10% DESIGN REPORT
Sack Dam Fish Passage and Arroyo Canal Fish Screen

San Joaquin River Restoration Program, California
California Great Basin Region

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prepared by

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Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms

ADCP	Acoustic Doppler Current Profiler
CCID	Central California Irrigation District
cfs	Cubic feet per second
CDFW	California Department of Fish and Wildlife
CMP	Comprehensive
D_{50}	The median diameter of the particle size distribution
D&S	Reclamation Directives and Standards
DWR	California Department of Water Resources
FAC	Project Planning and Facility Operations
fps	Feet per second
FWUA	Friant Water Users Authority
HMRD	Henry Miller Reclamation District
LiDAR	Light Detection and Ranging
MSL	Mean Sea Level
NAVD	North American Vertical Datum
NGS	National Geodetic Survey
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
PIT	Passive Integrated Transponder
RM	Reclamation Manual
SJRRP	San Joaquin River Restoration Program
TSC	Technical Service Center
USFWS	United States Fish and Wildlife Service
WSE	Water Surface Elevation

Executive Summary

In order to provide both fish passage at the Sack Dam site and fish screening for the Arroyo Canal, thirteen alternatives (seven passage and six screen alternatives) were taken to a 10% design level. These include options suggested by the San Joaquin River Restoration Program (SJRRP), Henry Miller Reclamation District (HMRD), South-Central California Area Office, and those developed by Reclamation – Technical Services Center (TSC).

The fish passage options consist of passage around the east side of the dam, using either a roughened channel or a rock weir type fishway. Five of the alternatives stay within the existing levees while the remaining two options require relocation of the levees.

For the fish screen, five of the options are in-river consisting of perforated vertical flat plates, double cylindrical screens, and river invert cone screens. The sixth alternative is a V-screen designed by Jacobs Engineering located within the entrance of Arroyo Canal.

The preferred fish passage alternatives for the TSC are Alternative 5 and Alternative 7. These both contain a rock weir fishway with an upstream headworks structure. The only difference between the two is the cofferdam and foundation preparation for the headworks. Alternatives 5 and 7 are the options that require the least cost, lowest environmental impact, and fully meet the project goals.

The preferred fish screen alternatives for the TSC are Alternative 1 and Alternative 4. Both alternatives are in-river fish screens. Alternative 1 is a flat plate screen option and Alternative 4 is a cylindrical fish screen option. These alternatives meet project goals and are fish compliant.

10% Design Discussion

10% Design Versus Appraisal Study

Reclamation has a design process that starts at an appraisal study and ends at 100% design. The activities from appraisal to feasibility are referred to as pre-design activities. The activities after feasibility are referred to as the design activities and are assigned a percentage. Appendix C-1: USBR Final Design Process contains a flowchart that shows the Reclamation design process.

Many other stakeholders refer to the designs in a different way. The start of design work begins at 0% and ends at 100%. There is no work before 0%. Appraisal studies are often referred to as 10% designs. Feasibility studies are often referred to as 30% designs.

Because of the numerous stakeholders, for this report the terms "10% Design" and "Appraisal" will have the same meaning.

General 10% Design Information

As was described previously, Reclamation would refer to this effort as an Appraisal Study. The Reclamation directives and standard CMP 09-01 describe the requirements of an Appraisal Study. Portions of the standard are shown below.

Appraisal studies are used to determine the nature of water and related resource problems and needs, formulate and assess preliminary alternatives to address the problems, establish whether there is a Reclamation interest in working with partners to pursue a solution, and identify potential project beneficiaries. If a Reclamation interest exists and one or more viable alternatives are identified, then a completed appraisal report may recommend a feasibility study of a new Reclamation project or modification of an existing project.

Appraisal studies primarily use existing data and information but may involve collecting new information when necessary.

Appraisal-level designs and layouts of major features will be developed to evaluate and compare alternatives, support preparation of cost estimates, and determine technical viability of an alternative. Appraisal-level designs will also be used to define problems and uncertainties to be investigated during the feasibility design phase. The level of effort of design data collection will be limited to the minimum level of data necessary to support an appraisal level design and cost estimate. Data collected for appraisal studies are not typically of sufficient detail to support feasibility-level designs. An appraisal design report will present the essential features of the structural alternatives that were analyzed. The appraisal design report will include appraisal design figures to depict general facility layouts. The appraisal design report will be included as part of the appraisal report.

Level of Information

An Appraisal Study utilizes existing data to the greatest extent possible.

This report used the following sources for design data:

- 2016 LiDAR topographic survey
- Sack Dam drawings provided by HMRD
- Restoration hydrographs provided by SJRRP
- Subsidence surveys provided by SJRRP
- Fish Passage requirements provided by the SJRRP
- Meetings with Reclamation – SJRRP staff
- Meetings with SJRRP federal and state implementing agencies
- Meetings with Reclamation and attended by HMRD
- NMFS Fish Screening Criteria for Anadromous Salmonids
- Jacobs Engineering 30% V-Screen Design
- 10% Design Report, Sack Dam Fish Passage
- Comments provided on Fish Passage Design by HMRD, NMFS, USFWS, CDFW and SJRRP

Alternatives

Alternatives were generated for the site that included options recommended by Reclamation - SJRRP, HMRD, and developed by Reclamation – TSC. The goal was to analyze a wide range of alternatives. Then these would be compared to show how well the alternatives meet the project goals. Metrics used to define project goals include costs, effectiveness, complexity, overall alternative benefits, and alternative disadvantages.

Options for fish passage include roughened channels and chevron weir fishways. Different slopes and layouts were analyzed. A total of 7 alternatives were generated. Detailed descriptions of each of the alternatives are provided later in this document.

Fish screen options analyzed include flat plate, cylindrical, and conical screens located either in-river or in-canal. A total of 6 alternatives were generated. Detailed descriptions of each of the alternatives are provided later in this document.

Background

San Joaquin River Restoration Program

Purpose

The SJRRP is a comprehensive, long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts from Restoration Flows.

The San Joaquin River Restoration Program is the direct result of the San Joaquin River Restoration Settlement reached in September 2006 by the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council (NRDC), and the Friant Water Users Authority (FWUA). The Settlement, which followed an 18-year lawsuit, received Federal court approval in October 2006.

Federal legislation, the San Joaquin River Restoration Settlement Act, was passed in March 2009 authorizing Federal agencies to implement the Settlement. Directed by Public Law 111-11, the Settlement requires modifications at Sack Dam and the Arroyo Canal, Paragraph 11a6 and 11a7.

The Settlement is based on two goals:

> Restoration: To restore and maintain fish populations in "good condition" in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.
>
> Water Management: To reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

Sack Dam

Location

Sack Dam is located on the San Joaquin River, approximately 18 miles south-east of Los Banos, California. It can only be accessed through private land.

Purpose

Water is impounded behind Sack Dam and diverted into the Arroyo Canal by the HMRD. Water that is not diverted passes through Sack Dam using its sluice gates and will overtop under some conditions. In normal conditions, the only flow in the San Joaquin River below Sack Dam is the SJRRP instream flow dedication.

Original Dam

The original Sack Dam was a small structure of piled sacks in the river. Over time and due to subsidence, the structure was raised in order to impound more water. The structure includes concrete piers with flashboard slots that are used to maintain a set pool elevation for the Arroyo Canal diversion. The flashboards could be installed to a maximum height of 9 feet to account for changing site and flow conditions. The canal diversion is year-round and can vary from 100 cubic feet per second (cfs) to over 600 cfs.

Sack Dam Improvements

Early in SJRRP implementation, to facilitate the release of Restoration Flows downstream of Sack Dam, the SJRRP paid to install Hydra – LOPAC gates in the four westernmost bays of Sack Dam. Prior to this installation, HMRD would remove flashboards to release water downstream, typically only in flood flow conditions. The river downstream of Sack Dam was otherwise dry.

Since the construction of Sack Dam, there has been regional ground subsidence at both the Sack Dam site, and to a lesser degree, the lands served by the Arroyo Canal. This has required a deeper impoundment at Sack Dam to maintain the delivery water surface elevation (WSE). Using the original dam, it was becoming more difficult to maintain these deliveries.

In 2018 HMRD modified the existing Sack Dam by adding in taller flashboard guides that raised the impoundment potential another three feet.

Sheetpiles were also placed around the sides of the dam. This protects the dam structural abutments.

Flood Operations at Dam

When the flowrate rises above 1500 cfs, the irrigation district will begin removing the flashboards and remove the Hydra-LOPAC gates. This prevents damage to those components, as well as reducing the upstream pool level.

When the flowrate lowers to below 1500 cfs the features removed previously are replaced.

Figure 1 - Flood flow, approximately 3500 cfs. Flashboards and gates have been removed. Notice flood flow outflanking the structure to the left of the dam.

Project Stakeholders

There are various federal, state and private parties that are listed as stakeholders. A stakeholder register is provided in Appendix C-3: Stakeholder Register.

Arroyo Canal

Location

Arroyo Canal is located just upstream of Sack Dam on river left of the San Joaquin River about 18 miles south-east of Los Banos, California. The canal conveys water from the river to the west intersecting its first lateral, the Temple-Santa Rita Canal, approximately three miles from the river.

Purpose

Henry Miller Reclamation District owns and operates Arroyo Canal. Sack Dam and the canal are the main point of diversion for HMRD. Arroyo Canal supplies agricultural supply water to nearly 47,000 acres of productive lands as well as water supply to Federal and State wildlife refuges. The Arroyo Canal begins on the west side of the river, and continues approximately 20 miles to the northwest, where it becomes part of the Santa Fe Canal, near the town of Los Banos.

