

Final

PARADISE CUT EXPANSION AND SOUTH DELTA RESTORATION PROJECT

Existing and Needed Technical Studies

Prepared for
**San Joaquin County Resource
Conservation District**

April 2023



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ATTACHMENTS

- A Project Alternatives Analyzed in American Rivers (2019)
- B Peak Flow Results from Hydraulic Analysis of Preferred Conceptual Design in American Rivers (2019)
- C Water Surface Elevation Results from Hydraulic Analysis of Preferred Conceptual Design in American Rivers (2019)

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PARADISE CUT EXPANSION AND SOUTH DELTA RESTORATION PROJECT

Existing and Needed Technical Studies

1 Introduction

This report provides a comprehensive summary of existing technical studies pertinent to the Paradise Cut Expansion and South Delta Restoration Project's (Project)¹ Preferred Conceptual Design, as described below and in American Rivers' Conceptual Design Technical Memorandum, dated April 9, 2019. It also identifies additional technical studies that may need to be undertaken by the lead agency or others before the Project as currently defined can be permitted or constructed. The San Joaquin Area Flood Control Agency (SJAFCA) was selected to lead the next phase of the Project in collaboration with the California Department of Water Resources, the San Joaquin County Resource Conservation District, the South Delta Water Agency, American Rivers, and a consortium of local reclamation districts.

Technical studies are defined to include those pertaining to the following issues, both within and downstream of Paradise Cut:

- Current and proposed hydrology and hydraulics
- Current and proposed sediment transport and deposition
- Current and proposed riparian, aquatic, and terrestrial ecosystem conditions
- Current and proposed channel capacities
- Current and proposed levee conditions
- Current and anticipated water quality conditions

Broadly speaking, these issues can be classified into two groups – a “hydrology and engineering” group encompassing the hydrology, hydraulics, geomorphology, and geotechnical topics and an

¹ The Paradise Cut Expansion and South Delta Restoration Project was formerly known (including in the American Rivers technical memorandum) as the Paradise Cut Conservation and Flood Management Project. The change in names reflects an increased emphasis on the inclusion of channel restoration dredging in the South Delta as part of the project. The quantity of channel restoration dredging ultimately to be included in the project is, along with many other elements of the project, subject to revision in future phases of project analysis, planning and design. The present document focuses on the project concept as described in the American Rivers technical memorandum, which includes channel restoration dredging, as summarized in Section 3.2.

“ecosystem and water quality” group encompassing those topics. These issues are discussed within these two groupings for the remainder of this report.

The existing studies include those that examined potential expansion of Paradise Cut directly as well as others that examined adjacent or nearby geographies (such as the River Islands development just northeast of Paradise Cut on Stewart Tract) or the lower San Joaquin region² as a whole. The needed technical studies include those that must be performed for the Project as currently defined to receive necessary permits and approvals, as well as other studies that may be necessary to further refine the project concept and address local stakeholder concerns, significant knowledge gaps, or areas of uncertainty pertinent to the project.

This report is based upon, and a successor to, a previous report outlining an environmental compliance and permitting strategy for the Preferred Conceptual Design.³ That study preliminarily identified the following permits and approvals that the Preferred Conceptual Design would need to attain to proceed to construction:

- Central Valley Flood Protection Board Encroachment Permit
- Section 408 Permit under federal River and Harbors Act
- California Environmental Quality Act (CEQA) compliance
- National Environmental Policy Act (NEPA) compliance
- Federal Endangered Species Act Incidental Take Permits
- Clean Water Act Section 404 Permits
- Clean Water Act Section 401 Water Quality Certifications
- California Endangered Species Act Incidental Take Permit
- California Fish and Game Code Section 1602 Lake and Streambed Alteration Agreement
- Delta Plan consistency determination

The present report identifies needed technical analyses in the context of these permitting and compliance requirements so that SJAFCA and others can prioritize any information gaps pertinent to these applications and compliance documents accordingly.

2 Anticipated Use of This Document

This document is intended to summarize relevant information on the existing technical studies that have been performed on Paradise Cut, as well as to identify needed studies that have not yet been performed. This document was shared with stakeholders in the Project area as part of a public meeting in March 2023 in order to help establish a shared understanding of what has been

² The “lower” San Joaquin region refers to the lower-elevation, downstream end of the San Joaquin Valley, not its relative position on a map. Because the San Joaquin River flows northward, the “lower” San Joaquin Valley is north of the “upper” Valley.

³ San Joaquin County Resource Conservation District and American Rivers. 2019. *Paradise Cut Conservation and Flood Management Plan Project Environmental Compliance and Permitting Strategy*. Sacramento-San Joaquin Delta Conservancy Grant Agreement #Prop1-2015-Y1-012, Task 5. Prepared by Environmental Science Associates.

and what should be studied in preparation for the Project. The document has been revised to reflect their initial feedback. SJAFCA will continue to share the document with local stakeholders and other partners to continue to solicit feedback on these issues over time.

In December 2021, the SJAFCA Board of Directors passed two motions affirming that SJAFCA will serve as the Project Lead for the Project, and that SJAFCA will enter into a funding agreement with the California Department of Water Resources (DWR) to perform a feasibility study and other work to identify a preferred project alternative and advance project planning. The feasibility study will assess the likely performance of potential project alternatives under both existing and anticipated future conditions, including the new estimations of potential future flood flows on the lower San Joaquin River produced by DWR in the 2022 Update to the Central Valley Flood Protection Plan (2022 CVFPP Update). Specification of a preferred alternative will enable additional fundraising from state and federal sources, development of engineering and restoration designs, and, once those designs have reached a sufficient level of refinement, commencement of the California Environmental Quality Act (CEQA) process and other permitting processes. This report is also intended to inform these efforts and other work that may be necessary to develop a complete engineering and restoration design for the Project.

3 Project Overview and Background

The goals of the Project are to (1) protect lives and property from catastrophic flooding, (2) restore areas of floodplain and riparian habitat as part of an expanded flood bypass, and (3) restore channel depths in the South Delta for multiple benefits.

3.1 Context of San Joaquin River flood management challenges

Paradise Cut is located near the lower end of the San Joaquin River, branching off from the mainstem of the river at approximately River Mile 60, several miles upstream from the cities of Manteca, Lathrop, and Stockton. Under current conditions, water periodically spills over a rock weir into Paradise Cut from the San Joaquin River during high flows. Water flows generally northwest through Paradise Cut for approximately six miles and empties into Old River. Paradise Cut is a component of the federal Lower San Joaquin River and Tributaries Project and California's State Plan of Flood Control (SPFC). The design channel capacity of Paradise Cut in the state and federal flood control projects is 15,000 cubic feet per second (cfs); however, due to sedimentation and other factors, the channel does not currently meet its design capacity (DWR 2017a).

By virtue of its location, Paradise Cut has potential to play a significant role in reducing serious flood risks in the lower San Joaquin Valley (Valley). DWR has estimated that under current conditions, the Expected Annual Damages (EAD) from flooding in the San Joaquin Basin are approximately \$333 million per year, with an Expected Annual Life Loss (EALL) of 36 people, and that these risks are heavily concentrated in the lower (and more urbanized) end of the Valley (DWR 2022). Under the highest projected climate change scenarios modeled by DWR, EAD rises to as high as \$1.96 billion per year and EALL to as high as 277 deaths per year in the San Joaquin

Basin by 2072 if no additional action is taken to reduce these risks in the interim (DWR 2022). Lowering flood water levels along the levees protecting the urbanized areas of the lower San Joaquin Valley, as the Project would do, would therefore make a significant contribution to flood risk reduction for the Valley as a whole.

For these reasons, expansion of Paradise Cut has consistently been identified as a key system-wide flood management priority in the Central Valley Flood Protection Plan (CVFPP) since its first edition in 2012 and continuing in the recent 2022 CVFPP Update. It is also recognized as a major multi-benefit project opportunity, given the ecosystem restoration potential at the site. The CVFPP Conservation Strategy (CS) sets out Conservation Strategy Measurable Objectives (CSMOs) for the restoration of identified ecosystem processes, habitats, and stressors in each of six sub-regions of the Central Valley. The CSMOs for the Lower San Joaquin region are shown in **Table 1** below. Achievement of these regional objectives is unlikely without a significant multi-benefit project at Paradise Cut.

TABLE 1
CONSERVATION STRATEGY MEASURABLE OBJECTIVES (CSMOs) FOR THE LOWER SAN JOAQUIN REGION*

Measurable Objective	Quantity
Inundated Floodplain – Major River Reaches (ac)	11,600
Inundated Floodplain – Bypasses and Transient Storage Areas (ac)	200
Riverine Geomorphic Processes – Natural Bank (mi)	13
Riverine Geomorphic Processes – River Meander Potential (ac)	200
Shaded Riparian Aquatic Cover – Natural Bank (mi)	13
Shaded Riparian Aquatic Cover – Riparian-Lined Bank (mi)	6
Riparian Habitat (ac)	5,800
Marsh and Other Wetland Habitat (ac)	100
Fish Passage Barriers: Channel-Wide Structures	0
Invasive Plants: Prioritized Species (infested acres)	34

NOTE:

* From Merced River confluence downriver

Governor Gavin Newsom’s Water Resilience Portfolio, issued in 2020, included Action 25.4, which directed DWR to “update and refine the regional flood management strategy in the Central Valley Flood Protection Plan to account for the projected impacts of climate change in order to protect vulnerable communities and infrastructure and restore floodplains along the San Joaquin River and its tributaries.” Expansion of Paradise Cut has been identified as one of the key components of this Valley-wide flood management strategy in subsequent working groups convened by DWR to execute Action 25.4.

3.2 Preferred Conceptual Design description

The Preferred Conceptual Design for Paradise Cut was developed in 2019 and is described in a technical memorandum authored by American Rivers (see Section 4.1.1.1). Though this version

of the Project is accepted as the current Preferred Conceptual Design and is treated as such in this document, it will be subject to further evaluation and potential alteration in the feasibility study described briefly in Section 2. There are no engineering drawings, restoration plans, formal project descriptions or project specifications (beyond those summarized below) at the time of this writing.

