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) are the co-licensees of the 168-megawatt (MW) Don Pedro Project (Project) located on the Tuolumne River in western Tuolumne County in the Central Valley region of California. The Don Pedro Dam is located at river mile (RM) 54.8 and the Don Pedro Reservoir formed by the dam extends 24-miles upstream at the normal maximum water surface elevation of 830 ft above mean sea level (msl; NGVD 29). At elevation 830 ft, the reservoir stores over 2,000,000 acre-feet (AF) of water and has a surface area slightly less than 13,000 acres (ac). The watershed above Don Pedro Dam is approximately 1,533 square miles (mi^2).

Both TID and MID are local public agencies authorized under the laws of the State of California to provide water supply for irrigation and municipal and industrial (M&I) uses and to provide retail electric service. The Project serves many purposes including providing water storage for the beneficial use of irrigation of over 200,000 ac of prime Central Valley farmland and for the use of M&I customers in the City of Modesto (population 210,000). Consistent with the requirements of the Raker Act passed by Congress in 1913 and agreements between the Districts and City and County of San Francisco (CCSF), the Project reservoir also includes a "water bank" of up to 570,000 AF of storage. CCSF may use the water bank to more efficiently manage the water supply from its Hetch Hetchy water system while meeting the senior water rights of the Districts. CCSF's "water bank" within Don Pedro Reservoir provides significant benefits for its 2.6 million customers in the San Francisco Bay Area.

The Project also provides storage for flood management purposes in the Tuolumne and San Joaquin rivers in coordination with the U.S. Army Corps of Engineers (ACOE). Other important uses supported by the Project are recreation, protection of the anadromous fisheries in the lower Tuolumne River, and hydropower generation.

The Project Boundary extends from approximately one mile downstream of the dam to approximately RM 79 upstream of the dam. Upstream of the dam, the Project Boundary runs generally along the 855 ft contour interval which corresponds to the top of the Don Pedro Dam. The Project Boundary encompasses approximately 18,370 ac with 78 percent of the lands owned jointly by the Districts and the remaining 22 percent (approximately 4,000 ac) is owned by the United States and managed as a part of the U.S. Bureau of Land Management (BLM) Sierra Resource Management Area.

The primary Project facilities include the 580-foot-high Don Pedro Dam and Reservoir completed in 1971; a four-unit powerhouse situated at the base of the dam; related facilities including the Project spillway, outlet works, and switchyard; four dikes (Gasburg Creek Dike and Dikes A, B, and C); and three developed recreational facilities (Fleming Meadows, Blue Oaks, and Moccasin Point Recreation Areas). The location of the Project and its primary facilities is shown in Figure 1.1-1.