Original Canal

The Arroyo Canal was historically a natural waterway called Temple Slough. At some point, the channel was dredged and straightened to become the Arroyo Canal.

Figure 2 – Poso Canal (foreground) crossing the Arroyo Canal (background)

Operation

Flow through the Arroyo Canal is controlled by 3 radial gates at the headworks structure. The radial gates are 10 ft by 6 ft with as-builts dating 1984. Just downstream of the headworks is an ADCP (acoustic doppler current profiler) that HMRD uses to measure the flow of water in the canal. The canal diversion is year-round and can vary from 100 cfs to over 600 cfs. The maximum allowable flowrate for the canal is 700 cfs.

Poso Canal

The Poso Canal is located on the west side of the river and passes over the Arroyo Canal by a flume structure. The Poso Canal originates as a diversion off Main Canal in the town of Firebaugh, which is located upstream of the project area, and continues at least 15 miles downstream. A new access bridge across Poso Canal will be needed for construction of the fish screen and overall access following installation. For more details on the

Figure 3 – Poso Canal looking north, adjacent to San Joaquin River and Sack Dam

Subsidence

Measured and Predicted Subsidence

As part of the regional subsidence monitoring, Reclamation has collected data at the site. Data from surveys at PT 121 (NGS Monument 375 U.S.E.D) are shown in Figure 4. The California Great Basin Region began semi-annual subsidence surveys in December 2011, data prior to this is not available.

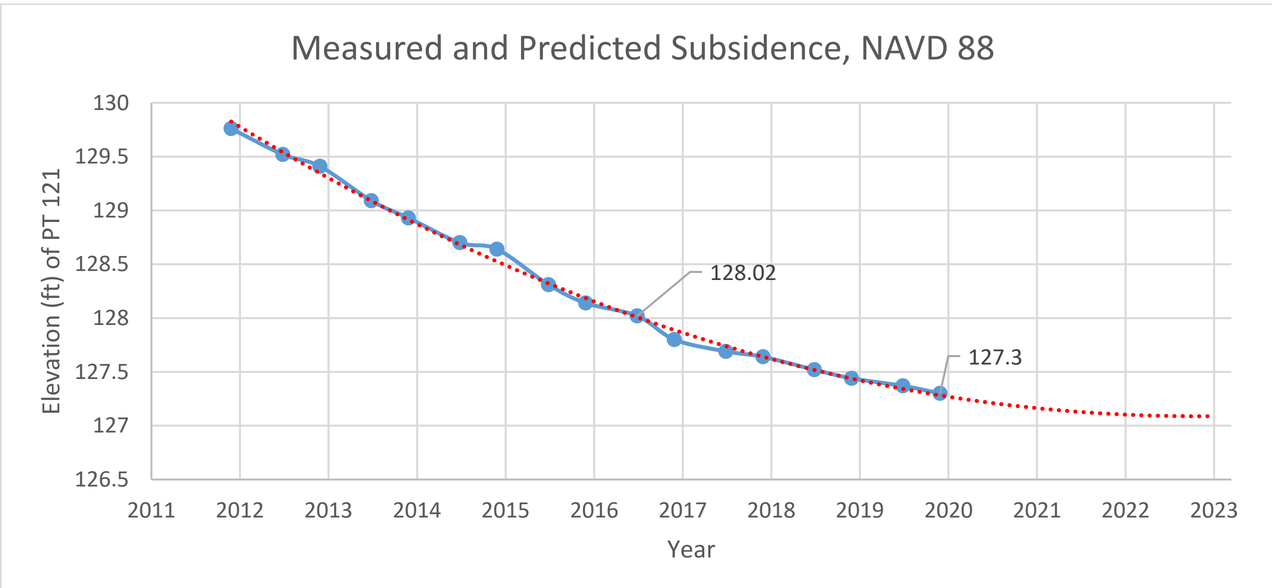

Figure 4– Subsidence near Sack Dam

The predicted subsidence at the site from the date of the lidar (2016) survey to 2023 (approximate midpoint of construction) is approximately one foot.

10% Design Subsidence

The "design subsidence" will be the elevation difference between PT 121 on the "site survey" and a future assumed elevation at the same point. The "design subsidence" will be determined by Reclamation before the 30% design.

The 10% Design drawings and estimates for the fish passage alternatives were performed using a more preliminary subsidence assumption of 2 feet.

The 10% Design drawings and estimates for the fish screen alternatives were performed using no assumed subsidence. A note on each sheet acknowledges the data source and the year the data was taken.

Maximum Site Subsidence

The fishway and screen design will consider future subsidence rates at the site. This will ensure that the facility not only functions at day one, but also up to a "maximum design subsidence".

This is currently understood as when the diverted water surface is 3 feet below the top of the levees. The constant water surface elevation is 121.3 meaning that this condition would exist when the top of the levees have subsided to elevation 124.3. Current survey data needs to be collected to accurately show the elevation of the levees. PT 121 which is on the Poso Canal flume was measured at El. 127.3 in December of 2019.

When the "maximum design subsidence" has been achieved, the number of installed flashboards on Sack Dam (to achieve the maximum water surface of 121.3) cannot be increased. If subsidence past the "maximum design subsidence" occurs, then the operational water surface elevation behind Sack Dam will decrease; additional height cannot be added to the installed flashboards or the water surface will encroach into the freeboard of the levees.

The maximum design subsidence has not been determined, because additional survey data is needed to accurately determine its value.

Estimating Conditions at Time of Award

Using the Reclamation vertical datum tied to the North American vertical datum (NAVD) will mean the elevations are likely to change between the time of the survey and the time of the fishway construction.

There are two ways that TSC could proceed.

The first is to leave all elevations on the design drawings and specifications unchanged after the site survey is complete. Then prior to construction, the actual elevation at PT 121 will be surveyed, and the change in vertical elevation noted. The design drawings could all be modified, or just noted that the vertical offset will be provided to the contractor prior to construction.

The second is to assume an elevation based on the rate of subsidence, and the time to construction. This will be noted as an assumed elevation on the drawings and specifications. Like the condition above, a vertical elevation conversion would be provided to the contractor prior to construction.

The TSC will be using the second method unless objections are noted. This will provide a more accurate measure of the actual ground elevations at the time of award.

Elevation Datums

Vertical Datum

This area is unique in that elevations are changing. Most sites have constant elevations, and reference datums that are consistently the same. All local survey points and local datums are lowering over time relative to a fixed area datum such as mean sea level (MSL) or NAVD.

HMRD Local Datum

There are different ways to describe the changing elevations. The approach used by Jacobs Engineering and HMRD is to use a local datum for reference. As long as the vicinity of the dam is all lowering at the same rate, the site is easily described without tie-in to regional datums. A figure describing the Sack Dam local datum is shown in Figure 5.

There is a survey marker on the bridge above where the Poso Canal crosses over the Arroyo Canal. This is designated as PT 121 and for their analysis it is considered a constant elevation of 132.25 feet based on the Central California Irrigation District (CCID) Datum. This elevation was surveyed around 2009 and has been assumed as a constant elevation ever since.

From Figure 4, it can be seen that from 2012 to 2020, there has been approximately 2.4 feet of subsidence at the site.

Confusion arises when describing the water surface elevation. If the site is considered to be at a constant elevation, but additional flashboards are required to check the water surface, then the water surface elevation needs to be portrayed as rising.

This simplified approach could be interpreted as stating the diversion water surface elevation would increase over time. This may be true when only comparing to a local datum, however, is incorrect in comparing to a regionally accepted datum such as NAVD. The water surface elevation as measured against a datum such as NAVD would show it being constant. Therefore, Reclamation is choosing not to use the Sack Dam local datum for their analysis.

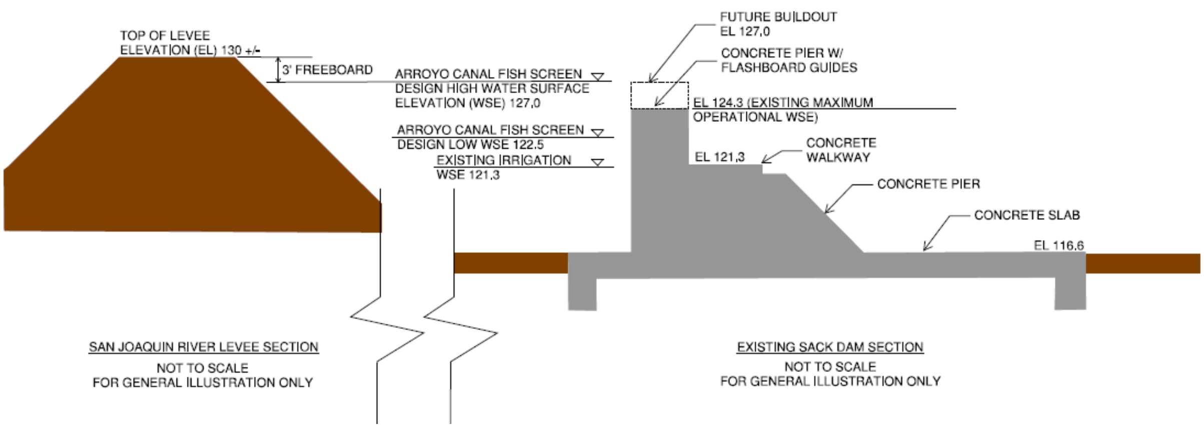

Figure 5 – Elevations in the Sack Dam local datum, source Jacobs Engineering

Reclamation's Use of NAVD

As the SJRRP covers a large area, it does not rely on a local datum. Reclamation is using a datum that is tied into the NAVD. Reclamation periodically measures several points in and around the SJRRP, including PT 121. Around the same time as a reading, several other features at Sack Dam and the fishway site will be surveyed as well as part of the "site survey". This will establish the relative heights of the facilities in relation to PT 121. The date of the surveys will be recorded. Future surveys are likely to show PT 121 lowering or remaining constant. However, the water surface required at Sack Dam for deliveries will be a constant elevation tied to NAVD that is independent of site subsidence, until the maximum design subsidence has been reached.