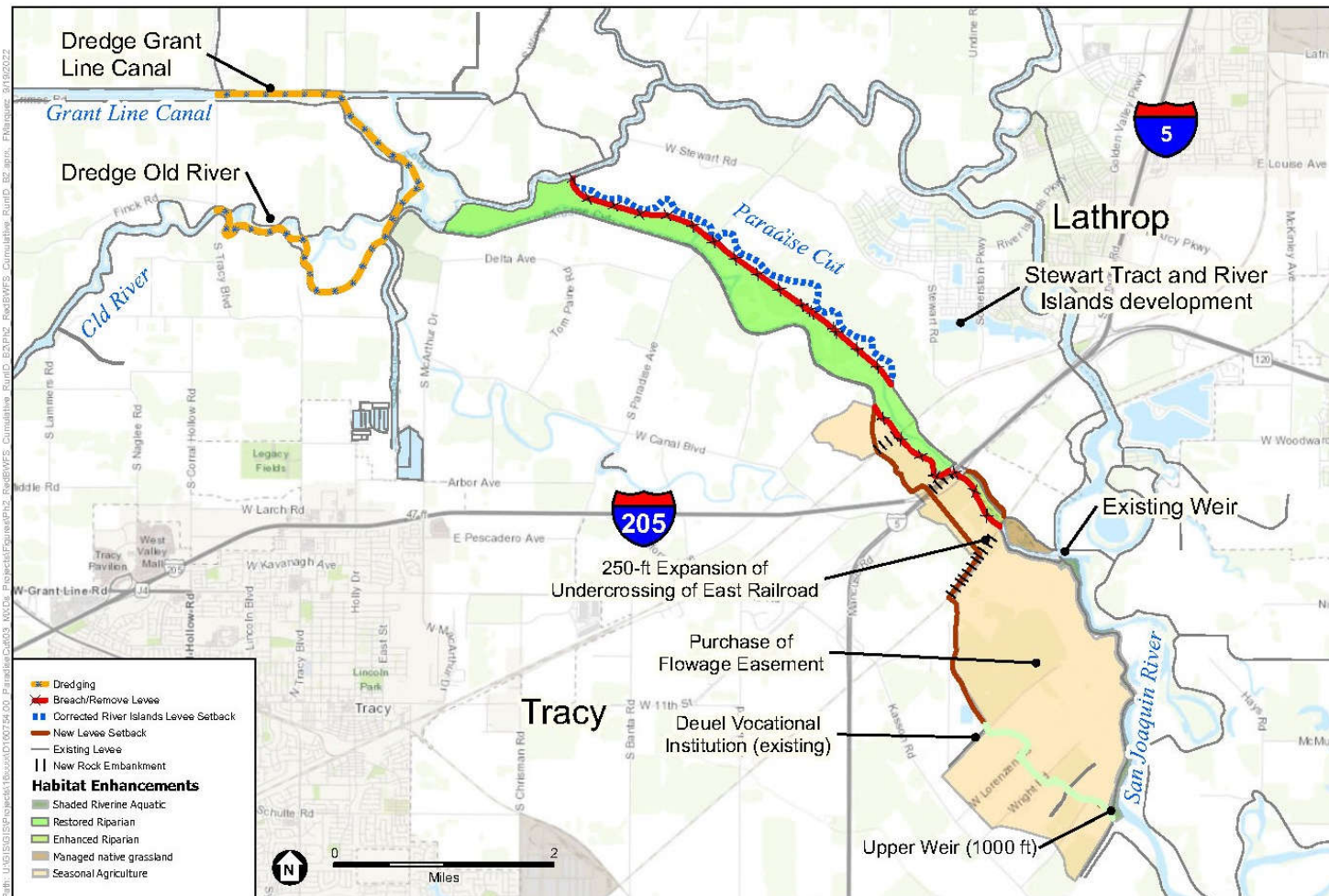
The current Preferred Conceptual Design is positioned at the same location as the existing Paradise Cut, although an additional new weir located upstream, setback levees and other features would substantially expand it (see **Figure 1**). The current Preferred Conceptual Design includes:

- Installation of a new 1,000-foot weir on the left bank of the San Joaquin River approximately 3.1 river miles upstream of the existing rock weir
- Construction of about 7.8 miles of new setback levee, beginning about 1.3 miles away from the new weir at the southwest corner of the Deuel Vocational Facility, and including a 3.6-mile stretch of new setback levee on the right bank that was permitted, and constructed by the ongoing River Islands Development project.
- Removal of approximately 5.1 miles of existing levee, on the left bank of Paradise Cut between the eastern railroad to a point just downstream of the western railroad, and on the right bank from approximately the latter point to the western tip of Stewart Tract.
- Modifications to rock embankments where two railroad lines, the eastern Union Pacific Railroad (a.k.a. the “eastern railroad”), and the western Southern Pacific Railroad (a.k.a. the “western railroad”) and Interstate 5 cross Paradise Cut
- A 250 ft. expansion of the eastern railroad undercrossing
- Channel depth restoration, including dredging of about 2 feet in depth, along approximately 5 miles of Old River and Grant Line Canal
- Installation of a new check valve structure on an existing conveyance structure that brings water into Tom Paine Slough, to limit floodwaters from entering Tom Paine Slough at times of high flow
- Conversion of about 0.5 miles of breached existing levee to high-ground refuge habitat for small mammals and reptiles
- Purchase of new flood and conservation easements on agricultural land between the new weir and a point just downstream of the western railroad
- Retention of existing seasonal agriculture suitable for Swainson’s hawk foraging habitat between the new weir and a point just downstream of the western railroad
- Restoration of riparian habitat within the existing Paradise Cut footprint from the eastern railroad track to the vicinity of the Old River confluence, a distance of about 6.1 miles of varying width
- Restoration of native grassland habitat within the channel between the existing rock weir and the eastern railroad, a distance of approximately 0.65 miles
- Restoration of shaded riverine aquatic habitat along the left bank of the mainstem San Joaquin River between the existing and proposed weirs, a distance of approximately 2.7 miles

3.3 Preferred Conceptual Design anticipated benefits

According to technical analysis performed in American Rivers (2019), the Preferred Conceptual Design would result in a flood stage reduction in the San Joaquin River between Mossdale and Stockton of up to two feet for the authorized design flood condition. It would expand the area subject to flooding in Paradise Cut from approximately 875 acres to 2,970 acres, a net increase of 2,095 acres. Most of that new area would remain in agriculture but be subject to occasional flooding (estimated as less than a 10 percent chance in any given year). Initial modeling of the Preferred Conceptual Design indicated that channel capacity restoration activities would reduce flood stage along Old River and Grant Line Canal by about 1.5–2.0 inches (0.13–0.17 feet).

Figure 1 Preferred Conceptual Design from American Rivers (2019)



4 Existing Technical Studies

State and local agencies have contemplated potential expansion of Paradise Cut, in various forms, for over 20 years. It has been identified as a system-wide flood management priority since the initial edition of the CVFPP in 2012. While mentions of Paradise Cut expansion exist in technical documents from as long ago as 1999, many early descriptions of potential project concepts are too general to be of specific applicability today and have been refined over time through substantial additional analysis and dialogue among stakeholders. Furthermore, to the extent that any modeling was performed on early iterations of Paradise Cut expansion proposals, it made use of hydraulic models that have now been superseded. This summary therefore focuses on the most recent technical studies of the greatest relevance to future progress on project definition and development.

4.1 Engineering and hydraulic studies

Previous hydraulic studies pertinent to the Project fall into three broad categories:

- Studies of alternative preliminary project proposals for Paradise Cut
- Studies of the impacts of the River Islands project on Stewart Tract
- Data and research pertinent to channel capacity restoration in the South Delta

These are summarized in **Table 2** and described in greater detail below.

TABLE 2
SUMMARY OF EXISTING HYDRAULIC STUDIES OF PARADISE CUT

Organization	Year	Title	Local Geography	Project version	Dredging included?	Hydraulic modeling	Modeled flows	Model outputs	Levee analysis?
American Rivers	2019	Conceptual Design Technical Memo: Paradise Cut Expansion Project	Paradise Cut from proposed Upper Weir to Fabian Tract	Minimum Viable Project (current project definition); Potential Maximum Project	Yes	Yes	SJ River Flood Control Project design flood; 1997 flood; 100-yr flood with climate change (235,000 cfs)	Peak flood discharge (cfs), freeboard, and velocity at key measurement points	Freeboard at key measurement points
MBK	2018	Hydraulic Impact Analysis for River Islands at Lathrop, Update for New Existing Condition and Revised No Action Scenario	Vernalis to Fabian Tract, Stockton ship channel and Tracy Blvd crossing of Middle River	Scenarios of MBK (2012) with revisions to scenarios #2 and #3, including completion of River Islands Phase 2A and 2B interior levees	No	Yes	Existing 50-, 100- 200- and 500-year floods	Peak water surface elevation	No
DWR	2017b	Basin Wide Feasibility Study for San Joaquin Basin	Paradise Cut from proposed Upper Weir to Stark Tract	13 options modeled; Option M-Ag similar to American Rivers (2019) Minimum Viable Project	No	Yes	Existing hydrology 200-year flood	Peak water surface elevation (ft); Ecosystem, recreation, land conversion metrics	Downstream levee improvement costs
MBK	2015	Delta Dialogues Paradise Cut Expansion Scenario	Vernalis to Fabian tract	Primary scenario included new 1,000-ft weir and 500-ft opening in Union Pacific Railroad east embankment plus PC levee setbacks	No	Yes	1986 100% (~50,000 cfs), 1956 120% (~85,000 cfs) and 1997 115% (~112,000 cfs) simulations, w/ and w/o SLR	Peak water surface elevation with and without project	No
PBI	2014	200-Year Freeboard Analysis & Floodplain Mapping within RD 17	Vernalis to Fabian Tract, Stockton ship channel and Tracy Blvd crossing of Middle River	Existing conditions (as of 2014)	No	Yes	Existing hydrology 200-year flood	Peak water surface elevation, 200-year floodplain under levee breach scenarios for right-bank SJR only	Levee breach analysis for right-bank SJR below PC only