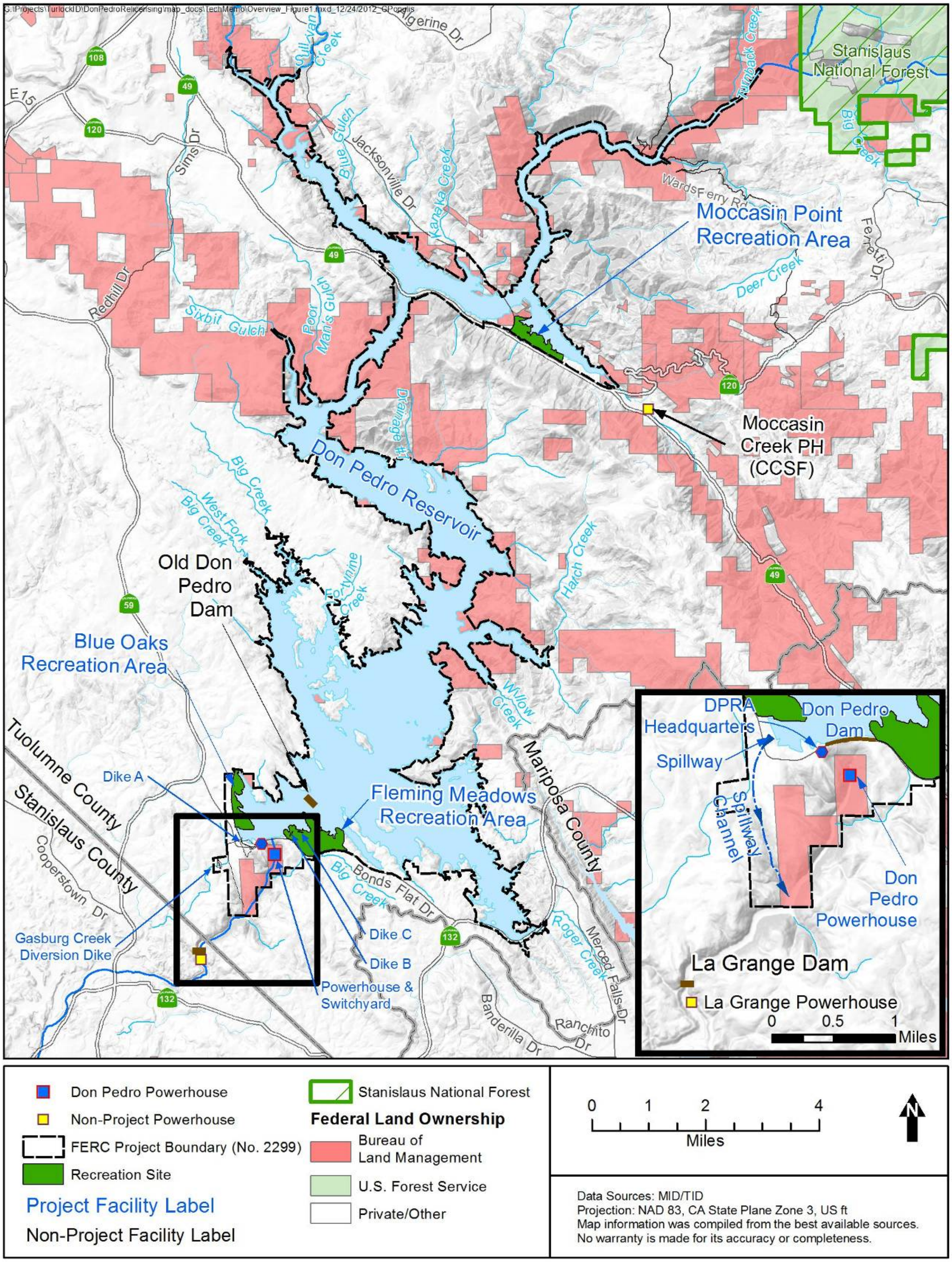

Figure 1.1-1. Don Pedro Project location.

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2016, and the Districts will apply for a new license no later than April 30, 2014. The Districts began the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on February 10, 2011, following the regulations governing the Integrated Licensing Process (ILP). The Districts' PAD included descriptions of the Project facilities, operations, license requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources. The PAD also included ten draft study plans describing a subset of the Districts' proposed relicensing studies. The Districts then convened a series of Resource Work Group meetings, engaging agencies and other relicensing participants in a collaborative study plan development process culminating in the Districts' Proposed Study Plan (PSP) and Revised Study Plan (RSP) filings to FERC on July 25, 2011 and November 22, 2011, respectively.

On December 22, 2011, FERC issued its Study Plan Determination (SPD) for the Project, approving, or approving with modifications, 34 studies proposed in the RSP that addressed Cultural and Historical Resources, Recreational Resources, Terrestrial Resources, and Water and Aquatic Resources. In addition, as required by the SPD, the Districts filed three new study plans (W&AR-18, W&AR-19, and W&AR-20) on February 28, 2012 and one modified study plan (W&AR-12) on April 6, 2012. Prior to filing these plans with FERC, the Districts consulted with relicensing participants on drafts of the plans. FERC approved or approved with modifications these four studies on July 25, 2012.

Following the SPD, a total of seven studies (and associated study elements) that were either not adopted in the SPD, or were adopted with modifications, formed the basis of Study Dispute proceedings. In accordance with the ILP, FERC convened a Dispute Resolution Panel on April 17, 2012 and the Panel issued its findings on May 4, 2012. On May 24, 2012, the Director of FERC issued his Formal Study Dispute Determination, with additional clarifications related to the Formal Study Dispute Determination issued on August 17, 2012.

This study report describes the objectives, methods, and results of the Sturgeon Study (W&AR-18) as implemented by the Districts in accordance with FERC's SPD and subsequent study modifications and clarifications. Documents relating to the Project relicensing are publicly available on the Districts' relicensing website at www.donpedro-relicensing.com.

1.3 Study Plan

The continued operation and maintenance (O&M) of the Project may potentially contribute to cumulative effects on habitat availability for in-river life stages of the Southern Distinct Population Segment (DPS) of North American green sturgeon (Acipenser medirostris) and the potential for green sturgeon to occur in the lower Tuolumne River. The Districts filed the Sturgeon Study Plan (W&AR-18) with FERC on February 28, 2012, and FERC approved the study on July 25, 2012.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study is to conduct a literature review and synthesize applicable studies and reports on green sturgeon life history and habitat requirements in the Central Valley and San Joaquin Basin, and to evaluate the potential for green sturgeon to be affected by Project operations and maintenance activities. The study approach developed to meet these goals includes:

- collect and summarize available information on green sturgeon distribution in order to evaluate the likely presence of green sturgeon in the lower Tuolumne River;
- characterize green sturgeon habitat requirements;
- evaluate potential habitat availability for in-river life stages of green sturgeon in the lower Tuolumne River; and
- identify if there are Project-related factors that could potentially limit green sturgeon habitat in the Tuolumne River.