As can be seen in Figure 6, defining elevations of structures is more difficult using the NAVD. All the elevations marked as "VARIES" will be surveyed in before the 30% design. That will allow for interim elevations to be determined for use in the design process.

The conversion between the CCID datum and the NAVD datum is unknown at this time. In Figure 6, the water surface elevation shown assumes the NAVD elevation is the same as the CCID elevation.

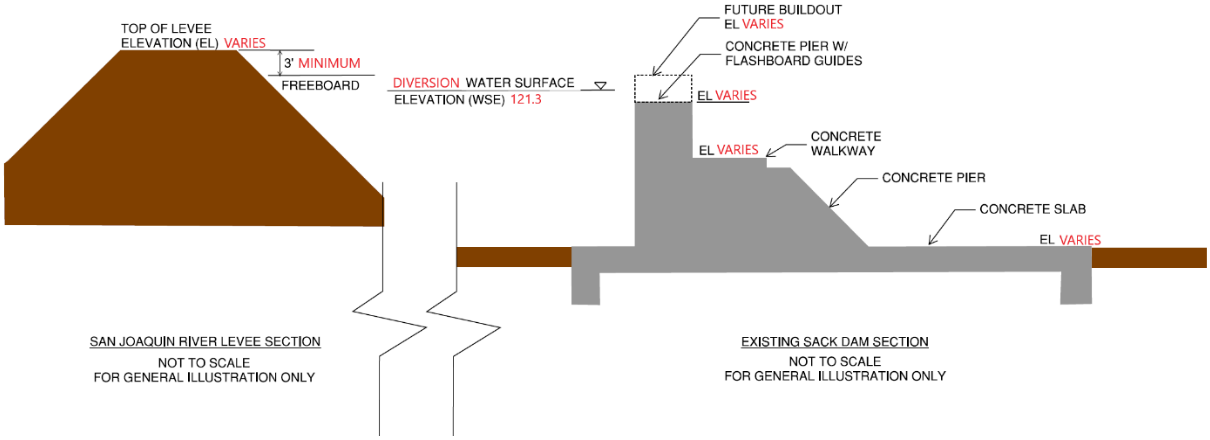

Figure 6 – Elevations in the NAVD, modified figure from Jacobs Engineering (changes in red text)

Diverted Water Surface Elevation

HMRD operates Sack Dam to maintain an elevation of 121.3 ft as measured in the CCID Datum. As the local area subsides, the diversion elevation based on this datum remains the same. Taking headloss through the system into consideration, the design water surface elevation of 122.5 ft (CCID datum) will be used until the losses through the fish screen are determined. A conversion value of -2.15 ft provided by Jacobs and HMRD yields a Reclamation NAVD design water surface elevation of 120.35 ft.

Aquatic Growth at Site

Historically, there has been minimal aquatic growth in the Sack Dam impoundment. Fairly recently, a significant mat of growth has developed at the Dam. Figures 7 and 8 show the conditions during a site visit in October 2020.

Figure 7 – Aquatic growth at the entrance to Arroyo canal

Figure 8 – Aquatic growth upstream of Sack Dam

While the growth causes minimal impact currently during operation, it has the potential to entrain the growth in the fishway where it may be more difficult to remove.

All the fish passage alternatives contain a headworks with a trashrack, and automated raking system. This would be effective in removing growth in the immediate vicinity of the trashrack but would do little to reduce the overall aggradation of vegetation in the impoundment.

To protect the fish screen for Arroyo Canal, a log boom will be installed to prevent vegetation and debris from impacting the screens. The log boom will be installed to divert vegetation and debris to one side of the San Joaquin River upstream of the fish screen and Sack Dam. Refer to the Fish Screen Alternatives Descriptions section for details on the upstream protection.

Recent studies in the San Joaquin estuary have shown that increased aquatic growth can lead to increased juvenile predation[1]. As the designs continue past 10%, the larger team needs to evaluate what measures, if any, need to be undertaken to control the aquatic growth.

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[1] https://fishbio.com/field-notes/the-fish-report/weeds-invasive-aquatic-plants-can-increase-juvenile-salmon-predation-risk

Cost Estimating

Origin and Source of the Cost Estimate

These cost estimates were prepared by Reclamation's Technical Service Center Estimating Services Group (Denver, Colorado). The estimates are in accordance with RM Policy, Cost Estimating (FAC P09), and D&Ss Cost Estimating (FAC 09-01), Construction Cost Estimates and Project Cost Estimates (FAC 09-02), and Representation and Referencing of Cost Estimates in Bureau of Reclamation Documents Used for Planning, Design and Construction (FAC 09-03).

Purpose and Intended Use of the Cost Estimates

It has been determined by the design team that this 10% Design effort is the equivalent of Reclamation's Appraisal study (see 10% Design Discussion section in this document). Therefore, the cost estimates as presented within this report correspond most closely with an Appraisal-level cost estimate. The associated cost estimates are based on information available and the level of completeness of the design, and are a measurement of the designs, itemization, and quantification at this stage of maturity. Refer to the Reclamation Manual Policy and Directives and Standards – FAC 09-01 which describe the typical sequence of development of cost estimates for various project stages. Cost estimate levels are generally assigned based on the degree of detail, refinement, use, and confidence, and are dependent upon the amount of certainty contained in the available engineering and geological data, and other factors (e.g., environmental considerations, land acquisitions costs, and procurements methods) known at the time of preparation of the cost estimates.

Due to the early project stage and limited design data, the 10% Design concepts and the associated Appraisal cost estimates are typically not at a maturity to determine and establish project budgets. In accordance with FAC 09-01, Appraisal cost estimates are intended to be used as an aid in selecting the most economical plan by comparing alternatives. Additionally, the Appraisal-level cost estimates may be used for evaluating whether more detailed studies and/or investigations of potential project alternatives are economically justified. Appraisal cost estimates are not suitable for requesting project authorization or construction fund appropriations from Congress. Reclamation has provided the cost estimates as a resource for use in discussions among interested parties that are evaluating this specific project. Presentation of these estimates does not in and of itself imply Reclamation's support for moving forward with any specific alternative. When appropriate, Reclamation specifically will articulate support for further action through other means, such as a report containing recommendations.

Appraisal Cost Estimates – Basic Scope

For each of the thirteen alternatives (seven passage and six screen alternatives), Appraisal-level field cost estimates were prepared. Summaries of the estimates are presented within tables in each of the Alternative sections, and details of quantity and cost estimates are presented on Estimate Worksheets included in Appendices 1 through 13. Field costs are a measurement of the capital costs of a feature or project from award to construction closeout. Field costs include allowances for mobilization, design contingencies, procurement strategies, and construction contingencies as described in more detail in the following sections.

It is important to note that field costs do not include non-contract costs. Non-contract costs refer to the cost of work or services in support of the project such as (but not all inclusive):

- Environmental mitigation and restoration.
- Cultural resources preservation.
- Services facilities: camps, construction roads, utility systems, temporary plants used for construction, etc.
- Planning (Investigations): studies and surveys (collection, assembly, analysis of data and preparation and review of reports such as environmental impact studies, cultural resources studies, mitigation studies, etc.).
- Engineering and other costs: designs and specifications, construction engineering and management, other costs such as general office salaries, supplies and expenses, general transportation expenses, security, environmental oversight, legal services, etc.

Typical non-contract costs can range from 20 to 50 percent of the field cost. As referenced on the Estimate Worksheet summary sheets that are included within the appendices, non-contract costs shall be determined by the appropriate responsible office.

Basis of Cost Estimate

The field cost estimates presented within this report were developed from 10% Design concepts and approximate quantities based on data available at the time of this study. The estimated unit prices include costs associated with job management and expenses, submittal requirements, prime contractor and sub-contractor overheads, performance bonds, and prime contractor and sub-contractor profits. The unit prices captured in these field cost estimates are based on historical bid information, select detailed estimating for items unique to this project, and industry standard cost estimate reference data. Manufacturer's or supplier's budgetary quotes were obtained on the following significant cost drivers: fish screens, ready-mix concrete, commercially sourced aggregates/backfill, the automated trash raking system, and the prefabricated metal bridges.

Price Level

All costs noted in the field cost estimates for the fish passage alternatives represent July 2020 dollars. The field cost estimates for the fish screen alternatives represent January 2021 dollars. Cost estimates do include an escalation to Notice to Proceed of July 2022.

Mobilization

A value of 5 +/- percent was assumed for mobilization. Mobilization costs include contractor bonds and mobilizing contractor personnel and equipment to and from the project site, including initial project startup. The 5 +/- percent value assumed in these cost estimates is based upon experience with similar projects.

Escalation

There are two distinct periods of time that must be considered when evaluating the need for escalation: (1) the time period from preparation of the field cost estimate until notice to proceed (NTP), and (2) the time period during the execution of the construction contract. It is assumed the construction of this project will not begin until the middle of 2022; therefore, an allowance of 3 +/- percent escalation per year from the current Price Level to NTP has been included in these field cost estimates. Typically, escalation during construction is calculated from NTP to the mid-point of construction and is included in the unit prices. However, due to the relatively short period of construction, these Appraisal level estimates do not include for escalation during execution of the construction contract.