Organization	Year	Title	Local Geography	Project version	Dredging included?	Hydraulic modeling	Modeled flows	Model outputs	Levee analysis?
USACE	2014	Draft Environmental Impact Statement for River Islands at Lathrop, Phase 2B		[Used MBK 2012 hydraulic analysis]					
MBK	2014	River Islands at Lathrop Hydraulic Impact Analysis		[Editorial revisions only to MBK 2012 below]					
MBK	2012	River Islands at Lathrop Hydraulic Impact Analysis	Vernalis to Fabian Tract, Stockton ship channel and Tracy Blvd crossing of Middle River	(1) Pre-River Islands conditions; (2) 2010 existing conditions after River Islands Phase I levee built; (3) setback of right bank PC non-federal levee; (4) River Islands full project w/ Old River levee setback	No	Yes	Existing 50-, 100-, 200- and 500-year floods	Peak water surface elevation; Maximum inundation area; Change in exceedance probability	Levee failure assumed when water level reaches top of levee; overtopping analysis also included
MBK	2010	River Islands at Lathrop Hydraulic Analysis in Support of Risk Based Hydraulic Impact Analysis	Vernalis to Fabian Tract, Stockton ship channel and Tracy Blvd crossing of Middle River	(1) Pre-River Islands conditions; (2) 2010 existing conditions after River Islands Phase I levee built; (3) setback of right bank PC non-federal levee; (4) River Islands full project w/ Old River levee setback	No	Yes	Existing 2-, 10-, 25-, 50-, 100-, 200- and 500-year floods	Peak water surface elevation and peak discharge (cfs)	No
MBK	2006	River Islands at Lathrop Analysis of Hydraulic Impacts on Federal Flood Project Design Capacity	Vernalis to Fabian Tract, Stockton ship channel and Tracy Blvd crossing of Middle River	(1) Pre-River Islands; (2) River Islands project completion; (3) River Islands plus Paradise Cut Improvement Project with setback levee on right bank of PC downstream of Union Pacific Railroad	No	Yes	San Joaquin River Flood Control Project design flood	Peak water surface elevation and peak discharge (cfs)	No
MBK	2002	River Islands at Lathrop Hydraulic Impact Analysis	Vernalis to Fabian Tract, Stockton ship channel and Tracy Blvd crossing of Middle River	(10) Pre-River Islands conditions; (2) River Islands completion plus Paradise Cut Improvement Project with setback levee between Union Pacific Railroad and I-5	No	Yes	Existing 10-, 50-, 100-, and 200-year floods	Peak water surface elevation	Levee failure assumed when water level reaches to within 3 ft of top of levee

SOURCE: ESA 2022

4.1.1 Recent studies of Paradise Cut alternatives

4.1.1.1 American Rivers (2019)

This study identified and examined the Preferred Conceptual Design as a refined variant of project alternatives previously developed in DWR (2017b). It examined four alternatives, as shown in **Table 3**.

TABLE 3
DESCRIPTION OF PARADISE CUT PROJECT ALTERNATIVES IN AMERICAN RIVERS (2019)

Alternative Name	Alternative Description
CVFPP	Option M-Ag from the 2017 Central Valley Flood Protection Plan, as analyzed in the 2017 Draft San Joaquin River Basin-Wide Feasibility Study
Modified CVFPP	CVFPP plus 5 miles of channel capacity restoration in Old River and Grant Line Canal and with adjustments in setback levee configuration
Minimum Viable Project (MVP)	Modified CVFPP without levee setback along the western edge of the bypass expansion area south of Deuel Vocational Institute (DVI) and with 250-foot opening at eastern Union Pacific Railroad crossing instead of 500-foot opening
Potential Maximum Project (PMP)	MVP with 500-foot openings at all rail and highway crossings and major new setback levee along the northern end of Paradise Cut

The Minimum Viable Project (which subsequently became the Preferred Conceptual Design) was developed as a less expensive alternative that eliminated 1.5 miles of setback levee from the two CVFPP alternatives and reduced the size of the undercrossing of the eastern railroad. The Potential Maximum Project, by contrast, included 500-foot openings beneath both railroads and I-5, as well as 2.5 additional miles of levee setback on the northern end of the project area. Figures from *American Rivers (2019)* illustrating the alternatives are shown in Attachment A.

These alternatives were evaluated under three hydrologic scenarios:

- The design flood for the federal San Joaquin River Flood Control Project (52,000 cfs at Vernalis)
- The 1997 flood (110,000 cfs at Vernalis)
- The 100-year (1 percent annual exceedance probability) flood plus anticipated effects of climate change (235,000 cfs at Vernalis)

In the 1997 flood scenario, levee breaches and relief cuts were assumed to be the same as those that actually occurred in 1997, except in cases where levees have been significantly improved since then or are part of the Project. In the other two scenarios, no levee breaches or relief cuts are assumed and flooding is therefore modeled to occur only where levees overtop.

Hydraulic modeling was performed for all alternatives under all scenarios listed above, with particular focus on the following hydraulic performance criteria:

- Peak flood stage reduction on the San Joaquin River downstream of the existing weir adjacent to Mossdale Tract

- Peak flood stage change on Grant Line Canal and Old River downstream of Paradise Cut
- Peak flood velocity on Grant Line Canal and Old River downstream of Paradise Cut
- Change to freeboard in above locations

Modeled changes in peak flows are summarized in Figures 7 and 8 in American Rivers (2019), included as Attachment B. Modeled changes in water surface elevations and freeboard from American Rivers (2019) are included as Attachment C. Overall, the modeling showed incremental decreases in freeboard, generally in the range of five to seven percent loss of available freeboard, under the 1997 flood scenario.

The modeling also showed velocity spikes at multiple locations within the Project footprint and recommends further analysis to avoid or mitigate such spikes.

4.1.1.2 DWR (2017a) and (2017b)

Both the 2017 Central Valley Flood Protection Plan (DWR 2017a) and the 2017 Basin-Wide Feasibility Study for the San Joaquin Basin (DWR 2017b) included a version of a Paradise Cut project referred to as “Option M-Ag” that is similar to the Preferred Conceptual Design, except for the following major differences:

- They did not include channel capacity restoration activities in downstream channels.
- They included an additional 1.5-mile setback levee south of Deuel Vocational Institution.
- They included a 500-foot (as opposed to 250-foot) opening under the eastern railroad.

Option M-Ag was one of fourteen Paradise Cut project alternatives assessed in DWR (2017b), including two variants of Option M: one that left most land within the levee setback area in agriculture (Option M-Ag) and another that assumed more extensive restoration of agricultural lands to riparian and grassland (Option M-Riparian). Compared to Option M, the other alternatives all had either significantly shorter lengths of left-bank setback levee (e.g., 1,000 feet or less, compared to more than 4,000 feet for Option M) and expanded the existing weir rather than constructing a new weir. Each of the fourteen project alternatives was evaluated for a 200-year flood event under existing hydrology. For this scenario, the following performance criteria were evaluated:

- Paradise Cut Weir peak flow
- Changes in distribution of flow relative to baseline downstream of Paradise Cut Weir
- Peak stage reduction relative to baseline on the San Joaquin River at Mossdale
- Peak stage increase relative to baseline at Paradise Cut – Old River confluence
- Peak stage reduction relative to baseline on the San Joaquin River at Howard Rd. Bridge
- Potential increase in habitat acreage
- Estimated cost

Compared to other alternatives, Option M produced significantly more stage reduction for the San Joaquin River at Mossdale (2.0 feet compared to <1 foot) and at the Howard Rd. Bridge

(1.7 feet compared to <0.63 feet) with roughly comparable peak stage increases at the Paradise Cut–Old River confluence (0.5 feet, compared to a range from 0.3 to 0.9 feet for other alternatives). Option M-Ag was estimated to cost \$217 million and Option M-Riparian to cost \$231 million, not including the cost of additional downstream levee improvements, estimated at \$91 million in both Option M alternatives.

4.1.1.3 Delta Dialogues

MBK (2015) summarizes a hydraulic modeling exercise performed for the Paradise Cut expansion scenario resulting from the “Delta Dialogues,” a voluntary and non-binding series of dialogue workshops held with key Delta stakeholders in 2014. The Delta Dialogues scenario was a preliminary version of project alternatives later analyzed in DWR (2017a and b) and American Rivers (2019). It included the construction of a new 1,000-foot-wide weir approximately 2,000 feet downstream of the Banta Carbona Canal; creation of a transitory storage area east of the Union Pacific Railroad and the Deuel Vocational Institution; a new 2.8-mile-long setback levee on the south bank of Paradise Cut; and a 500-foot-wide opening in the Union Pacific Railroad east embankment. The hydraulic modeling for the largest flow examined (115 percent scaling of the 1997 flood, or approximately 112,000 cfs at Vernalis) showed peak water surface elevation decreases of 2.76 feet at Banta Carbona Canal, 1.68 feet at Old River, and 1.26 feet at Howard Road, adjacent to Mossdale Tract. Peak water surface elevations within and downstream of Paradise Cut were modeled to increase by 0.25 feet at Paradise Road, 0.41 feet at Tracy Boulevard on Old River, and 0.35 feet at Tracy Boulevard on Grant Line Canal.

4.1.2 Studies of River Islands impacts

A series of hydraulic impact analyses were performed for the River Islands development on Stewart Tract (MBK 2002, 2006, 2010, 2012, 2014, and 2018), and the 2012 analysis was also incorporated into the Draft Environmental Impact Statement for River Islands (USACE 2014). Paradise Cut forms the western boundary of Stewart Tract, and the River Islands project set back 3.6 miles of levee on the right bank of Paradise Cut in 2019.

The most recent of these hydraulic analyses (MBK 2012, 2014, and 2018) examined 50-, 100-, 200-, and 500-year floods under existing hydrology and assessed peak water surface elevations and (in 2012) the maximum inundation area and change in exceedance probability for a given flow event. These studies were limited to only the potential hydraulic impacts of the River Islands project and therefore did not include any characterization of a larger Paradise Cut expansion apart from the actions listed above. The hydraulic modeling environment developed for these studies was subsequently used to assess Paradise Cut alternatives directly in American Rivers (2019).

4.1.3 Studies and activity pertinent to channel depth restoration in South Delta

Restoration of channel depths in various South Delta watercourses has been the subject of various studies and activities in recent years, summarized below.

4.1.3.1 Planning Guide for the Channel Depth Restoration Program for the South Delta Channels

Anchor (2021) presents a strategy for implementing a channel depth restoration program in the South Delta, including (but not limited to) the following detailed planning-level information:

- An assessment of known site conditions and identification of missing site condition information
- A description of applicable channel depth restoration methods
- An order-of-magnitude assessment of dredging volumes and site capacity needs
- A framework for completing the environmental compliance and permitting process

Among the data and findings presented in this document are:

- Results of investigative testing of sediment in Old River and Middle River in 2021, which show a very wide range of sediment grain sizes and geotechnical conditions within the Program area.
- Results of chemistry analysis performed on the samples collected above, showing that the examined samples:
 - Do not contain contaminant⁴ levels of concern for potential upland placement of dredge spoils
 - Do not show exceedances for standards pertinent to potential landfill disposal (but will likely require further testing for confirmation)
 - Do show some exceedances for standards pertinent to potential placement in or near water, but that these results do not necessarily preclude such placement (additional testing is likely to be required for confirmation)
- Potential reuse of sediment to build levees “may be limited” but dredged sediment “could be used to increase upland elevations of dry land and marshes to protect against sea level rise and flooding” (Anchor 2021, p. 9).
- Ongoing maintenance dredging is likely to be required, but its scale and frequency depend on the shoaling rate (i.e., sediment deposition rate) in the channels, which has not yet been sufficiently estimated. A sediment budget for the San Joaquin River is not available; were such information available, it would yield a much better understanding of shoaling and channel sediment-related processes (see Anchor 2021, Section 5.1.1.2).
- Target dredging elevations for South Delta channels, including Paradise Cut, Old River, and Fabian & Bell Canal, are generally identified as the deepest historical elevations as identified in the 1934 National Oceanographic and Atmospheric Administration (NOAA) soundings.
- Reconnaissance-level estimates of dredging quantities from South Delta channels, including Paradise Cut, Old River, and Fabian & Bell Canal.
- Reconnaissance-level estimates of dredging quantities from South Delta channels, including Paradise Cut, Old River, and Fabian & Bell Canal range from a lower bound of 1,520,000

⁴ Tests were performed for trace metals, sulfide, pesticides, polychlorinated biphenyl (PCB) congeners, polycyclic aromatic hydrocarbons (PAHs), and methyl mercury.

cubic yards to an upper bound of 6,507,000 cubic yards (including a 1-foot overdredge allowance in both cases).