3.0 STUDY AREA

The study area includes the Tuolumne River from La Grange Dam (RM 52) downstream to its confluence with the San Joaquin River (RM 0). The lower Tuolumne River watershed, the subbasin from RM 0 to 54, covers approximately 430 square miles of drainage area, and contains one major tributary, Dry Creek at RM 16. Other contributions come from Peaslee Creek as well as McDonald Creek (via Turlock Lake) primarily during and after storm events. In this reach, the Tuolumne River extends from about elevation 35 feet at the confluence with the San Joaquin River to elevation 300 feet at the tailrace of the Don Pedro powerhouse. The lower Tuolumne River watershed is long and narrow and is dominated by irrigated farmland and the urban/suburban areas associated with the City of Modesto, Waterford, and Ceres.

The lower Tuolumne River watershed below Don Pedro Dam transitions from gently rolling hills near its easterly reaches to uniformly flat floodplain and terrace topography in the downstream direction. Soils are deep and fertile and irrigated agriculture and urban land use dominates the landscape. The Tuolumne River downstream of La Grange Dam flows 52 river miles to its confluence with the San Joaquin River. The Tuolumne River leaves its steep and confined bedrock valley and enters the eastern Central Valley downstream of La Grange Dam near La Grange Regional Park, where hillslope gradients in the vicinity of the river corridor are typically less than five percent. From this point to the confluence with the San Joaquin River, the modern Tuolumne River corridor lies in an alluvial valley. Within the alluvial valley, the river can be divided into two geomorphic reaches defined by channel slope and bed composition: a gravel-bedded reach that extends from La Grange Dam (RM 52) to Geer Road Bridge (RM 24); and a sand-bedded reach that extends from Geer Road Bridge to the confluence with the San Joaquin River (McBain & Trush 2000). The gravel- and sand-bedded zones have been further subdivided into seven reaches based on present and historical land uses, the extent and influence of urbanization, valley confinement from natural and anthropogenic causes, channel substrate and slope, and salmonid use (McBain & Trush 2000).

Large-scale anthropogenic changes have occurred to the lower Tuolumne River corridor since the California Gold Rush in 1848. Gold mining, grazing, and agriculture encroached on the lower Tuolumne River channel before the first aerial photographs were taken by the Soil Conservation Service in 1937. Excavation of bed material for gold and aggregate to depths below the river thalweg eliminated active floodplains and terraces and created large in- and off channel pits. Agricultural and urban encroachment in combination with reduction in coarse sediment supply and high flows has resulted in a relatively static channel within a narrow floodway confined by dikes and agricultural fields. Although the tailing piles are primarily the legacy of gold mining abandoned in the early 20th century, gravel and aggregate mining continued alongside the river for a number of miles, particularly upstream of the town of Waterford around RM 34.

4.0 METHODOLOGY

In accordance with the FERC-approved study plan, this study relied upon information from previous studies and ongoing fisheries monitoring activities in the study area and in the Central Valley to (1) describe the distribution and habitat requirements of the in-river life stages of green sturgeon, (2) analyze potential habitat availability in the lower Tuolumne River, and (3) analyze the potential influence of Project-related factors on habitat availability. Relicensing Participants were encouraged to provide additional relevant information for this study.

A number of studies and databases were reviewed to determine green sturgeon distribution, life history timing, instream habitat requirements, and habitat conditions within the San Joaquin Basin. References included peer reviewed scientific literature, grey literature, instream habitat and water quality studies conducted by and for the Districts, and the California Department of Fish and Game (CDFG) catch report card data.

The higher priority reviews and consideration were given to data and reports specific to the Tuolumne River, then to data and reports related to the San Joaquin Basin, followed by information from other rivers and tributaries within the Central Valley. Information obtained was compiled and supplemented with relevant biological, hydrologic, physical habitat, and water quality data in the study area.