Design Contingency

A value of 20 +/- percent was assumed for design contingencies based upon the Appraisal level and completeness of the listed items of work. Design contingencies are intended to account for three types of uncertainties inherent as a project advances from the planning stage through final design which may affect the estimated cost of the project. These include: (i) minor unlisted items, (ii) minor design and scope changes, and (iii) minor cost estimating refinements. The design contingencies are included in a line item under Contract Cost Allowances on the summary sheet of the Estimate Worksheets.

Allowance for Procurement Strategies

The Allowance for Procurement Strategies (APS) was estimated at 5 +/- percent. A line item for Contract Cost Allowances includes APS along with the design contingency discussed in the section above. APS is intended to anticipate additional costs when solicitations will be advertised and awarded under other than full and open competition. These may include solicitations that will be set aside under mandated socio-economic programs, as well as those solicitations that may limit competition or allow award to other than the lowest bid or proposal. A Request for Proposal procurement was assumed for these field cost estimates.

Construction Contingency

A value of 25 +/- percent was assumed for construction contingencies, based upon the completeness and reliability of the engineering design data, geological information, estimated items and quantities, and the general knowledge (or lack thereof) of the conditions at the site.

Appraisal cost estimates include a percentage allowance for construction contingencies as an allowance to cover minor differences in actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties. The allowance is based on engineering judgment of the major pay items in the estimate, reliability of the data, adequacy of the projected quantities, and general knowledge of site conditions.

Fish Screening for the Arroyo Canal

Screening Goals

As part of the SJRRP, fish protection and screening measures will be implemented at Arroyo Canal. The fish screen will meet fisheries design criteria and prevent fish from entering the canal. The goal of the fish screen is to prevent entrainment of anadromous fish while maintaining full operations of the Arroyo Canal. Reclamation has developed five preliminary fish screening alternatives and included a sixth alternative developed by Jacobs Engineering for comparison.

Fish Screen Design Criteria

The following are based on discussion with SJRRP, National Marine Fisheries (NMFS), California Department of Water Resources (DWR) and the United States Fish and Wildlife Service (USFWS). Screen out-migrating fish from entering Arroyo Canal and prevent areas of entrapment

- Maintain delivery flows into the canal while minimizing headloss
- For in-river screens: 0.33 fps maximum approach velocity, 0.66 fps minimum sweeping velocity
- For in-canal screens: 0.40 fps maximum approach velocity, 0.80 fps minimum sweeping velocity
- The maximum flowrate for the fish screens is 700 cfs
- 1.75 mm screen opening size

Flow Gauge Downstream of Arroyo Canal screen

The existing HMRD ADCP gauge below the headworks will be used to measure flow through the screens.

Fish Screen Alternative Descriptions

Fish Screen Common Components

Within the fish screen design, there are (3) types of fish screens that are considered in the six alternatives, each posing unique advantages and challenges. In addition to the screens, the alternatives contain many similar features such as fish passage facilities, log boom or trashrack, a new bridge over Poso Canal, a maintenance building, a control building, and turnaround area. See Appendix A for design drawings.

Fish Passage and Headworks Structure

Each alternative will function jointly with a fishway allowing passage around Sack Dam. The fish passage consists of a flow controlling headworks structure, and either a roughened channel, or boulder weir fishway.

The headworks will be a concrete structure located upstream of Sack Dam on the right bank. It will have slide gates, radial gates, stoplogs, or some combination of those.

The fish passage will either incorporate a roughened channel or a boulder weir fishway to allow fish migration upstream of Sack Dam. A roughened channel is a shallow sloped open channel that's primarily lined with rocks while a boulder weir fishway consists of a steeper sloped open channel that utilizes an array of chevron weirs.

Sheet Piling

Permanent sheet piling will be utilized to limit the fish screen design footprint on the surrounding embankment. This will preserve existing structures within close proximity and minimize earthwork. The sheet piles will act as a retaining wall for the existing embankment while the river side will be graded to facilitate proper screen hydraulics.

A sheet pile cofferdam will be used for the construction of the fish screen structure. The sequencing of sheet piles will be designed to ensure that HMRD receives its allocated flowrate during construction.

Upstream Protection

For the 10% design, a log boom will be placed upstream of the fish screen to protect the structure from debris and vegetation. The log boom will be placed diagonally across the San Joaquin River, diverting debris and vegetation to the east bank of the river, upstream of the fish passage headworks. Debris will be collected and disposed of accordingly on a routine basis. A 330-ft long log boom was incorporated into alternatives 1-5.

Trashrack Structure

A trashrack structure is unique to Alternative 6. This structure would be located at the entrance to Arroyo Canal. The trashrack will allow for vehicular access across the Arroyo Canal and includes an automatic raking system, trash rack, and bulkhead gates.

Before the 30% milestone, Reclamation will discuss whether a log boom or a trash rack is most appropriate for the fish screen design.

Poso Canal Access Bridge

An access bridge over Poso Canal will allow access to the fish screen, maintenance building, and any upstream structure protection such a log boom or trash rack. The bridge will be permanent and would eliminate the need to access the fish screen via the existing access bridges.

The new access bridge over Poso Canal would need to accommodate typical heavy construction traffic as well as regular O&M traffic.

For an estimate, a 16 ft wide bridge was assumed, with a 75.0 ft span. Access to the bridge would be via Valeria Avenue. A security gate will be placed between Valeria Avenue and the bridge to control access and prevent the public from entering the site and accessing the fish screen.

Alternative 6 would require the construction of two bridges. One as mentioned above across Poso Canal on the south side of the Arroyo Canal, and the second bridge would be across Poso Canal to access the north side of the Arroyo Canal. This bridge would allow access to the north side fish screen for Alternative 6.

Maintenance Area and Turnaround Access Road

A maintenance and turnaround area will be provided access to the fish screen, storage for equipment, and protection of the structure.

A maintenance area directly south of the fish screen structure on the west bank of the San Joaquin River would house a small minimally powered building used for storing equipment. This maintenance building will be a pre-fabricated metal structure. The area will include a gravel access road, parking area, and vehicle turnaround. Surrounding the maintenance area will be a security fence to deter the public from entering the site and accessing the fish screen structure.

Control Building

The fish screens will require a small control building closer to the screens. The control building will house the electrical controls and instrumentation for the fish screens.

Subsidence Buffer

The screens themselves should not be negatively impacted by the greater depth of the pool in front of Sack Dam, but access to the screens may be impacted by subsidence. To accommodate subsidence at the site, a flat panel above the screens and their respective support structures could be constructed taller than normal to allow access for maintenance and future operations. Alternative 6 uses screens that are taller to handle subsidence.

Fish Screen Alternative 1

Brief Description

Alternative 1 uses perforated vertical stainless steel plates for fish screening located at the entrance of the Arroyo Canal. See Appendix A-1.

Fish Screen

The fish screen is comprised of (4) groups of seven individual wedge wire bar, 1.75 mm opening stainless steel screens. Each screen is 7.4 ft high and 10 ft wide. The screens are secured to steel supports spaced 10 ft apart, comprised of w-sections, welded angles, and a 4.5 ft wide metal grating for operation and maintenance access. A mechanical cleaning system is attached to a small cantilevered w-section at the top of each steel support. The cleaning brushes are housed at the end of the overall screen and the middle in a “parked” condition. Louvers or baffle plates installed immediately behind the wedge wire panels to allow for flow velocity tuning of the structure. This alternative allows for maintenance of a single bay without significant loss in capacity.

The fish screen and steel supports are anchored to a concrete base that spans approximately 330 ft in length, 10 ft in width, and is 1 ft thick. The concrete base includes a 3 ft deep shear key to prevent sliding and increase stability. The sides of the fish screen structure are connected to the existing grade through concrete retaining wall abutments. There will be a metal walkway at the top of the fish screen structure for access across the structure.

The fish screen structure foundation concept consists of driven steel H-piles beneath the concrete slab, which are driven through potentially liquefiable soils in the subgrade and into underlying dense/stiff soil layers at depth in the subsurface. Based on preliminary analysis of historic geotechnical data from project subsurface investigations by others, there is a high likelihood of liquefaction in response to the 2,500-year return period ground motions at the site. The deep foundation transfers loads to a non-liquefiable layer to avoid excessive settlement of the structure in case of seismic loading and liquefaction in the subgrade.

Fish Passage and Headworks Structure

The fish passage consists of a roughened fishway or boulder weir channel as described in the "Fish Screen Common Components" section above. A concrete headworks structure controls the flow through the fish passage and is also described in the above section.

Sheet Piling

Sheet piling will be utilized on both sides of the Arroyo Canal entrance. On the north side of the Arroyo Canal entrance, sheet piling totaling approximately 140 ft will be used to provide a consistent depth behind the fish screen at the canal entrance. On the south side, sheet piling totaling approximately 330 ft will be utilized to provide a 15 ft wide channel behind the fish screen while minimizing disturbance to the surrounding grade and existing structures. Construction sequencing will be performed to maintain the historic HMRD flowrate allocation.