- A new hydrographic survey should be performed since available bathymetric data are more than a year old; the cost of such a survey is estimated at \$280,000–\$350,000.
- To estimate sediment accretion rates and patterns, data from at least three hydrographic surveys conducted at least a year apart is needed. Variability in flood flows during these years is an implicit assumption in seeking at least 3 years of data; during droughts or periods without flood flows additional data collection may be merited.
- “No modeling or analysis has been conducted to evaluate how the restoration of these historical channel depths would influence net flows, water quality, fish migration, or conditions during floods” and such analysis must be performed as part of any channel restoration program design.
- “Prior to engineering design, an analysis of the sediment engineering characteristics should be performed to evaluate the sediment behavior for dredging and dewatering, slope stability, and post-construction uses...A more robust geotechnical evaluation may be required to assess potential impacts of dredging to the adjacent levees and banks, as well as the potential for levee soils to support equipment loads if landside access is required during mobilization or dredging operations.”

4.1.3.2 Bathymetric data comparison

MBK Engineers reviewed the status of bathymetric data of Paradise Cut and the channels immediately downstream, including Old River below the Paradise Cut confluence and Grant Line Canal (see **Figure 2**), as part of the modeling effort undertaken for American Rivers (2019). While finely detailed bathymetry is generally not necessary for effective hydraulic modeling (since the effects of localized bathymetric variations are accounted for in a hydraulic model’s calibration), the intent of the review was to assess the magnitude of any discrepancies between the bathymetric data used in the Central Valley Flood Evaluation and Delineation (CVFED) analysis (upon which the MBK hydraulic modeling effort was based) and newer bathymetric data from 2018 made available to MBK by the South Delta Water Agency on behalf of the local Reclamation Districts.

Channel cross-sections present in both datasets were directly compared, as in the examples shown in **Figure 3**. Discrepancies at locations-in-common varied in magnitude across the study area. The newer bathymetric data were incorporated into the hydraulic modeling for American Rivers (2019) to ensure that it reflected best-available information.

The 2018 bathymetric data may also be of use in scoping channel depth restoration activities, and any needed mitigation or long-term maintenance strategy for these channels, in a final Project. The South Delta Water Agency has also committed to providing annual bathymetry data to provide additional data for sediment tracking.

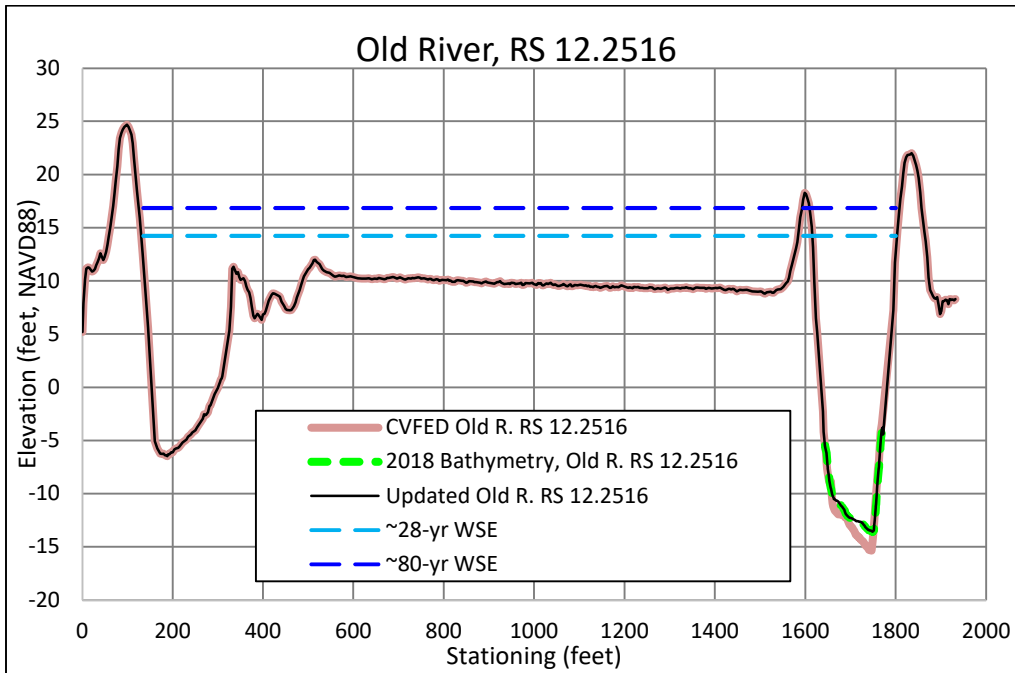
Figure 2 **Locations of Bathymetric Data Comparisons**



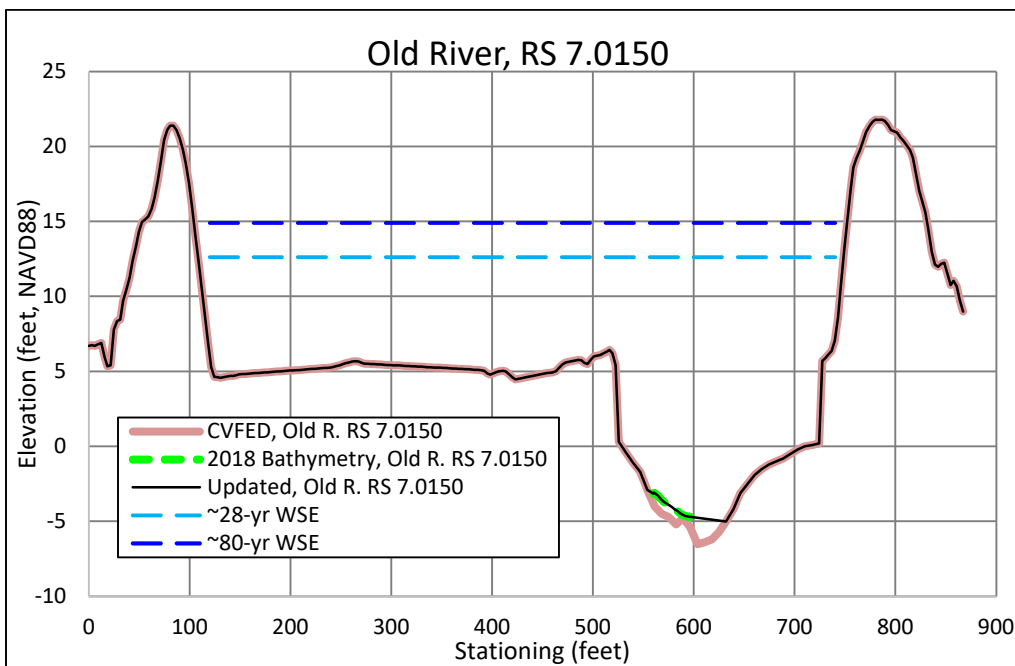
Figure 3 Example Bathymetric Cross-Section Comparisons

Prepared by MBK Engineers for American Rivers (2019)

(a) Paradise Cut (left channel) and Old River (right channel) in vicinity of



(b) Old River in vicinity of



4.1.3.3 South Delta barriers programs

DWR implemented the South Delta Temporary Barriers Project from 1987 to 2008, with the dual purposes of improving conditions for migrating salmon and improving conditions for agricultural diversions (DWR 2013). More recently, DWR's Temporary Barriers Program (TBP) has distinguished between the Agricultural Barriers Project Element, which is intended to protect senior water rights in the South Delta, and the Head of Old River Barriers (HORB) Project Element, which is intended to benefit anadromous fish migrating through the South Delta.

The TBP Agricultural Barriers Project Element consists of three barriers at the following locations:

- Middle River (near the confluence of Middle River with Victoria Canal)
- Grant Line Canal (about 100 yards upstream of Tracy Boulevard bridge)
- Old River (east of the Delta-Mendota Canal, approximately 4,000 feet southeast of the intersection of the Alameda, Contra Costa, and San Joaquin County lines)

The TBP Agricultural Barriers Project Element was developed to mitigate impacts of the State Water Project and Central Valley Project export facilities' operation on agricultural diverters in the South Delta. State Water Project and Central Valley Project operation lowers water levels, causes reverse flows, diminishes the influence of tides, and may affect water quality in the South Delta channels. To lessen these impacts and protect senior water rights, the TBP Agricultural Barriers Project Element is intended to accomplish the following benefits in the South Delta channels:

- Maintain water levels
- Improve circulation patterns
- Improve water quality

The TBP HORB Project Element consists of a seasonal fish barrier, installed twice per year in the Old River channel at the San Joaquin River. These two installations are referred to as the spring and fall fish barriers and have the following objectives:

- The spring HORB is intended to increase the survival of juvenile outmigrating salmon by blocking the Old River divergence from the San Joaquin River, thus preventing their use of this migratory pathway, which leads toward the State Water Project and Central Valley Project pumping plants.
- The fall HORB is intended to minimize the water quality effects of tidal flow reversals (low levels of dissolved oxygen) and increase attractive flows to benefit returning adult salmon in the San Joaquin River.

The fall HORB has been put in place most years since 1963. Installation of the spring HORB began in 1992, and the rock barrier has been installed 15 times since then (high flows on the San Joaquin, or court rulings, prevented installation in the other years). A nonphysical fish barrier was tested at the Head of Old River in 2009 and 2010 (see Section 4.2.4, below).

The South Delta Improvement Program was intended to replace the temporary rock barriers of the TBP with permanent operable gates. A final Environmental Impact Report/Statement was prepared for the program in 2006 but, as of this writing, has not yet been implemented (DWR 2013).