The findings are organized into the following major sections:

- Southern DPS of Green Sturgeon Distribution;
- Green Sturgeon In-River Habitat Requirements;
- Potential Green Sturgeon Habitat Availability in the lower Tuolumne River; and
- Potential influence of Project-related Factors on Green Sturgeon Habitat Availability in the Tuolumne River

4.1 Green Sturgeon Distribution

A literature review of the historical and current distribution of Southern DPS of green sturgeon within the Central Valley was performend. The Southern DPS of green sturgeon is listed as threatened under the federal Endangered Species Act (NMFS 2006). The Southern DPS includes green sturgeon that spawn and live within the Sacramento River, Sacramento-San Joaquin Delta [Delta], and the San Francisco Bay estuary. Adult migrations and spawning of this DPS have only been confirmed within the Sacramento River (NMFS 2006). Critical habitat for the Southern DPS of green sturgeon was designated in 2009, and includes the Sacramento-San Joaquin Delta, except for specific excluded areas as described in NMFS (2009a). The San Joaquin River and its tributaries upstream of the Delta, including the Tuolumne River, are not designated as critical habitat.

4.2 Green Sturgeon In-River Habitat Requirements

For purposes of evaluation, in-river habitat requirements were taken directly from the primary constituent element (PCE) concept used for the Southern DPS of green sturgeon critical habitat designation (NMFS 2009a) and include those biological and physical habitat features necessary for survival and successful reproduction within freshwater riverine systems, as follows:

(1) **Food Resources.** Abundant prey items for larval, juvenile, subadult, and adult life stages.

(2) **Substrate.** Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to ‘‘collect’’ eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (e.g., substrates for holding and spawning).

(3) **Water Flow.** A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.

(4) **Water Quality.** Water quality (e.g., salinity, temperature, oxygen content, etc.), necessary for normal behavior, growth, and viability of all life stages.

(5) **Migratory Corridor.** A migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).

(6) **Water Depth.** Deep (□5 m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.

(7) **Sediment Quality.** Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

4.3 Potential Habitat Availability

Information on instream habitat attributes within the Tuolumne River was compared with in-river habitat requirements identified in Section 4.2 to gain an understanding of potential habitat availability in the Tuolumne River.

4.4 Potential Influence of Project-related Factors on Habitat Availability

The potential of Project-related factors to influence green sturgeon habitat availability was evaluated based on information compiled regarding distribution, habitat requirements, and habitat availability.

5.0 RESULTS

5.1 Southern DPS of Green Sturgeon Distribution

The only spawning population of the Southern DPS of green sturgeon known to have spawned historically or currently in the Central Valley occurs in the Sacramento River (NMFS 2006, Adams et al. 2002), where spawning migrations have been documented to extend upstream to Cow Creek (RM 280) (Heublein et al. 2009), and eggs, larvae, and post-larval green sturgeon are commonly captured during sampling efforts (Beamesderfer et al. 2004; Brown 2007). Juveniles have also been observed in the Sacramento River around the Red Bluff Diversion Dam (NMFS 2009a).

NMFS critical habitat determination notes that the San Joaquin River is accessible to green sturgeon (i.e., there are no physical barriers blocking upstream migration into the system), yet they do not appear to currently occupy this river system upstream of the Delta (NMFS 2009a) and there is no evidence that spawning has ever occurred in the San Joaquin River or its tributaries, including the Tuolumne River (Adams et al. 2002; CDFG 2002; Beamesderfer et al. 2004; BRT 2005; NMFS 2009a). Numerous fisheries studies have been conducted in the Tuolumne River since the 1980s, and no adult, larval, or juvenile green sturgeon have ever been found (Ford and Brown 2001).

Juvenile green sturgeon have been collected in the San Joaquin Delta at water diversion facilities (ranging from 17 to 7,313+ annually between 1968 and 2001; Adams et al. 2002) and at Santa Clara Shoal (Radtke 1966), and a single specimen was collected from Old River (CAS collection, D. Catania, pers. comm. as cited in Moyle et al. 1995). Although it is unclear whether these fish originated from the San Joaquin or Sacramento rivers, CDFG (2002) concluded that "based on movement of other fishes in the Delta, young green sturgeon found in the lower San Joaquin River could easily, and most likely, come from known spawning populations in the Sacramento River." This conclusion is understandable given that the south Delta pumping facilities result in reverse flows (i.e., upstream from the Delta) in the Old and Middle rivers of between 2,000 and 7,500 cubic feet per second (cfs) during the spring and summer months (USDI 2008).

Israel and Klimley (2008) and Moyle (2002) have suggested that green sturgeon may have historically spawned in the San Joaquin River based on the presence of juvenile green sturgeon at Santa Clara Shoal (Radtke 1966) in the "lower San Joaquin." This location is near the confluence with the Sacramento River and is in the tidally influenced portion of the San Joaquin River (i.e., the Delta) where negative flows occur, which led the original author (Radtke 1966, page 126) to surmise that these juveniles "probably moved upriver [into the San Joaquin] from the bay, perhaps to feed."