Temporary sheet pile wall cells around the fish screen are assumed for cofferdams and excavation support as part of Alternative 1. The sheet pile cofferdam cells are constructed in sequence, around the perimeter of approximately half of the structure footprint at a time, allowing isolation of half of the canal channel for structure construction while maintaining flows through the other half of the channel. The temporary sheet pile cofferdam concept consists of cantilevered sheet piles, embedded into a clay layer in the subsurface, to a depth of twice the cantilevered height, to cut off seepage into the excavation and provide passive resistance. The sheet piles are assumed to be cut down to the finished grade following construction, providing added benefits of grade control and a barrier to seepage beneath the structure.

Cost Estimate

Escalated field costs for fish screen Alternative 1 are summarized in Table 1 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-1.

Table 1. Breakdown of Appraisal Field Cost Estimate for Fish Screen Alternative 1

8150 & 8311 Alternative 1 Subtotal	**$11,992,520**
Mobilization (5%) +/-	$600,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$2,907,480
Construction Contingencies (25%) +/-	$4,000,000
Escalation to Notice to Proceed	$500,000
Total Field Cost* (July 2022)	**$20,000,000**

* Field costs do not include non-contract costs in support of the project.

Fish Screen Alternative 2

Brief Description

Alternative 2 uses perforated vertical stainless steel plates for fish screening located at the entrance of the Arroyo Canal. The flat plate screens are located further downstream and closer to Sack Dam compared to Alternative 1. See Appendix A-2.

Fish Screen

The fish screen is comprised of (4) groups of seven individual wedge wire bar, 1.75 mm opening stainless steel screens. Each screen is 7.4 ft high and is 10 ft wide. The screens are secured to steel supports spaced 10 ft apart, comprised of w-sections, welded angles, and a 4.5 ft wide metal grating for operation and maintenance access. A mechanized cleaning system is attached to a small cantilevered w-section at the top of each steel support. The cleaning brushes are housed at the end of the overall screen and the middle in a "parked" condition. Louvers or baffle plates installed immediately behind the wedge wire panels to allow for flow velocity tuning of the structure. This alternative allows for maintenance of a single bay without significant loss in capacity.

The fish screen and steel supports are supported by a concrete base that spans approximately 330 ft in length, 10 ft in width, and is 1 ft thick. The concrete base includes a 3 ft deep shear key to prevent sliding and for better stability. The sides of the fish screen structure are connected to the existing grade through 10.84 ft high, 1 ft thick concrete retaining wall abutments. There will be a metal walkway at the top of the fish screen structure for access across the structure.

The fish screen structure foundation concept consists of driven steel H-piles beneath the concrete slab, which are driven through potentially liquefiable soils in the subgrade and into underlying dense/stiff soil layers at depth in the subsurface. Based on preliminary analysis of historic geotechnical data from project subsurface investigations by others, there is a high likelihood of liquefaction in response to the 2,500-year return period ground motions at the site. The deep foundation transfers loads to a non-liquefiable layer to avoid excessive settlement of the structure in case of seismic loading and liquefaction in the subgrade.

Fish Passage and Headworks Structure

The fish passage consists of a roughened or boulder weir channel as described in the "Fish Screen Common Components" section above. A concrete headworks structure controls the flow through the fish passage and is also described in the above section.

Sheet Piling

Sheet piling will be utilized on both sides of the Arroyo Canal entrance. To provide a 15 ft wide channel behind the screen, 191 ft and 265 ft of sheet piling will be needed on the north and south side of the Arroyo Canal entrance, respectively. Additionally, the sheet piling will minimize grading impacts and protect nearby existing structures. Construction sequencing will be performed to maintain the historic HMRD flowrate allocation.

Temporary sheet pile wall cells around the fish screen are assumed for cofferdams and excavation support as part of Alternative 2. The sheet pile cofferdam cells are constructed in sequence, around the perimeter of approximately half of the structure footprint at a time, allowing isolation of half of the canal channel for structure construction while maintaining flows through the other half of the channel. The temporary sheet pile cofferdam concept consists of cantilevered sheet piles, embedded into a clay layer in the subsurface, to a depth of twice the cantilevered height, to cut off seepage into the excavation and provide passive resistance. The sheet piles are assumed to be cut down to the finished grade following construction, providing added benefits of grade control and a barrier to seepage beneath the structure.

Cost Estimate

Escalated field costs for Alternative 2 are summarized in Table 2 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-2.

Table 2. Breakdown of Appraisal Field Cost Estimate for Fish Screen Alternative 2

8150 & 8311 Alternative 2 Subtotal	**$12,054,790**
Mobilization (5%) +/-	$600,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$3,345,210
Construction Contingencies (25%) +/-	$4,000,000
Escalation to Notice to Proceed	$1,000,000
Total Field Cost* (July 2022)	**$21,000,000**

* Field costs do not include non-contract costs in support of the project.

Fish Screen Alternative 3

Brief Description

Alternative 3 uses vertical stainless steel plates for fish screening placed diagonally across the river upstream of the Arroyo Canal entrance. The structure aligns with the headworks structure and fish passage on the east bank of the San Joaquin River. See Appendix A-3.

Fish Screen

The fish screen is comprised of (4) groups of seven individual wedge wire bar, 1.75 mm opening stainless steel screens. Each screen is 7.4 ft high and is 10 ft long. The screens are secured to steel supports spaced 10 ft apart, comprised of w-sections, welded angles, and a 4.5 ft wide metal grating for operation and maintenance access. A mechanized cleaning system is attached to a small cantilevered w-section at the top of each steel support. The cleaning brushes are housed at the end of the overall screen and the middle in a “parked” condition. Louvers or baffle plates installed immediately behind the wedge wire panels to allow for flow velocity tuning of the structure. This alternative allows for maintenance of a single bay without significant loss in capacity.

The fish screen and steel supports are supported by a concrete base that spans approximately 330 ft in length, 10 ft in width, and is 1 ft thick. The concrete base includes a 3 ft deep shear key to prevent sliding and for better stability. One side of the fish screen structure is connected to the existing grade through 10.84 ft high, 1 ft thick concrete retaining wall abutments. For Alternative 3, the other abutment will tie directly into the headwork structure of the fish passage to better convey screened fish away from Arroyo Canal and past Sack Dam. There will be a metal walkway at the top of the fish screen structure for access across the structure.

The fish screen structure foundation concept consists of driven steel H-piles beneath the concrete slab, which are driven through potentially liquefiable soils in the subgrade and into underlying dense/stiff soil layers at depth in the subsurface. Based on preliminary analysis of historic geotechnical data from project subsurface investigations by others, there is a high likelihood of liquefaction in response to the 2,500-year return period ground motions at the site. The deep foundation transfers loads to a non-liquefiable layer to avoid excessive settlement of the structure in case of seismic loading and liquefaction in the subgrade.

Fish Passage and Headworks Structure

The fish passage consists of a roughened or boulder weir as described in the "Fish Screen Common Components" section above. A concrete headworks structure controls the flow through the fish passage and is also described in the above section.

The fish passage option for Alternative 3 will convey all flows from the San Joaquin River not being diverted by Arroyo Canal.

The headworks structure for fish passage will be aligned with the fish screen to prevent any fish entrapment areas and to better convey flows around Sack Dam.

Sheet Piling

Alternative 3 will have little to no need for permanent sheet piling.

Temporary sheet pile wall cells around the fish screen are assumed for cofferdams and excavation support as part of Alternative 3. The sheet pile cofferdam cells are constructed in sequence, around the perimeter of approximately half of the structure footprint at a time, allowing isolation of half of the river channel for structure construction while maintaining flows through the other half of the river channel. The temporary sheet pile cofferdam concept consists of cantilevered sheet piles, embedded into a clay layer in the subsurface, to a depth of twice the cantilevered height, to cut off seepage into the excavation and provide passive resistance. The sheet piles are assumed to be cut down to the finished grade following construction, providing added benefits of grade control and a barrier to seepage beneath the structure.

Cost Estimate

Escalated field costs for Alternative 3 are summarized in Table 3 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-3.

Table 3. Breakdown of Appraisal Field Cost Estimate for Fish Screen Alternative 3

8150 & 8311 Alternative 3 Subtotal	**$11,022,990**
Mobilization (5%) +/-	$550,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$2,927,010
Construction Contingencies (25%) +/-	$3,500,000
Escalation to Notice to Proceed	$1,000,000
Total Field Cost* (July 2022)	**$19,000,000**

* Field costs do not include non-contract costs in support of the project.

Fish Screen Alternative 4

Brief Description

Alternative 4 uses a series of submerged double cylindrical fish screens (also known as "tee" screens) mounted on a concrete headwall at the entrance to Arroyo Canal. See Appendix A-4.

Fish Screen

The fish screen structure is comprised of sixteen tee screens with an individual overall length of 17.67 ft. Each drum is 4 ft in diameter and approximately 6 ft long, separated by a 5 ft manifold section. The tee screens are currently spaced 1 ft apart. Each tee screen will have its own cleaning mechanism.

Each screen is supported by two steel guide rails. These rails extend above the concrete headwall for maintenance and access and total approximately 16 ft in length each. Utilizing removable cylindrical tee screens may result in a sole source acquisition when constructed.

The fish screens and guide rails are mounted on a concrete headwall at the entrance of Arroyo Canal. The base of the headwall is approximately 320 ft long, 13 ft wide, and 1 ft thick. A 3 ft deep shear key is provided at the front of the headwall base to prevent sliding and to increase stability. The headwall is 12 ft high and 1 ft thick. For added support, 1 ft thick corbels are located 18.67 ft apart along the canal side of the wall, numbering fifteen in total.

The screened flow from the cylindrical fish screens is conveyed to Arroyo Canal through individual discharge outlet pipes.