4.2 Ecosystem studies

Previous ecosystem studies pertinent to the Project generally fall into three categories:

- Regional assessments of ecological conditions in the South Delta
- Environmental compliance documents for the River Islands project
- Species-specific studies and plans

These are described in greater detail below and summarized in **Table 4**.

4.2.1 Regional assessments of ecological conditions

Three studies contain descriptions and assessments of the overall ecological and habitat conditions in the region. The Basin Wide Feasibility Study for the San Joaquin Basin (DWR 2017b), though not primarily an ecosystem study, identifies needed habitat in the lower San Joaquin Valley with a focus on the target species of conservation concern identified in the CVFPP CS. These species are identified in **Table 5**. The CS also identifies Measurable Objectives for each of six Conservation Planning Areas in the Central Valley, as shown in Table 1. The Project is within the Lower San Joaquin River Conservation Planning Area (defined as the entire San Joaquin River reach below the Merced confluence) and is expected to make a substantial contribution to the achievement of the region's Measurable Objectives. The CS also contains a summation of existing conservation objectives from other plans in both its 2016 edition (DWR 2016, Appendix J) and 2021 Update (DWR 2021, Appendix C).

**TABLE 4
SUMMARY OF EXISTING ECOSYSTEM STUDIES OF PARADISE CUT**

Organization	Year	Title	Local Geography	Species included	Existing habitat description?	Habitat features/needs quantified?	Habitat mapping?	Incidence of species recorded?	Mitigation measures identified?
City of Lathrop	2021	River Islands at Lathrop Phase 2 Project Draft Subsequent Environmental Impact Report	Paradise Cut, Stewart Tract and vicinity	~49 species including all CS target species present in the San Joaquin Valley	Yes	No	No	Yes	Yes
NMFS	2018	Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon	Lower San Joaquin Valley	Green sturgeon	Yes	Yes	Yes	Yes	Yes
DWR	2017	Basin Wide Feasibility Study for San Joaquin Basin	Paradise Cut	Not species specific, but focus is on CS target species esp. salmon and steelhead	No	Yes	Yes	No	No
USFWS	2017	Recovery Plan for the Giant Garter Snake	Lower San Joaquin Valley and Delta	Giant garter snake	Yes	Yes	Yes	Yes	Yes
Matocq et al.	2017	Final Report: Population Genetic Structure of the Riparian Brush Rabbit (<i>Sylvilagus Bachmani</i> Riparius): Using Multiple Marker Systems to Gain Insight into Historic and Ongoing Genetic Connectivity	Lower San Joaquin Valley and South Delta	Riparian brush rabbit	Yes	Yes	Yes	Yes	No
DWR	2016	Central Valley Flood Protection Plan Conservation Strategy (esp. Appendix G, Focused Conservation Plans)	Lower San Joaquin Valley Conservation Planning Area (below Merced River confluence)	All CS target species (see Table 5)	Yes	Yes	No	No	No
Ascent	2016	USFWS and NMFS Biological Assessment for the River Islands at Lathrop Project	Paradise Cut, Stewart Tract and vicinity	Riparian brush rabbit, giant garter snake, Delta smelt, green sturgeon, Central Valley steelhead, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon	Yes	Yes	Yes	Yes	No

Organization	Year	Title	Local Geography	Species included	Existing habitat description?	Habitat features/needs quantified?	Habitat mapping?	Incidence of species recorded?	Mitigation measures identified?
City of Lathrop	2021	River Islands at Lathrop Phase 2 Project Draft Subsequent Environmental Impact Report	Paradise Cut, Stewart Tract and vicinity	~49 species including all CS target species present in the San Joaquin Valley	Yes	No	No	Yes	Yes
NMFS	2014	Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead	Lower San Joaquin Valley	Central Valley Spring-Run Chinook salmon and Central Valley steelhead	Yes	Yes	Yes	Yes	Yes
USACE	2014	Draft Environmental Impact Statement for River Islands at Lathrop, Phase 2B	Paradise Cut, Stewart Tract and vicinity	55 species including all CS target species except riparian woodrat, bank swallow, California black rail, Least Bell's vireo, and western yellow-billed cuckoo	Yes	Yes	Yes	Yes	Yes
ESA PWA	2012	BDCP South Delta Habitat and Flood Corridor Planning Corridor Description and Assessment Document	South Delta to Vernalis	Not species specific; focused on habitats w/r/t tidal elevation zones	Yes	Yes	Yes	No	No
Sycamore	2004	Riparian Brush Rabbit Mitigation and Management Plan for River Islands at Lathrop	Paradise Cut, Stewart Tract and vicinity	Riparian brush rabbit	Yes	Yes	Yes	Yes	Yes
City of Lathrop	2003	Final Subsequent Environmental Impact Report for River islands at Lathrop	Paradise Cut, Stewart Tract and vicinity	38 species including all CS target species except bank swallow, CA black rail, least Bell's vireo, western yellow-billed cuckoo, riparian woodrat, and green sturgeon	Yes	No	No	Yes	Yes
San Joaquin County	2000	San Joaquin County Multi-Species Habitat Conservation and Open Space Plan	San Joaquin County	97 species including all CS target species except Least Bell's vireo and Central Valley steelhead and salmon runs	Yes	Yes	Yes	To USGS quad sheet level	Yes
USFWS	1998	Recovery Plan for Upland Species of the San Joaquin Valley	San Joaquin Valley	34 species including riparian brush rabbit and riparian woodrat	Yes	No	No	Yes	Yes

NOTES:

4. Existing Technical Studies

BDCP = Bay Delta Conservation Plan
CS = Conservation Strategy of the Central Valley Flood Protection Plan
DWR = CA Department of Water Resources
NMFS = National Marine Fisheries Service

USACE = US Army Corps of Engineers
USFWS = US Fish and Wildlife Service
USGS = US Geological Survey

SOURCE: ESA 2022

TABLE 5
CVFPP CONSERVATION STRATEGY TARGET SPECIES PRESENT IN LOWER SAN JOAQUIN VALLEY

Common name	Scientific name
California black rail	<i>Laterallus jamaicensis coturniculus</i>
California Central Valley steelhead DPS	<i>Oncorhynchus mykiss</i>
Chinook salmon – Central Valley fall- and late-fall-run, Central Valley spring-run ESUs	<i>Oncorhynchus tshawytscha</i>
Delta button-celery	<i>Eryngium racemosum</i>
Delta smelt	<i>Hypomesus transpacificus</i>
Giant garter snake	<i>Thamnophis gigas</i>
Greater sandhill crane	<i>Grus canadensis tabida</i>
Green sturgeon – southern DPS	<i>Acipenser medirostris</i>
Least Bell's vireo	<i>Vireo bellii pusillus</i>
Riparian brush rabbit	<i>Sylvilagus bachmani riparius</i>
Riparian woodrat	<i>Neotoma fuscipes riparia</i>
Slough thistle	<i>Cirsium crassicaule</i>
Swainson's hawk	<i>Buteo swainsoni</i>
Valley elderberry longhorn beetle	<i>Desmocerus californicus dimorphus</i>
Western yellow-billed cuckoo	<i>Coccyzus americanus occidentalis</i>

NOTES:

DPS = Distinct population segment
ESU = Evolutionarily significant unit

SOURCE: ESA 2022

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (San Joaquin County 2000) includes 97 species, including all CS target species except for the Chinook salmon, Central Valley steelhead, and least Bell's vireo. It includes descriptions, mapping, and quantification of habitats as they existed at the time of authorship (now over 20 years ago), and also indicates actual incidences of these species to the USGS quad sheet level. The Plan is still in force in San Joaquin County and is the basis for a number of operating habitat preserves within the county that provide potential mitigation acreage for a variety of species and habitat types.

ESA PWA (2012) contains quantification, mapping, and written descriptions of existing habitat types in Corridor 2A (Paradise Cut from the weir to Grant Line Canal). It depicts a corridor in which agriculture is the predominant land use, with only very slender strips of riparian habitat (concentrated on the upper end of the reach) and a small area of wetlands at the downstream end. It also assesses the potential expansion of riparian habitat resulting from levee setbacks on both sides of Paradise Cut that would increase the floodway from 1,189 acres to 2,289 acres.

4.2.2 Environmental compliance documents for the River Islands project

City of Lathrop (2021, 2003), US Army Corps of Engineers (USACE 2014) and Ascent (2016) are major environmental compliance documents related to the River Islands project on Stewart Tract. Paradise Cut forms the southwestern boundary of Stewart Tract, and thus some of the land area encompassed within the Preferred Conceptual Design is included within these analyses. City of Lathrop (2003) was the primary Environmental Impact Report covering the River Islands project under CEQA and was amended six times (in 2005, 2007, 2021, 2014, 2015 and 2018) to provide CEQA coverage to ongoing refinements of the River Island project. City of Lathrop (2021) ultimately supplemented and superseded City of Lathrop (2003) and its amendments. USACE (2014) is an Environmental Impact Statement covering the River Islands project under the National Environmental Policy Act (NEPA) and covers a somewhat larger number of species (about 55) than the City of Lathrop documents, including most of the CS target species. USACE (2014) describes, quantifies, and maps habitat areas, reports incidences of these species within the study area, and identifies potential mitigation measures for impacts to species and habitats.

Ascent (2016) is a federal Biological Assessment that focuses primarily on fish species – two runs of Chinook salmon (Central Valley spring-run and Sacramento River winter-run), Central Valley steelhead, green sturgeon, and Delta smelt – along with the riparian brush rabbit and giant garter snake. It describes, quantifies, and maps habitats areas and reports incidences of these species within the study area. Given the proximity to, and partial overlap with, the footprint of the Project, these studies offer useful information for restoration planning as well as for the anticipation of potential impacts of project construction and potentially suitable mitigation measures.

4.2.3 Species-specific studies and plans

Target species of conservation importance in the lower San Joaquin Valley and South Delta are subject to several conservation and recovery plans, as well as status reviews and other single-species studies and assessments.

The CVFPP CS formulated Focused Conservation Plans for each of the CS target species listed in Table 5. These are presented in DWR (2016) Appendix G. Each Focused Conservation Plan is a comprehensive summation of the scientific literature pertinent to the species and its associated conservation needs. They include descriptions of each species' conservation status, physical distribution, and life history, as well as the threats, impacts, and conservation opportunities that exist for each species, including the potential impacts of specific floodplain management actions (e.g., “modification of floodplain topography” or “invasive plant management”) on the species.