Since 2007, CDFG has implemented a Sturgeon Fishing Report Card (Card) Program that requires anglers in California to identify any white or green sturgeon retained (only white sturgeon allowed to be retained) or released and the river reach where they were captured. In the San Joaquin River, the Card defines two reaches (1) Stockton to HWY 140 bridge and (2) upstream of HWY 140 bridge. Based on annual Card reports (Gleason et al. 2008; DuBois et al.

2009, 2010, and 2011), six green sturgeon have been self-reported by three anglers in the San Joaquin River, including one captured upstream of HWY 140 bridge and five between Stockton and HWY 140 Bridge, ranging in size from 0.6 to 0.8 m (24 to 31 inches). The capture records were from the spring of 2009 and 2010. Although these data could indicate the occasional presence of juvenile green sturgeon in the San Joaquin River, the reach between Stockton and HWY 140 Bridge where most of the individuals were reported includes a portion of the Delta and thus extends into the zone of critical habitat.

White sturgeon are regularly observed in the San Joaquin River upstream from the Delta (Beamesderfer et al. 2004) and spawning has long been suspected to occur in wet years (Shaffter, CDFG retired, 2004 personal communication as cited in Beamesderfer et al. 2007). A recent study (Gruber at al. 2012) provided the first documented evidence of white sturgeon spawning in the San Joaquin River. This evidence was based on the collection of white sturgeon eggs that were believed to be from a single spawning event upstream of the Tuolumne River at RM 88 (Gruber et al. 2012). Average daily discharge in the San Joaquin River in early 2011 was two to three times higher than those experienced for water years 1991 to 2010 (Gruber et al. 2012). The authors speculated that river discharge levels of this magnitude triggered white sturgeon to enter and spawn within the San Joaquin River system (Gruber et al. 2012). Anglers and game wardens report that white sturgeon caught in prior years in the San Joaquin River commonly expel eggs or milt during handling, which suggests that spawning of white sturgeon has occurred near traditional fishing locations in other years (Gruber et al. 2012).

No information was found to suggest that adult green sturgeon migrate into, spawn, or in any way occupy the Tuolumne River. Despite the numerous Tuolumne River fisheries studies that have been conducted for the Districts since the 1980s, there is no information documenting occurrence of larval, juvenile, or adult green sturgeon in the Tuolumne River.

5.2 Southern DPS of Green Sturgeon In-River Habitat Requirements

Although green sturgeon habitat requirements have not been extensively studied, general in-river habitat requirements relative to seven different PCEs are discussed below.

5.2.1 Food Resources

Very little information is available on the food and nutrient requirements of green sturgeon (Klimley et al. 2006). Although specific data are lacking for juvenile green sturgeon, nutritional studies on the closely-related white sturgeon in riverine systems indicate that amphipods, bivalves, and fly larvae are the primary prey (NMFS 2009a).

5.2.2 Substrate Type or Size

Spawning may occur over a wide range of substrates, such as clean sand to bedrock (Moyle 2002); however, there appears to be a preference for gravel, cobble, and boulders (Poytress et al. 2010, 2011). Substrates suitable for egg deposition and development include bedrock sills and shelves, boulders, or cobbles and gravel with interstices or irregular surfaces to “collect” eggs; free of excessive silt and debris that could smother eggs during incubation; and suitable for providing protection from predators (BRT 2005, NMFS 2009a; Deng et al. 2002). Substrates suitable for larval development include those that contain spaces (e.g., interstices or voids) providing refuge from predators and high flow conditions (NMFS 2009a). Newly hatched larvae have poor swimming ability and prefer to stay in contact with structure, cover, and dark (very low light) habitat as opposed to open river bottoms (Kynard et al. 2005 as cited in NMFS 2009a).

5.2.3 Water Flow

Specific flow ranges are unknown, but suitable flows are considered by NMFS (2009a) to be those that would provide for adult upstream migration, trigger spawning, trigger post-spawning downstream migration, maintain water temperatures within the optimal range for eggs, larvae, and juveniles, reduce fungal infestations of eggs, and flush silt and debris from substrates.

5.2.4 Water Quality

NMFS (2009a) considers suitable water temperatures for green sturgeon to be: 11–17 °C in spawning reaches for egg incubation during March–August (Van Eenennaam et al. 2005); <20°C for larval development (Werner et al. 2007); <24 °C for juveniles (Mayfield and Cech 2004; Allen et al. 2006); and NMFS (2009b) states that subadults and adults may need a minimum dissolved oxygen level of at least 6.54 mg O_2/l (Kelly et al. 2007; Moser and Lindley 2007).

5.2.5 Migratory Corridor

An unimpeded migration pathway (i.e., no physical, chemical or biological human-induced impediments) within and between riverine and estuarine spawning and rearing habitats is necessary for adults and juveniles (NMFS 2009a).