The fish screen structure foundation concept consists of driven steel H-piles beneath the concrete slab, which are driven through potentially liquefiable soils in the subgrade and into underlying dense/stiff soil layers at depth in the subsurface. Based on preliminary analysis of historic geotechnical data from project subsurface investigations by others, there is a high likelihood of liquefaction in response to the 2,500-year return period ground motions at the site. The deep foundation transfers loads to a non-liquefiable layer to avoid excessive settlement of the structure in case of seismic loading and liquefaction in the subgrade.

Fish Passage and Headworks Structure

The fish passage consists of a roughened or boulder weir channel as described in the "Fish Screen Common Components" section above. A concrete headworks structure controls the flow through the fish passage and is also described in the above section.

Sheet Piling

Sheet piling will be utilized on both sides of the Arroyo Canal entrance. To provide a 15 ft wide channel behind the screen, 180 ft and 244 ft of sheet piling will be needed on the north and south side of the Arroyo Canal entrance, respectively. Additionally, the sheet piling will minimize grading impacts and protect nearby existing structures. Construction sequencing will be performed to maintain the historic HMRD flowrate allocation.

In addition, sheet piling will be used behind the concrete headwall of the fish screen to create an earthen access way for operation and maintenance vehicles. This access way will be 12 ft wide and will run the length of the structure. Using permanent sheet piling will reduce cost (compared to concrete) and reduce footprint size (compared to an earth embankment).

Temporary sheet pile wall cells around the fish screen are assumed for cofferdams and excavation support as part of Alternative 4. The sheet pile cofferdam cells are constructed in sequence, around the perimeter of approximately half of the structure footprint at a time, allowing isolation of half of the canal channel for structure construction while maintaining flows through the other half of the channel. The temporary sheet pile cofferdam concept consists of cantilevered sheet piles, embedded into a clay layer in the subsurface, to a depth of twice the cantilevered height, to cut off seepage into the excavation and provide passive resistance. The sheet piles are assumed to be cut down to the finished grade following construction, providing added benefits of grade control and a barrier to seepage beneath the structure.

Cost Estimate

Escalated field costs for Alternative 4 are summarized in Table 4 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-4.

Table 4. Breakdown of Appraisal Field Cost Estimate for Fish Screen Alternative 4

8150 & 8311 Alternative 4 Subtotal	**$13,840,574**
Mobilization (5%) +/-	$690,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$3,469,426
Construction Contingencies (25%) +/-	$5,000,000
Escalation to Notice to Proceed	$1,000,000
Total Field Cost* (July 2022)	**$24,000,000**

* Field costs do not include non-contract costs in support of the project.

Fish Screen Alternative 5

Brief Description

Alternative 5 uses an array of conical fish screens placed at the bottom of the San Joaquin River and is separated from the Arroyo Canal by a concrete headwall. See Appendix A-5.

Fish Screen

The fish screen structure is comprised of thirteen 14 ft diameter conical fish screens, with a cone angle of 35 degrees and a height of 4 ft. The array is comprised of two rows (front row: 6, back row: 7) of conical fish screens separated in both directions by 19.22 ft. The screens are placed on a 1 ft thick slab at the bottom of the San Joaquin River.

The conical screens utilize a brush cleaner to meet active screen criteria. Utilizing conical screens may result in a sole source condition. The conical screens have no means of self-retrieval for maintenance and removal.

The screens are separated from the Arroyo Canal via a concrete retaining wall. The base of the wall is approximately 160 ft long, 13 ft wide, and 1 ft thick. A 3 ft deep shear key is provided at the front of the base to prevent sliding and to increase stability. The retaining wall is 12 ft high and 1 ft thick. For added support, 1 ft thick corbels are located 15 ft apart along the canal side of the wall, numbering nine in total.

The screened flow from the conical fish screens is conveyed to Arroyo Canal through thirteen individual discharge outlet pipes.

The fish screen structure foundation concept consists of driven steel H-piles beneath the concrete slab, which are driven through potentially liquefiable soils in the subgrade and into underlying dense/stiff soil layers at depth in the subsurface. Based on preliminary analysis of historic geotechnical data from project subsurface investigations by others, there is a high likelihood of liquefaction in response to the 2,500-year return period ground motions at the site. The deep foundation transfers loads to a non-liquefiable layer to avoid excessive settlement of the structure in case of seismic loading and liquefaction in the subgrade.

Fish Passage and Headworks Structure

The fish passage consists of a roughened or boulder weir channel as described in the "Fish Screen Common Components" section above. A concrete headworks structure controls the flow through the fish passage and is also described in the above section.

Sheet Piling

Sheet piling will be utilized on both sides of the Arroyo Canal entrance. To provide a 15 ft wide channel behind the screen, 101 ft and 130 ft of sheet piling will be needed on the north and south side of the Arroyo Canal entrance, respectively. Additionally, the sheet piling will minimize grading impacts and protect nearby existing structures. Construction sequencing will be performed to maintain the historic HMRD flowrate allocation.

In addition, sheet piling will be used behind the headwall of the fish screen to create an earthen access way for operation and maintenance vehicles. This access way will be 12 ft wide and will run the length of the structure.

Temporary sheet pile wall cells around the fish screen are assumed for cofferdams and excavation support as part of Alternative 5. The sheet pile cofferdam cells are constructed in sequence, around the perimeter of approximately half of the structure footprint at a time, allowing isolation of half of the canal channel for structure construction while maintaining flows through the other half of the channel. The temporary sheet pile cofferdam concept consists of cantilevered sheet piles, embedded into a clay layer in the subsurface, to a depth of twice the cantilevered height, to cut off seepage into the excavation and provide passive resistance. The sheet piles are assumed to be cut down to the finished grade following construction, providing added benefits of grade control and a barrier to seepage beneath the structure.

Cost Estimate

Escalated field costs for Alternative 5 are summarized in Table 5 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-5.

Table 5. Breakdown of Appraisal Field Cost Estimate for Fish Screen Alternative 5

8150 & 8311 Alternative 5 Subtotal	**$9,837,282**
Mobilization (5%) +/-	$490,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$2,672,718
Construction Contingencies (25%) +/-	$3,000,000
Escalation to Notice to Proceed	$500,000
Total Field Cost* (July 2022)	**$16,500,000**

* Field costs do not include non-contract costs in support of the project.

Fish Screen Alternative 6

Brief Description

Alternative 6 is an in-canal screen option designed by Jacobs Engineering. The screens are configured in a V shape within the canal. Jacobs designed the canal v-screen to a 30% design level and provided Reclamation, TSC, with their design drawings and quantity estimates. The TSC used their design drawings to confirm the quantities and compiled a 10% design level cost estimate. See Appendix A-6 for an overview drawing of Jacobs design.

Fish Screen

The Jacobs v-screen is located within the Arroyo Canal. A trashrack structure is proposed at the entrance of the canal as well as an upstream log boom to prevent debris from entering the canal. Since fish will enter the canal, a bypass pipeline is needed at the apex of the v-screen in order to return fish back to the river, downstream of Sack Dam. The v-screen consists of two vertical flat plate screens located within the canal. Two brush cleaning systems would be needed for each set of screens. To facilitate maintenance of the screens in the canal, concrete walls and a concrete slab would be built around the screening facility. The fish screens are designed to be 10 ft tall to accommodate future subsidence. This design also incorporates sheet piling around the trashrack structure.

Cost Estimate

Reclamation escalated field costs for Alternative 6 are summarized in Table 6 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-6.

Table 6. Breakdown of Appraisal Field Cost Estimate for Fish Screen Alternative 6

8150 & 8311 Alternative 6 Subtotal	**$24,409,982.50**
Mobilization (5%) +/-	$1,200,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$6,390,017.50
Construction Contingencies (25%) +/-	$8,000,000
Escalation to Notice to Proceed	$2,000,000
Total Field Cost* (July 2022)	**$42,000,000**

* Field costs do not include non-contract costs in support of the project.

Comparison of Fish Screen Alternatives

In order to provide a consolidated comparison, several tables have been developed and are shown below.

Table 7. Comparison of Alternatives

Alt. #	Fish Screen Type	Cleaning System	Notes
1	Flat Plate	Mechanical brush cleaner	In-river screen with mechanical brush cleaning system. Remote operable and minimal maintenance.
2	Flat Plate	Mechanical brush cleaner	In-river screen with mechanical brush cleaning system. Remote operable and minimal maintenance. Same as Alternative 1 but centered in front of the canal entrance.
3	Flat Plate	Mechanical brush cleaner	In-river fish screen with mechanical brush cleaning system. Fish screens are oriented diagonally across the river and ties into the fish passage headworks structure.
4	Cylindrical or “tee” screen	Mechanical brush cleaner	In-river submerged screens on the left bank. Internal brush cleaning system continually cleans inside and outside of screens. Screens will be mounted on guiderails and can be raised and lowered individually for maintenance
5	Conical	Mechanical brush cleaner	In-river cone screens located at the entrance to the canal at the river invert. Automatic brush cleaning system. Maintenance of these screens may be difficult if the brush cleaner fails and screens need to be pulled out of the water.
6*	Flat Plate V-Screen	Mechanical brush cleaners, sediment jetting system, portable high-pressure washer	In canal v-screen with bypass pipeline. Maintenance and sediment in front of the screens may be difficult.