Recovery plans are prepared for federally listed endangered species and include, among other things, detailed description of needed habitat characteristics, as well as prioritized actions and quantified recovery goals for relevant geographies. The riparian brush rabbit and riparian woodrat were both included in the US Fish and Wildlife Service (USFWS 1998) recovery plan for terrestrial species in the San Joaquin Valley. National Marine Fisheries Service (NMFS 2014) is a recovery plan focusing on three salmonid species, one of which (Central Valley Steelhead) has

critical habitat in the river channels of the lower San Joaquin Valley, including Paradise Cut and Old River. NMFS (2018) is a recovery plan focused on the green sturgeon, whose critical habitat includes the lower San Joaquin River and South Delta. USFWS (2017) is a recovery plan for the giant garter snake, whose critical habitat includes Paradise Cut and the remainder of the lower San Joaquin Valley. The riparian brush rabbit is endemic to the San Joaquin Valley and no longer exists in the wild anywhere else, so all studies of the species (e.g., Matocq et al. 2017; Sycamore 2004) include the lower San Joaquin Valley within their study context.

4.2.4 Studies of salmonid migration through South Delta

Buchanan et al. (2018) studied the survival of emigrating juvenile fall-run Chinook salmon through the lower San Joaquin River and South Delta from 2010 to 2015. They found that survival probability for juvenile Chinook between the study's release point at Durham Ferry and Chipps Island was extremely low through both the mainstem San Joaquin River (ranging between 0 and 4 percent probability of survival) and Old River (ranging between 0 and 11 percent probability of survival). In the wet year of 2011, overall survival probability from Durham Ferry to Chipps Island was only 2 percent, with mortality risk concentrated in the downstream portion of the Delta (i.e., downstream of the Turner Cut junction). In the 6 years studied, over half of the juvenile Chinook surviving through the Delta were salvaged at the Central Valley Project's water export facility and transported for release just upstream of Chipps Island, and thereby avoided transiting the downstream portions of the Delta.

DWR (2013 and 2015) examined the potential for installation of migratory fish guidance structures to reduce diversion of juvenile salmonids to the interior and southern Delta, to reduce exposure to the export pumping facilities of the State Water Project and the Central Valley Project. Among the sites studied was the Head of Old River, where Old River and the mainstem of the San Joaquin River diverge at approximately River Mile 52 of the San Joaquin, approximately five river miles downstream of the existing weir. In 2009 and 2010, a Bio-Acoustic Fish Fence was tested as an engineering solution to prevent outmigrant juvenile salmonids from entering Old River. The results from these 2 years showed no significant difference in the overall proportion of released fish that migrated down the mainstem of the San Joaquin River (ranging from 18.4 to 35.5 percent under various operational conditions and water years) once the results of predation were considered.

5 Needed Technical Studies

Research into needed technical studies focused on the following types of studies:

- Studies that must be performed if the Project as currently defined is to receive necessary permits
- Studies that may be necessary to address local stakeholder concerns
- Studies that may be necessary to fill knowledge gaps or areas of uncertainty pertinent to the Project

To identify such studies, we consulted the existing Permitting Strategy document, previous technical memoranda and other resources in the existing technical studies bibliography, and key staff within organizations involved in the development of the Project and the nearby Mossdale Tract Urban Flood Risk Reduction Project. The needed studies are summarized in Table 6 and described in greater detail below. All studies are currently unfunded, with the exception of the feasibility study (see Section 5.1.1.1), which will be funded by a forthcoming grant from DWR to SJAFCA (see Section 2).

TABLE 6
SUMMARY OF NEEDED STUDIES OF PARADISE CUT

	Hydraulic and Engineering Studies	Ecosystem studies
Needed for specification of a final Project	Feasibility study* (5.1.1.1) Sedimentation assessment (5.1.1.2) Geotechnical analysis (5.1.1.3) Establishment of common modeling (5.1.1.4)	Feasibility study* (5.1.1.1) Restoration potential assessment (5.2.1.1) Agency consultation on migratory fish (5.2.1.2) Soil and sediment contamination studies (5.2.1.3)
Needed for permit applications and environmental compliance**	Modeling of hydraulic impact of project levee alteration (5.1.2.1)	Wetland delineation study (5.2.2.1) Biological resources study (5.2.2.2) Cultural resources study (5.2.2.3) Air quality and greenhouse gas emissions study (5.2.2.4) Phase I environmental assessment (5.2.2.5)

Numbers in (parentheses) indicate report section containing more information about each study

* Funded by forthcoming DWR grant to SJAFCA

** Typically funded as part of permitting and environmental compliance phase of project development

5.1 Hydrology and Engineering needed studies

The Preferred Conceptual Design has been the subject of previous hydrologic and hydraulic modeling analysis as part of American Rivers (2019). Additional technical analyses are needed for two purposes:

- Specification of a finalized Project (as opposed to a conceptual design) that addresses local stakeholder concerns
- Permit applications and environmental compliance needs for a finalized Project

These are described in greater detail below.

5.1.1 Specification of a finalized Project

The following studies are recommended for potential contributions to the specification of a final Project description.

5.1.1.1 Feasibility study

While significant progress has been made in defining a Preferred Conceptual Design, as described in Section 3.2 above, more rigorous technical analysis of project alternatives should be conducted for a potential public investment of this magnitude. In addition, recent findings of the technical analysis performed for the CVFPP 2022 Update (conducted since the Preferred Conceptual Design was identified) show a major increase in anticipated flood peaks and risks in the lower San Joaquin Valley – as much as a 400 percent increase in peak flows at Vernalis under the highest climate change scenarios. Such findings suggest the need for additional analysis and quantification of the benefits that various Project alternatives, including larger alternatives, would provide in future decades under such scenarios.

The following issues are among those that should be considered for inclusion in the feasibility study:

- Flood risk reduction benefits of project alternatives under current and anticipated future hydrological conditions, including those estimated by the CVFPP climate change technical analysis
- Re-evaluation as necessary of constraints and opportunities present at the project site, including but not limited to: the routing of overland-flowing waters back into Paradise Cut; the fate of existing structures within the intended overland flow areas; the optimal size of the openings underneath I-5 and the two railroads; the potential repurposing of the RD 2095 levee on the left bank of the San Joaquin between the existing and proposed new weirs; and other topics to be determined.
- Potential for sedimentation and other downstream effects of project alternatives under current and anticipated future hydrological conditions
- The areal extent and depth of channel restoration dredging in the South Delta, including in reaches not within the footprint of the Preferred Conceptual Design
- Effects of various potential channel depth restoration actions on flood risks to levees downstream of Paradise Cut and water quality within the Delta
- Modeling of flow velocity dynamics under all project alternatives and identification of potential measures to prevent, reduce, or armor against velocity spikes
- Assessment of management alternatives for the levee that would remain on the left bank of the San Joaquin River between the new and existing weirs, including analysis of the potential need to maintain the levee to avoid unwanted hydraulic dynamics
- Additional potential restoration actions within or near the current project footprint
- Land acquisition, capital and operation and maintenance costs, and a project financing strategy
- Impact avoidance, minimization and mitigation strategies

Stakeholders at the March 2023 public meeting identified additional specific concerns that should be addressed within the feasibility study and subsequent modeling, planning and design. These issues include:

- Ensuring that dredging or any other Project action does not change the flow split between Old River and Grant Line Canal
- Ensuring that the effect of State Water Project and Central Valley Project export pumps, which periodically cause flows to reverse in some South Delta channels and can pull in fish, are considered in both the engineering and restoration designs of the Project
- Assessing locations where levees no longer conform to their original design specifications, particularly with regard to waterside slopes, which have become too steep in some locations
- Assessing potential benefits of additional flows in Tom Paine Slough
- Assessing potential benefits of dredging upper portion of Paradise Cut
- Assessing potential impacts of channel dredging on irrigation water access, particularly in cases where lowering the bed of the channel could increase pumping requirements
- Ensuring that the Project retains access to all pumps and pipelines to ensure that they can be maintained properly in perpetuity
- Assessing the potential opportunities presented by River Islands' plans to degrade the federal project levee along the Stewart Tract banks of Paradise Cut and Old River, which if approved and implemented would result in a large high-ground bench on the waterside of new levees along those reaches
- Ensuring that robust data collection on river elevations and levee conditions is used to inform all models and designs
- Assessing the long-term fiscal impact on Reclamation District 2095, which is where most new flowage easements would need to be obtained under the current Project design

5.1.1.2 Sedimentation assessment

It is currently unknown how much additional sediment might be deposited into channels within or downstream of Paradise Cut by the new flows it would receive as a result of bypass and weir expansion. To model this effectively, better information is needed about sediment transport dynamics in the lower San Joaquin River. Ideally, a model of sediment transport in the San Joaquin River would be built and calibrated for use in projecting sediment deposition in future high-flow scenarios. If that is not feasible before engineering design of a Project must be completed, study of the sediment dynamics of past high-flow events should be conducted to identify plausible ranges of potential deposition rates under different flow scenarios for the scoping of any needed mitigation or long-term maintenance strategy to address increased sedimentation (if any) of south Delta channels.

5.1.1.3 Geotechnical analyses

In accordance with the recommendation in Anchor (2021), a geotechnical assessment of the potential impacts of channel restoration activities on adjacent levees and banks should be undertaken, including an analysis of the potential of levee soils to support equipment loads if necessary for channel restoration operations. The best available geotechnical information about South Delta levees, especially those that are not part of the state and federal flood control project (which in this situation includes all levees downstream of the Paradise Cut–Old River confluence and the Preferred Conceptual Design) is held by the local Reclamation Districts that own and maintain those levees. A survey should be conducted to gather all available geotechnical information on these levees for the purposes of characterizing any potential hydraulic impacts of the Preferred Conceptual Design under different flow scenarios. Should any critical information gaps exist, focused geotechnical investigations should be scoped and executed to address them.

5.1.1.4 Establishment of a common modeling basis with other major projects

There are multiple hydraulic models in use to analyze the potential benefits and impacts of major flood management projects in the south Delta, including at least two that have been used to analyze conditions in and near Paradise Cut. Both models are based in data produced by DWR’s CVFED program, but they generate different water surface elevations in Paradise Cut for flow events of a given return period (e.g., the 100-year flood). Though it is likely the differences are not highly consequential for flood management planning in the region, it would be desirable for these models to be reconciled so that any future Project and the nearby Mossdale Urban Flood Risk Reduction Project, in particular, are using a common modeling basis. This is especially true given that SJAFCA serves as the lead entity for both projects.

In addition, any model used for Paradise Cut analysis should be reviewed consistently and independently as projects are planned and implemented in the region, and as DWR completes its intended update of its model of the San Joaquin River system to reflect new bathymetry and topographic survey data.

5.1.2 Studies required for permit applications and environmental compliance

The following hydrology and engineering studies would need to be performed to obtain needed permits and environmental compliance documents.