5.2.6 Water Depth

Spawning and holding adults prefer pools that are >5 m (16.4 ft) deep with complex hydraulic features and upwelling, bedrock shelves, and cobble/boulder substrate (Moyle 2002; Adams et al. 2002; BRT 2005; Heublein et al. 2009).

5.2.7 Sediment Quality

Sediment quality (i.e., chemical characteristics) that is sufficient to provide for normal behavior, growth, and viability of all life stages is necessary (NMFS 2009a). This includes sediments free of elevated levels of contaminants (e.g., selenium, PAHs, and pesticides) that may result in bioaccumulation in green sturgeon from feeding on benthic species.

5.3 Potential Green Sturgeon Habitat Availability in the Lower Tuolumne River

Existing conditions within the Tuolumne River relative to each in-river habitat requirement discussed in Section 5.2 are discussed below. Although criteria for individual habitat requirements may be satisfied within the Tuolumne River, this does not indicate that green sturgeon would be able to complete their life cycle in the river. Based on the more extensively studied white sturgeon, it appears that very specific combinations of "suitable" habitat conditions are necessary for sturgeon to select locations for breeding and subsequent rearing, as indicated by spawning fish that do not utilize many sites containing apparently suitable substrate, velocity, and depths; preference for these specific and suitable combinations of habitat conditions has made it difficult to implement successful habitat restoration (Beamesderfer et al. 2005). As such, the presence of apparently suitable, or restorable habitat elements is not an indication that those elements would actually function to support green sturgeon.

NMFS (2009a) did not designate the San Joaquin River or any of its tributaries as critical habitat for green sturgeon because there was insufficient information to determine that these areas were essential for conservation of the species, and the unknown "likelihood that habitat conditions within these unoccupied areas will be restored to levels that would support green sturgeon presence and spawning (e.g., restoration of fish passage and sufficient water flows and water temperatures)."

5.3.1 Food Resources

Although specific data are lacking for juvenile green sturgeon, nutritional studies on the closely-related white sturgeon in riverine systems indicate that amphipods, bivalves, and fly larvae are the primary prey (NMFS 2009a). All three of these prey types are found in the Tuolumne River (Stillwater Sciences 2010).

5.3.2 Substrate Type or Size

The Tuolumne River downstream of RM 24 is a sand-bedded reach (McBain and Trush 2000) that does not contain substrate to support spawning, egg incubation, and early larval development of green sturgeon. Habitat mapping between RM 29 and RM 51.8 suggests the possibility of suitable substrate in a 12 mile reach between RM 39.5 and RM 51.8 (Stillwater Sciences 2010).

5.3.3 Water Flow

Since green sturgeon instream flow needs are vaguely defined, poorly understood, and likely stream-specific due to variation in channel geometry and gradient, assessment of specific flows in the lower Tuolumne River relative to the requirements of green sturgeon is not possible.

5.3.4 Water Quality

The Districts have collected continuous water temperature data at numerous locations in the Tuolumne River since 1997. Daily mean water temperatures from 1997–2011, representing all water year types, were averaged across years to calculate historical mean daily water temperatures for each location (Figure 5.3-1). Flow releases during egg incubation, larval development, and juvenile rearing periods provide the coldest water available from the reservoir (<12°C year-round), and ambient air temperatures are the driving influence for the downstream extent of suitable water temperatures for each life stage dependent on time of year (Stillwater 2011).

Historical mean daily water temperatures are within the optimal range for egg incubation (11-17°C) during the entire incubation period (March-August) at Riffle 13B (RM 45.5), while temperatures are slightly below the optimal range until about June at Riffle 3B (RM 49.1) and La Grange Dam (RM 51.8) (Figure 5.3-1). Temperatures begin to increase above the optimal egg incubation range in early June at RM 36.7 and Roberts Ferry Bridge (RM 39.5) but generally remain within the optimal water temperatures for larvae (<20°C) and juveniles (<24°C) through the entire larval (mid-March to mid-September) and juvenile (year-round) periods, respectively. For sites further downstream (Hughson at RM 23.6 and Shiloh at RM 3.4), temperatures increase above optimal egg incubation beginning in late May and above optimal larval development by mid-June, but remain within optimal juvenile temperatures year-round.

Table 5.3-1. Water temperature station locations in the Tuolumne River and periods of record.