*Jacobs Engineering design

Table 8. Alternative Cost Comparison

Alt. #	Contract Cost	Field Cost	Construction Cost
1	$15,500,000	$20,000,000	TBD by Project Office
2	$16,000,000	$21,000,000	TBD by Project Office
3	$14,500,000	$19,000,000	TBD by Project Office
4	$18,000,000	$24,000,000	TBD by Project Office
5	$13,000,000	$16,500,000	TBD by Project Office
*6	$32,000,000	$42,000,000	TBD by Project Office

*Jacobs Engineering design

Notes: Field cost includes cost escalation to July 2022. The construction cost is the field cost plus non-contract costs. Non-contract costs shall be determined by the responsible office.

Options to be taken to 30% Design

The TSC design team recommends that for the fish screen, Alternatives 1, and 4 be taken to the 30% design level. The in-river flat plate screen option and cylindrical tee-screens will be further developed to the 30% design level. Hydraulics, subsidence, and operation and maintenance of these structures will be analyzed in the next design phase.

Fish Passage at Sack Dam

Brief History

Since the construction of Sack Dam, fish passage has been severely reduced. Under normal river flowrates, there is no opportunity for passage past the dam. When the hydrograph rises above 1500 cfs, flashboards in the dam are removed, and limited fish passage is possible. Also, under higher flowrates, the river can outflank the east side of the dam. Both high flow conditions are sporadic, and only provide passage to strong swimming species that are migrating at the same time.

Fish Passage Goals

As part of the SJRRP, fish passage will be created for downstream flows. Discussions to define this low flow boundary are ongoing. It is expected this value will either be 85 cfs or 120 cfs. Under higher downstream flows, passage will be maintained.

Sturgeon will require larger flow rates within the fishway to be able to pass. The minimum fishway flowrate for sturgeon passage is being analyzed.

Summary of Fish Passage Requirements

The following are based on discussion with SJRRP, National Marine Fisheries Service (NMFS), California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW) and the United States Fish and Wildlife Service (USFWS). A complete list of the fish passage requirements can be found in Appendix C-2: Fish Passage Requirements.

- Provide salmonid passage
- Provide passage for other resident species, including Sacramento pikeminnow, hardhead, hitch, Sacramento splittail, Sacramento sucker and Sacramento blackfish
- Provide sturgeon passage under higher flow conditions
- System must also pass pacific lamprey

Fish Passage Monitoring

At Sack Dam, monitoring is required, but handling is not. Monitoring equipment can be added including Passive Integrated Transponder (PIT) tag arrays, Vaki monitors, or similar remote monitoring systems.

Flow Gauge Downstream of Sack Dam

A gauge exists downstream of the dam. This gauge may need to be replaced or relocated.

Flow Measurement at Sack Dam

The downstream flow simply expressed will be the upstream river flow minus the diversion amount. However, in actuality flow is split several ways at Sack Dam. The following list shows flow destinations.

- Diverted into Arroyo Canal
- Flow through Sack Dam gates
- Flow over/ through Sack Dam flashboards
- Seepage flow under Sack Dam
- High flow flanking of east side of dam

- Flow down future fish screen bypass (if required)
- Flow down the fishway

Quantification of the flowrates corresponding to the flow destinations will be challenging. The diversion flow can be directly measured. Sack Dam gates operate to maintain the diversion pool, so a variable flowrate would be passing through them. During floods, flow will pass over Sack Dam, and the number of flashboards installed will affect the flowrate. Seepage under the dam could only be determined through numerical modeling. The flanking flow would be difficult to physically measure but could be quantified through numerical hydraulic modeling. Operation of some types of screens will require bypass flowrate that will be dependent on the reservoir WSE.

The fishway flow will be what is left after the aforementioned flows have been removed from the system. Therefore, flow monitoring within the fishway will be essential to ensure the minimum passage flows are being met.

Statements from the "Final Arroyo Canal Fish Screen and Sack Dam Fish Passage Project Design Requirements" include:

- Hourly flow data of releases from Sack Dam shall be made available in real-time to Reclamation.
- Measurement accuracy requirements must be met at all times when flows of any designation pass Sack Dam, including but not limited to Restoration Flows and flood flows.
- Release accuracy requirements must be met during all times when Restoration Flows are released from Sack Dam
- All flows up to and including 2,250 cfs past Sack Dam must be measured to an accuracy of +/-10 percent of the flow on an instantaneous, real-time, basis
- All flows from 2,250 cfs to 4,500 cfs past Sack Dam must be measured to an accuracy of +/-15 percent of the flow on an instantaneous, real-time, basis

Fish Passage Alternative Descriptions

Fishway Common Components

The alternatives contain many similar features such as the headworks structure. There are two primary types of fishways that are used in the seven alternatives.

Headworks Structure

The fishway is supplied through water from a headworks structure. This will be a concrete structure located upstream of the dam in the impoundment. It will be fixed with slide gates, radial gates, stoplogs, or some combination of those. The purpose of this structure is to either turn flow on or off. It will not be used to regulate flow.

The gates and related openings would be made taller than normally required, to allow for unimpeded flow during future conditions where the site may have subsided.

As the site subsides and HMRD increases the depth of impoundment behind Sack Dam to maintain the diversion elevation, more flow would be drawn through the headworks and into the fishway. To prepare for this, stoplog slots could be added at the upstream end of the headworks. The addition of stoplogs could be used to keep the fishway flowing at similar flowrate to before the subsidence occurred. These stoplogs would become permanent. Concrete could be added to the floor to transition the invert near the stoplogs to maintain passage conditions.

To access the dam, a bridge will be constructed over the top of the headworks structure. This could be used for maintenance of both the headworks, dam abutment as well as the fishway.

Trash Rack and Automated Rake

For the 10% Design, a trash rack will be placed upstream of the gates on the headworks. A trash raking system is included in the estimates. Before the 30% milestone, Reclamation will discuss whether this rake should be manual or automated.

Roughened Channel Fishway

A roughened channel consists of a low gradient fishway that is primarily lined with rock. The hydraulic grade line is near linear as the head loss occurs continuously over the length of the fishway. Occasional boulders will be placed to improve hydraulics, increase hydraulic complexity (for fish passage), and manage flow patterns around bends. The location of these boulders will be identified after hydraulic modeling has been completed.

The invert slope needs to be low for these types of fishways. The alternatives using this option vary from 0.78% to 1.00%.

The fishway has a bottom width of 4.0 ft, and 2:1 sideslopes. The cross-sectional geometry is subject to change after the hydraulic modeling has been completed.

Successful roughened channel fishways have been built around the world, incorporating a variety of features to handle project requirements.

Boulder Weir Fishway

A boulder weir fishway consists of a higher gradient than a roughened channel and is marked by the presence of chevron weirs that create discrete hydraulic drops. The boulders that make up the chevron weirs can be designed to create various passage conditions. Boulders can also be replaced by concrete cylinders with diameters in the range of 2 – 5 feet. These cylinders can create more predictable hydraulic conditions over changes in elevation than irregular boulders can. The fishway channel itself is similar to a roughened channel, in that it is lined with rock.

The invert slope can be higher, and the alternatives use slopes of 2% to 3%.

The fishway has a bottom width of 4.0 ft, and 2:1 sideslopes. The cross-sectional geometry is subject to change after the hydraulic modeling has been completed.

Successful boulder weir fishways Reclamation has constructed include:

- Derby Dam Fish Passage
- Tongue and Yellowstone Fishway
- P&M Fishway

Subsidence Buffer

As the site subsides over time, the hydraulic differential from the upstream pool to the downstream river will increase. This is because the elevation of the water diversion is tied to a regional datum and will be operated at the same elevation as regional subsidence occurs.

To maintain passage conditions, the fishway will need to be able to adapt to this changing hydraulic differential. Ideally, the fishway would only require minor modifications once the impoundment depth reaches certain intervals.

Various options exist for creating a "subsidence buffer". The descriptions below offer some solutions considered at the 10% design level.

One option would be to have the fishway only be designed for current conditions. A location would be identified where a future excavation could occur that would create something similar to an oxbow channel to the fishway as shown in Figure 7. In this area, additional fishway length and drop could be added. The oxbow would ideally be located near the headworks structure but could also be located downstream.

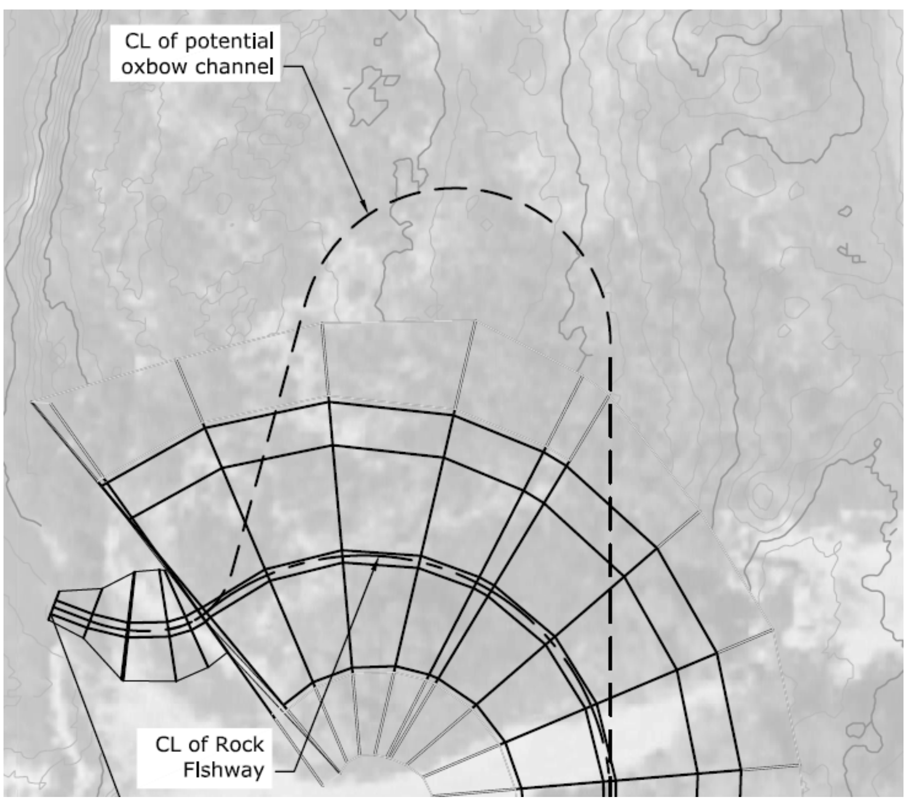

Figure 7 – Potential oxbow channel for added length

Another would be to have the fishway length designed to be long enough for future conditions but have the fishway slope and chevron weirs end before the upstream end of the fishway. This would create a flat area where additional rock and weirs could be placed to effectively add more hydraulic drop to the facility. This is the option the 10% Design Team determined would work best.