5.1.2.1 Modeling of hydraulic impact of project levee alteration (for 408 permit)

Since the Project would modify federal flood management infrastructure facilities, a permit would be required under Section 14 of the Rivers and Harbors Appropriation Act of 1899, also known as a “Section 408 permit.” The Central Valley Flood Protection Board (CVFPB) would initiate the Section 408 process with the USACE after the project proponents had applied to the CVFPB for an encroachment permit.

USACE staff would evaluate the Section 408 permit application to determine (a) whether the Project would impair the usefulness of the federal flood control project in the San Joaquin Valley and (b) whether the Project would be injurious to the public interest. For the former, hydraulic modeling results would be needed to demonstrate to the USACE’s satisfaction that the stage changes produced by the Project would not impair the usefulness of the federal flood control project. For the latter, study and documentation may be required to demonstrate that the Project has neutral or positive effects upon water quality, navigation, shore erosion/accretion and recreation.

5.2 Ecosystem needed studies

The Preferred Conceptual Design contains proposals for habitat restoration within and adjacent to the Paradise Cut channel. These include putting agricultural land under easement to protect foraging habitat for Swainson’s hawk, restoring native grassland, and restoring riparian habitat within the expanded Paradise Cut channel. Additional technical analyses are needed for three purposes:

- Specification of a final restoration design in the Project that specifically addresses the habitat needs of identified target species
- Examination of the potential for restoration and/or enhancement of aquatic habitat in the South Delta
- Generation of data and documentation needed for permit applications and environmental compliance needs for a formal Project description

These are described in greater detail below.

5.2.1 Specification of a final Project

5.2.1.1 Restoration potential assessment

The Preferred Conceptual Design includes preservation of agricultural land under flowage and/or agricultural easements to protect foraging habitat for Swainson’s hawk, restoration of native grassland, and restoration of riparian habitat within the expanded Paradise Cut channel. There are additional restoration opportunities in the South Delta that could be assessed for potential inclusion in an expanded Project. Sites both adjacent to, and downstream from, the current Paradise Cut project footprint have potential to be restored as mitigation for project impacts, mitigation for the impacts of other projects in the region, or as ecosystem “uplift” beyond the requirements of mitigation agreements. The South Delta Water Agency has identified the following potential opportunities that merit further assessment:

- Hyacinth/Egeria Removal: Assess the potential to remove water hyacinth (*Eichhornia crassipes*) and curly leaf pondweed (*Egeria densa*), two invasive non-native aquatic plants that clog Delta waterways, as part of developing the Project.
- Salmon Slough Restoration: Assess the potential to re-establish Salmon Slough as a functioning waterway/habitat with a potential control structure to help improve water quality. Salmon Slough is currently choked with non-native vegetation, silt, and trash,

which adversely affect channel habitat and prevent any meaningful flow in the Slough except during times of high flow.

- 100-Acre Interior Channel Island Restoration: Assess the potential to restore an interior channel island, of approximately 100 acres, located next to the Project as a suitable location to deposit dredging spoils and restore habitat for terrestrial and aquatic species.
- Grant Line Canal Habitat Restoration: Assess opportunities to improve habitat for native terrestrial and aquatic species along the southern border of Grant Line Canal from the Tracy Road Bridge to Doughty Cut, an area which does not currently benefit from tidal flows because of non-native vegetation and accumulated silt.
- Grant Line Canal/Fabian Bell Canal Channel Islands Preservation: Assess the potential to use dredge spoils to enhance and protect the valuable habitat on the channel islands between Grant Line Canal and Fabian Bell Canal, which currently erode as a result of high flows.
- Paradise Cut Habitat Enhancement: Assess the potential to alter Paradise Cut to allow tidal and river flows to freely move through the channel (not only at times of high flow) to achieve the twin goals of improving habitat and local water quality.
- Old River/Middle River Channel Island Preservation: Assess the potential to protect and, as possible, restore habitats on various channel islands in Old River and Middle River that are currently subject to erosion during high-flow events.
- Tom Paine Slough Habitat Enhancement Project: Assess the potential to restore the upper reaches of Tom Paine Slough, which may have potential to provide habitats distinct from those along and within the main Delta channels.

To assess these opportunities and advance existing restoration concepts to actual restoration design, additional analysis should identify the extent to which the site could provide habitat for specific target species of conservation concern (as identified in the CVFPP CS) in the lower San Joaquin and/or make contributions to the fulfillment of CSMOs in the Lower San Joaquin Valley. This analysis should include consideration of existing agricultural easements in the Project area and whether they present any barriers to habitat restoration. The analysis should also assess the extent to which specific design features that enhance habitat for those species should be incorporated into the final Project. For example, if the site has potential as habitat for the riparian brush rabbit, it may be necessary to ensure that the final Project contains sufficient high-ground refugia to which the rabbits can retreat when high flows arrive.

This restoration potential assessment should include:

- Identification of documented occurrences of target species in the lower San Joaquin region, and the typical movement range of those species
- Analysis of the actual or potential connectivity of the Project site and other potential nearby restoration sites to existing patches of habitat for the species in question

- Overall assessment of the potential for re-inhabitation of the site by each target species, either voluntarily or, if relevant, through intentional human action
- For species where re-inhabitation is judged likely, identification of specific habitat design features that would enhance habitat quality for the species in question
- For additional potential aquatic and riparian restoration sites adjacent and downstream of Paradise Cut, assess restoration potential through comparative analysis of potential native vegetation and native species recruitment and self-reproduction under both existing and conceptual restoration design conditions
- Initial cost estimates for potential restoration actions

5.2.1.2 Agency consultation on potential impacts to migratory fish

As described in Section 4.2.4, focused investigations have been conducted of migratory fish survival through the South Delta, particularly with respect to the comparative fate of juvenile salmonids migrating down Old River and the mainstem San Joaquin. A new weir built as part of the Project would create another point where migratory fish could, in times of high flow, be diverted out of the mainstem San Joaquin and toward South Delta channels.

Any new weir built as part of the Project would only spill on infrequent occasions, likely on the order of one or two high-flow events per decade, at most, as a long-term average. Previous studies have indicated that survival prospects for juvenile salmonids are almost equally poor in the mainstem San Joaquin and Old River migratory pathways. For these reasons, it appears unlikely that the Project as currently contemplated would result in significant new impacts to migratory fish survival. Nonetheless, early consultation with appropriate regulatory agencies on this issue is likely advisable to ensure that any potential negative effects for migratory salmonids can be anticipated and, if possible, avoided or mitigated in project design.

5.2.1.3 Soil and sediment contamination studies

As noted in Section 4.1.3.1, Anchor (2021, p.9) identified the need for additional testing of soil and sediment samples to confirm that contaminant⁵ levels do not preclude potential placement of dredge spoils in landfills, in locations in or near water, or to increase upland elevations of dry land and marshes. This testing is likely additional to the Phase I environmental assessment (see Section 5.2.2.5).

5.2.2 Studies required for permit applications and environmental compliance

Certain surveys and studies are required to support permit applications and environmental compliance documents prepared under CEQA and NEPA. These are described briefly below.

5.2.2.1 Wetland delineation study

An aquatic resources delineation (commonly known as a “wetlands delineation”) must be performed within the Project footprint to identify and document the boundaries of potential waters of the United States. The report resulting from this effort should provide sufficient

⁵ Tests were performed for trace metals, sulfide, pesticides, polychlorinated biphenyl (PCB) congeners, polycyclic aromatic hydrocarbons (PAHs), and methyl mercury.

information to support a Preliminary Jurisdictional Determination by USACE under Section 404 of the Clean Water Act, which regulates the discharge of dredged or fill material into waters of the United States.

5.2.2.2 Biological resources study

A study of sensitive biological resources, including the potential presence of special-status species and habitats, must be performed to support CEQA/NEPA review of the Project, as well as provide information pertinent to the preparation of Biological Assessments and Incidental Take Permit applications that may be required under the federal and state Endangered Species Acts.

5.2.2.3 Cultural resources study

A study of cultural resources in the Project area must be performed and would include at least two basic components: (1) a records search in the California Historic Resources Information System and any other pertinent databases known to identify cultural resources within the Area of Potential Effect (APE) of the Project, in order to assist in the development of a description of the historic context, and (2) a pedestrian survey to identify any cultural resources present on the land surface within the APE. Depending upon the findings of these two steps, a subsurface investigation of potential cultural resources could be deemed necessary in areas in which soil excavation may occur as part of the Project. The findings of these investigations would be used to support CEQA/NEPA assessment of potential project impacts, tribal consultation requirements under California Assembly Bill 52, and compliance with Section 106 of the National Historic Preservation Act.

5.2.2.4 Air quality and greenhouse gas emissions impact study

As part of environmental compliance efforts under CEQA and NEPA, air quality and greenhouse gas (GHG) emissions impacts must be analyzed. Given the air quality challenges of the Central Valley and the potential for significant impacts from the construction of a major infrastructure project, it may be advisable to conduct an analysis of potential air quality and GHG impacts of the Project during the early design phases to identify feasible means of avoiding or reducing these impacts. This analysis should include identification of regional and local attainment status for all criteria air pollutants, identification of sensitive receptors that may be located near proposed construction sites, estimation of short-term construction-related and long-term operation-related emissions, and assessment of the adequacy of the air quality analysis as it relates to health impacts.

5.2.2.5 Phase I environmental assessment

A Phase I Environmental Site Assessment should be performed to identify potential or existing environmental contamination liabilities. The assessment should cover both the underlying land as well as the physical improvements to the properties where construction of levees would occur.

6 Potential Funding Sources

The next steps of planning for the Project are anticipated to be funded by a \$3 million grant from DWR's Systemwide Flood Risk Reduction Program to SJAFCA in the winter of 2022-23. The

following sections describe some potential additional funding sources for all stages of Paradise Cut implementation, including planning, land acquisition, dredging, construction, revegetation, and monitoring.

At the time of this writing, a significant amount of federal and state money is available for reducing flood risk and restoring floodplain habitat in the United States and in the Central Valley. Large state budget surpluses in FY 2021-22 and 2022-23, as well as the \$1.2 trillion federal Infrastructure Investment and Jobs Act (IIJA) of 2022, may make billions of dollars available for improving California’s flood management infrastructure in the coming years. However, it is difficult to anticipate with precision how much money may be available in any of the programs listed below in future fiscal years, as funding allocations are generally determined on a year-by-year basis, economic and fiscal conditions are continually changing, and the precise timing of specific project funding needs is not yet firmly established. The descriptions below are therefore meant to provide an overview of potentially relevant sources worthy of further investigation as the Project advances, and funding amounts (where indicated) are meant to provide a general sense of the magnitude of potentially available resources within a given program.