RM	Location	Start Date	End Date
3.5	Shiloh Bridge	12/11/1997	11/2/2011
23.6	Hughson Treatment Plant	12/10/1997	11/2/2011
36.7	Ruddy Gravel	12/10/1997	11/2/2011
39.5	Roberts Ferry Bridge	8/11/1998	11/2/2011
45.5	Riffle 13B	11/14/2001	11/2/2011
49.1	Riffle 3B	12/10/1997	11/2/2011
51.8	La Grange Power House	11/14/2001	11/2/2011

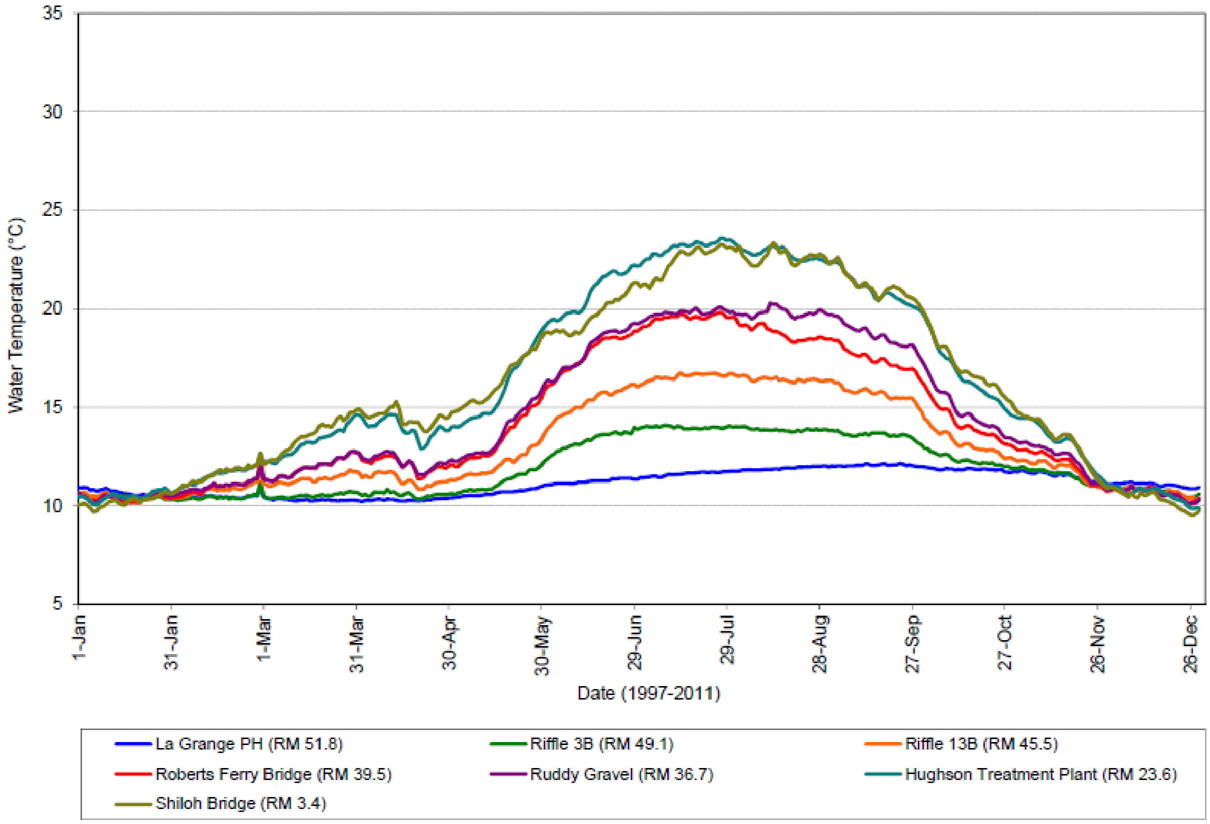

Figure 5.3-1. Average mean daily water temperatures in the Tuolumne River (1997–2011).

Dissolved oxygen measurements have been recorded periodically at six riffles between RM 25.4 and RM 51.6 during annual BMI sampling (July/August in years 2001-2005, 2007-2009) and have ranged from 8.0 to 13.1 mg/L (Stillwater Sciences 2010). Additionally, instantaneous dissolved oxygen measurements were recorded 3-7 days per week at the Tuolumne River Weir (RM 24.5) from September 16 to December 31, 2011, and ranged between 8.29 mg/L and 12.79 mg/L (10.60 mg/L season average; Cuthbert et al. 2012). Based on these data, it appears that dissolved oxygen is within suitable ranges for various life stages upstream of RM 25.4 from July-December.

5.3.5 Migratory Corridor

NMFS critical habitat determination notes that that the San Joaquin River is accessible to green sturgeon; there are no physical barriers blocking upstream migration into the system. There are no known physical impediments to passage of migrating fish in the Tuolumne River between La Grange Dam (RM 51.8) and the confluence with the San Joaquin River.