6.1 Federal funding sources

The following federal programs have potential to provide funding for Paradise Cut.

6.1.1 Federal Emergency Management Agency Building Resilient Infrastructure and Communities (BRIC)

The Federal Emergency Management Agency (FEMA) provides large-scale grant funding through the Building Resilient Infrastructure and Communities (BRIC) Program for projects that build community resilience and prevent or reduce risks from future natural disasters, including floods. A variety of eligibility criteria, including attainment of a specific benefit-cost ratio under FEMA’s benefit-cost assessment method, must be met to qualify for BRIC funding. The California Governor’s Office of Emergency Services is the agency designated to submit funding applications to BRIC on behalf of sub-applicants in California.

- *Available funding:* The IIJA appropriated \$1 billion per year over 5 years for a total of \$5 billion. At the time of this writing, individual BRIC awards are capped at a maximum of \$50 million.
- *Cost share:* FEMA’s non-federal cost share is 10 percent maximum.
- *Limitations:* SJAFCFA does not qualify for FEMA funding.

6.1.2 National Oceanic and Atmospheric Administration Transformational Habitat Restoration and Coastal Resilience Grants

This grant funding will “prioritize habitat restoration actions that rebuild productive and sustainable fisheries, contribute to the recovery and conservation of threatened and endangered

species, use natural infrastructure to reduce damage from flooding and storms, promote resilient ecosystems and communities, and yield socioeconomic benefits.”

- *Funding area:* NOAA only funds projects in coastal watershed counties – counties located along inland rivers and streams with a significant impact on coastal and ocean resources. San Joaquin County is considered a coastal watershed county.
- *What it funds:* Planning and assessments; feasibility studies; engineering design and permitting; on-the-ground implementation; pre- and/or post-implementation monitoring; or any combination of phases thereof. Proposals may also include capacity-building and stakeholder engagement to support the proposed restoration.

6.1.3 National Fish and Wildlife Foundation America the Beautiful Challenge

National Fish and Wildlife Foundation is consolidating grant funding from the private sector and multiple federal agencies (the Department of the Interior, Department of Defense, and the Department of Agriculture’s U.S. Forest Service and Natural Resources Conservation Service) to develop large-scale, locally led conservation and restoration projects, including projects that conserve and restore rivers, wetlands, and watersheds and improve ecosystem and community resilience to flooding.

- *Available funding:* \$85 million available in 2022 (year one); future years to be determined

6.1.4 FEMA STORM Revolving Loan Fund Program

FEMA’s STORM Program provides capitalization grants to states to make funding decisions and award loans directly to local communities and local governments to increase resilience and reduce risks from natural hazards and disasters such as floods.

- *Available funding:* The IJA appropriated \$100 million per year over 5 years for a total of \$500 million.
- *Eligible projects:* Zoning and land-use planning, wildland-urban interface management, conservation areas, reconnection of floodplain, and open space projects.
- *How it works:* The state contributes 10 percent of the grant into an established entity loan fund. The entity loan fund provides assistance to the local government to reduce flood risk. The local government repays the loan.

6.2 State funding

The following state programs have potential to provide funding for Paradise Cut. Several are administrated by DWR.

6.2.1 DWR Systemwide Flood Risk Reduction Program

The Systemwide Flood Risk Reduction Program oversees the work necessary to develop and implement Delta and Central Valley multi-benefit flood risk reduction and habitat restoration projects that further the goals and objectives of the CVFPP and other systemwide priorities identified by Governor Newsom or the Legislature. The State may improve the system through

direct investment in new or improved facilities for the State Plan of Flood Control or through proposal solicitations. The Systemwide Flood Risk Reduction Program is providing \$3 million to SJAFCAs to carry out the next phase of planning work for the Project.

- *Eligible projects:* Program activities may include development of feasibility studies, technical studies, preliminary and final flood system designs, construction documents and specifications, and other memorandums and reports.

6.2.2 DWR Floodplain Management, Protection, and Risk Awareness Grant Program

This is a competitive grant program that supports local agency efforts to prepare for flooding by providing financial assistance for flood risk reduction activities related to stormwater flooding, mudslides, and flash floods.

- *Status:* \$50 million was awarded in 2022; future allocations to be determined

6.2.3 DWR Urban Flood Risk Reduction Program

The Urban Flood Risk Reduction Program works to improve flood protection for urban areas (greater than 10,000 residents) associated with the State Plan of Flood Control facilities. The program partners with local flood control agencies, helps guide the development of flood risk reduction projects, and uses state funds to cost-share on design, real estate, and construction activities.

- *Status:* Future allocations to be determined

6.2.4 DWR Delta Levees Special Flood Control Projects

This program provides financial assistance for flood protection in the Delta and safeguarding public benefits, including roads, utilities, urbanized areas, water quality, recreation, navigation and fish and wildlife from flood hazards. The program mitigates the habitat impacts of each project and ensures a net long-term habitat improvement in the Delta.

- *Eligible applicants:* Local Maintaining Agencies, Reclamation Districts, and other government agencies responsible for levees in the Delta.

6.2.5 DWR Flood Corridor Program

This program provides grant funding to proponents of nonstructural flood management projects throughout the state that include wildlife habitat enhancement and/or agricultural land preservation.

- *Status:* Funding provided by Prop 84 and Prop 1E, passed in 2006.

6.2.6 California Wildlife Conservation Board Competitive Grants

The California Wildlife Conservation Board (WCB) runs a competitive grant program that has a significant amount of money to fund land acquisition, habitat restoration, and public recreational access projects across California. The WCB is authorized to acquire land on behalf of the

California Department of Fish and Wildlife and award grants for fish and wildlife habitat conservation, restoration, and for development of compatible public access facilities.

- *Available funding:* Over \$719 million as of August 25, 2022; future years to be determined.

6.2.7 California Infrastructure Plan

The California Infrastructure Plan could include money for flood control facilities, possibly including Paradise Cut, if Senate Bill (SB) 1253: Infrastructure Plan Modification (California State Senator Melissa Melendez, Riverside County) becomes law. SB 1253 is a proposed bill that would update the California Infrastructure Plan to include investments in the State Plan of Flood Control for flood control facilities in other areas of the state. The governor is required to submit a 5-year infrastructure plan each January with the proposed state budget. The plan does not currently include funding for flood control infrastructure.

6.3 Mitigation

If the Project were to create sufficiently large restoration areas of the appropriate kind and beyond that which may be needed to mitigate for the project's own impacts, it may be feasible to sell mitigation credits to outside parties in need of them. The following two programs could be of use in that endeavor. In addition, coordination with San Joaquin County's Multispecies Habitat Conservation Plan may be desirable to identify mutually beneficial opportunities for providing mitigation acreage.

6.3.1 National Fish and Wildlife Foundation Sacramento District California In-Lieu Fee Program

In-Lieu Fee (ILF) projects must be located in a designated priority service area and must provide benefits to aquatic resources. The ILF program offers permittees an in-lieu fee option to satisfy required mitigation obligations for impacts to aquatic resources (wetlands and vernal pools), as determined by regulatory agencies. The ILF program offers two types of credits for aquatic resource (wetland) and vernal pool credits.

- *Funding area:* The Program Area covers the geographic area under the jurisdiction of the USACE Sacramento District. The Program Area is divided into 17 "Aquatic Resource Service Areas" and 12 "Vernal Pool Service Areas." Paradise Cut is in the Calaveras/Stanslaus Rivers Aquatic Resource Service Area.
- *Available funding:* \$13.4 million total and \$1,206,000 as of August 2022 for the Calaveras/Stanslaus Rivers Service Area.
- *Eligible applicants:* Non-profit organizations, U.S. Federal Government agencies, state government agencies, local government agencies, Native American tribal entities, educational institutions, and private businesses.

6.3.2 US Department of Agriculture Natural Resources Conservation Service Wetland Mitigation Banking Program

The Wetland Mitigation Banking Program (WMBP) is a competitive grant program that supports the development and establishment of wetland mitigation banks to make credits available for agricultural producers.

- *Eligibility:* Local and state governments, Native American tribal government entities, special districts, institutions of higher education, nonprofits, and for-profit organizations.
- *What it funds:* Awardees may use WMBP funding to support mitigation bank site identification, development of a mitigation banking instrument, site restoration, land surveys, permitting and title searches, and market research. WMBP funding cannot be used to purchase land or a conservation easement.
- *Available funding:* USDA awarded \$5 million to the WMBP.

6.4 Other potential funding structures

Innovative funding structures such as those described below may also be of use to the Project.

6.4.1 Pay for Performance

The Pay for Performance model was developed and used by Ecosystem Investment Partners (EIP) to leverage private capital to restore Lookout Slough in Solano County, California, before getting reimbursed by DWR. DWR contracted EIP to restore Lookout Slough to provide habitat for the Delta smelt and create 40,000 acre-feet of flood storage by expanding flood conveyance capacity on the Yolo Bypass as mitigation for the operation of the State Water Project. There may be a similar opportunity for Paradise Cut.

6.4.2 Carbon Sequestration

There may be an opportunity to restore Paradise Cut based on the environmental asset provided by restoration of habitat or creation of a flood bypass. For example, the soil in the expanded bypass lands at Paradise Cut may sequester carbon and be eligible for carbon credits, which can be bought and sold. The Earth Partners is one company that identifies revenue and investment opportunities, including carbon credits, for large-scale restoration projects.

6.4.3 Environmental Impact Bonds

There may be an opportunity for the flood risk reduction benefits at Paradise Cut to attract private investors to invest in the financial benefits of reducing flood risk for downstream residents. For example, Blue Forest Conservation raised \$4 million from private foundations and insurance companies for a Forest Resilience Bond to restore 15,000 acres of the North Yuba River Watershed. The bond was repaid by agencies benefiting from the restored watershed including the Yuba Water Agency, Cal Fire and the US Forest Service and investors received 2.5% in interest on the bond.

7 Conclusions

This report is intended to summarize relevant information on the existing technical studies that have been performed on and near Paradise Cut, as well identify needed studies that have not yet been performed and potential funding sources. These include additional studies that are needed to further specify the engineering, hydraulic, and restoration components of the Project, along with studies that will be needed to obtain necessary permits.

A key next step will be a feasibility study that can systematically assess the likely performance of potential Project alternatives under both existing and anticipated future conditions, including the new estimations of potential future flood flows on the lower San Joaquin River produced by DWR in the 2022 CVFPP. Specification of a preferred alternative will enable additional fundraising from state and federal sources, development of engineering and restoration designs, and, once those designs have reached a sufficient level of refinement, commencement of the CEQA process and other permitting efforts.

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