5.3.6 Water depth

The Tuolumne River downstream of RM 24 is a sand-bedded reach (McBain and Trush 2000) that does not contain suitable water depths for adult spawning and holding. Habitat mapping conducted between RM 29 and 51.8 indicates that more than 75 percent of the reach was riffles, runs, and glides (Stillwater Sciences 2010). All riffles, runs, and glides were too shallow to support adult holding and spawning. Several pools exceeding 5 m in depth were reported between RM 39.5 and 51.8 (TID/MID 2013).

5.3.7 Sediment Quality

Studies have not been conducted in the Tuolumne River to assess levels of contaminants in sediments, and no data were found to support any conclusions about sediment quality.

5.4 Potential Influence of Project-related Factors on Green Sturgeon Habitat Availability in the Lower Tuolumne River

FERC's scoping document directed the Districts to evaluate Project O&M that could contribute to cumulative effects to aquatic resources in the Tuolumne River between La Grange Dam and the confluence with the San Joaquin River. However, most of the river has conditions that do not support several of the life stages of green sturgeon, and downstream conditions (in the Tuolumne or San Joaquin rivers) would preclude spawning migrations into the area in most years. The lack of historical documentation of green sturgeon in the Tuolumne River, and rarely in the San Joaquin River, is consistent with these observations.

Project O&M does not have the potential to influence green sturgeon as there is no evidence that green sturgeon historically or currently exist in the Tuolumne River. Project- O&M also does not have the potential to influence critical habitat availability for Southern DPS of green sturgeon because the Tuolumne River is not designated by NMFS to be critical habitat (NMFS 2009a).

Fisheries monitoring has been conducted in the Tuolumne River since at least 1973, including annual seining surveys since 1983, rotary screw trap monitoring since 1995, and weir monitoring since 2009 (Table 5.4-1). While the objectives, methods, and locations of sampling have varied, there has been a general trend of increasing monitoring effort over this period. Despite intensive fisheries research and monitoring efforts over the past 40 years, sturgeon have never been observed.

Table 5.4-1. Summary of fisheries monitoring efforts in the lower Tuolumne River.

Sampling Activity	Location	Duration	References
Seining	Old La Grange Bridge to Shiloh Bridge	1983-2012	Ford and Brown 2001; TID/MID 2005; Stillwater Sciences 2012a
Fyke netting	TLSRA to McClesky Ranch	1973-1974; 1977; 1980-1983; 1986	Ford and Brown 2001
Predation Studies (electrofishing)	Roberts Ferry to Grayson	1990; 1998-1999; 2003; 2012	TID/MID 1992; Stillwater Sciences and McBain and Trush 2006; TID/MID 2013
RST Monitoring	Grayson	1995-2012	Ford and Brown 2001; Fuller 2006; Fuller et al. 2007; Fuller 2008; Palmer and Sonke 2008; Palmer and Sonke 2010; Sonke and others 2010; Sonke and others 2012

Sampling Activity	Location	Duration	References
	TLSRA/7-11/ Deardorff	1998-2000	TID/MID 2005
	Hughson/ Charles Rd	1998-2000	TID/MID 2005
	Waterford	2006-2012	Fuller et al. 2007; Fuller 2008; Palmer and Sonke 2008; Palmer and Sonke 2010; Sonke and others 2010; Sonke and others 2012
Summer Surveys (seining, snorkeling, and electrofishing)	Riffle A3 to Shiloh Bridge	1988-1994	Ford and Brown 2001
Snorkel Surveys	La Grange Dam to Waterford	1982-2011	Stillwater Sciences 2012b
Weir Monitoring	Hughson	2009-2012	Cuthbert et al. 2010; Becker et al. 2011; Cuthbert et al. 2012; FISHBIO 2013

6.0 SUMMARY AND CONCLUSIONS

The pre-historical (pre-human disturbance) presence of green sturgeon within the San Joaquin Basin remains unknown, and there is no evidence that adult, larval, or juvenile green sturgeon currently or historically occupied the Tuolumne River. There are some habitat features within the river that meet requirements for various lifestages; however, this does not imply that the green sturgeon could utilize this habitat, particularly since spawning adults appear to select areas containing a suite of habitat suitability components that are not readily separable. Based on the long-term unoccupied status of the river, NMFS' determination that the river does not provide critical habitat for green sturgeon, and 36 years of fisheries monitoring without encountering any sturgeon, Project operations are not likely to affect or influence habitat availability for green sturgeon in the Tuolumne River.

7.0 SUMMARY AND CONCLUSIONS

As stated in Section 2, the goals of this study were to synthesize applicable studies and reports on green sturgeon distribution, life history, and habitat requirements in the Central Valley and San Joaquin Basin, and to evaluate the potential for this species to be cumulatively affected by the Project. There were no variances from the Study Plan.

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