There is always the option to do nothing; however, this would create unpredictable hydraulic conditions that is unlikely to meet project requirements.

The design team preferred to have the option with the flat area. During initial construction, this area could be added for a minimal cost. Future operations to add rock and boulders would also be relatively easy as well.

The option with the oxbow type channel would add more complexity to the system, and harder to implement in the future.

Maintenance of Irrigation Deliveries

Throughout all the alternatives, the water supply and pool elevation will remain unaltered. To achieve this, construction will require a cofferdam at the upstream and downstream ends of the fishway.

Grouted Riprap at Entrance and Exit

The grouted riprap slope protection at the entrance and exit of the fish passage for the 10% Design are generally based on erosion protection designs from similar reference projects. Grouted riprap coverage includes the area within the fish passage channel entrance for approximately 20 linear feet at the downstream end of the alignment and extending 30 feet upstream and downstream of the alignment centerline on the surrounding San Joaquin River bank slope, as well as a comparable area of coverage along the river bank surrounding and below the fish passage exit (headworks structure).

The grouted riprap section is based on slopes not steeper than approximately 2H:1V. A layer thickness of 24 inches was selected on the basis of comparable designs, with a maximum riprap diameter of 18 inches, minimum diameter of 6 inches, and D_{50} of 12 inches, based on the selected layer thickness and gradation criteria from Reclamation Design Standards.

Upstream Cofferdam

A cast-in-place concrete headworks structure is envisioned for the fish passage exit (upstream end) to control flows through the fish passage channel. Construction of the headworks structure will require excavation below the design water surface elevation in the San Joaquin River, based on a typical restoration flow stage (assumed at elevation 121.3), which generally controls the groundwater level in the floodplain area based on current understanding of geotechnical conditions. Thus, control of water is necessary for construction of the headworks structure.

The understanding of ground conditions for the 10% design of control of water for the headworks structure is based on geotechnical data from historic subsurface explorations performed for the Arroyo Canal and Sack Dam Project by a consultant to HMRD (see Appendix C-4). Two options were considered for control of water at the headworks structure (fish passage exit) for the 10% Design. These are referred to as G1 and G2. A description of each is given below.

G1 consists of a sheet pile wall cell surrounding the footprint of the headworks structure and embedded to approximately 20 to 25 feet deep, into a clay layer beneath more permeable sand deposits anticipated within the excavation profile, to cut off groundwater seepage into the excavation.

G2 consists of a cofferdam constructed within the river channel, consisting of supersacks and an impermeable geomembrane, combined with a well point dewatering system surrounding the headworks structure excavation.

G1 would require unwatering of the area within the sheet pile cofferdam, likely using submersible pumps, and periodic pumping of minor amounts of groundwater inflow from a small sump extending a few feet below the headworks structure excavation bottom.

G2 would require continual dewatering of the excavation throughout the duration of construction using a well point dewatering system. The sheet pile cofferdam and well point dewatering systems included in the options for 10% Design are based on historic subsurface exploration data (see Appendix C-4), experience on similar projects, and engineering judgement. A minimum crest elevation of 124 was assumed for the upstream cofferdams, allowing for 2.7 feet of freeboard.

The excavation for G1 would be within the vertical sheet pile walls, as opposed to a sloped temporary excavation not steeper than 1.5H:1V for G2, resulting in a small relative reduction in excavation and backfill quantities for G1. The 10% Cofferdam and Excavation Designs for both options allow for several feet of working space between the headworks structure and the sheet piles or base of excavation slopes.

Downstream Cofferdam

The placement of grouted riprap along the fish passage channel entrance, as well as other earthwork within the downstream end of the fish passage channel, are likely to require control of water. For the 10% Design, control of water at the fish passage channel entrance includes a cofferdam constructed within the river channel, consisting of supersacks and an impermeable geomembrane, and unwatering of the area within the downstream cofferdam using submersible pumps. A design tailwater surface elevation of 118 was assumed for the downstream cofferdam, with a minimum crest elevation of 120, allowing for 2 feet of freeboard.

Fish Passage Monitoring

All the alternatives will contain the ability to add Pit Tag arrays, or other monitoring systems. Because these are inexpensive items, they were not included in the 10% cost estimates. Prior to completion of the 30% Design, the type of monitoring system should be defined.

Fish Passage Alternative 1

Brief Description

Alternative 1 uses a roughened channel for fish passage. It has an invert slope of 1%. The option stays completely within the levees.

Headworks Structure

The headworks is the same as described in the "Fishway Common Components" section above.

Roughened Channel Fishway

The fishway consists of a roughened channel as described in the "Fishway Common Components" section above.

The invert slope for this alternative is 1.00%.

Subsidence Buffer

The fishway only has a short area of zero slope at the upstream end. This results in a subsidence buffer of 0.20 ft.

It should be noted that if a larger subsidence buffer is required, the invert slope of the entire fishway could be increased slightly, or the length increased.

River Side Improvements

Near the headworks structure, grouted riprap is placed to protect the headworks, and also to connect the headworks to the existing dam abutment.

On the downstream end of the fishway, grouted riprap would be used to stabilize the channel against flood velocities.

Cost Estimate

Escalated field costs for Alternative 1 are summarized in Table 9 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-7.

Table 9. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 1

8150 Alternative 1 & 8311 Alternative G2 Sub-Total	**$5,182,120**
Mobilization (5%) +/-	$260,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,357,880
Construction Contingencies (25%) +/-	$1,700,000
Escalation to Notice to Proceed	$500,000
Total Field Cost* (July 2022)	**$9,000,000**

* Field costs do not include non-contract costs in support of the project.

Fish Passage Alternative 2

Brief Description
Alternative 2 uses a boulder weir fishway for fish passage. It has an invert slope of 2%. The option stays completely within the levees.

Headworks Structure
The headworks is the same as described in the "Fishway Common Components" section above.

Boulder Weir Fishway
The fishway consists of a boulder fishway as described in the "Fishway Common Components" section above.

The invert slope for this alternative is 2.00%.

Subsidence Buffer
The fishway only has a 100-foot section of zero slope at the upstream end. This results in a subsidence buffer of 2.00 ft.

It should be noted that if a larger subsidence buffer is required, the invert slope of the entire fishway could be increased slightly, or the length increased.

River Side Improvements
Near the headworks structure, grouted riprap is placed to protect the headworks. Because the fish exit is relocated upstream in the river significantly, the grouted riprap will only be in the vicinity of the headworks and will not extend all the way down to the existing dam abutment.

On the downstream end of the fishway, grouted riprap would be used to stabilize the channel against flood velocities.

Cost Estimate
Escalated field costs for Alternative 2 are summarized in Table 10 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-8.

Table 10. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 2

8150 Alternative 2 & 8311 Alternative G2 Sub-Total	**$4,203,140**
Mobilization (5%) +/-	$210,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,086,860
Construction Contingencies (25%) +/-	$1,400,000
Escalation to Notice to Proceed	$400,000
Total Field Cost* (July 2022)	**$7,300,000**

* Field costs do not include non-contract costs in support of the project.

Fish Passage Alternative 3

Brief Description

Alternative 3 uses a roughened channel for fish passage. It has an invert slope of 0.78%. The option impacts the levees and will require replacement / relocation of levee sections. Additionally, the levee access road will be impacted, and a bridge is used to cross over the fishway sections.

Note on Alternative Alignment

Alternatives 3 and 4 were requested to show a fishway alignment that goes outside of the levees. Alternatives 3 and 4 depict the minimum fishway length in order to exit the current levees. The alignment of the fishway could be modified to include meanders and more bends, however, would increase fishway length and therefore cost. The invert slope of Alternatives 3 and 4 is the lowest of all the options and is much flatter than is required for a successful fishway.

It is noted that the alignment of the fishways in Alternative 3 and 4 look different than the initial sketches that show the nature like fishway containing meanders, bends, vegetation etc. The addition of a longer length and the other features would only increase the cost of this option. To evaluate the minimum cost of Alternatives 3 and 4, the design was modified to reduce length and complexity.

In Alternative 3, bridges are placed for crossing the fishway. This creates a situation where the levees are relocated to the outside of the fishway. The existing road would cross the bridge rather than making a sharp turn to match the fishway. Alternative 4 is similar to 3, except that the bridges are removed, and the existing road is relocated alongside of the fishway.

Headworks Structure

The headworks is the same as described in the "Fishway Common Components" section above.

Roughened Channel Fishway

The fishway consists of a roughened channel as described in the "Fishway Common Components" section above.

The invert slope for this alternative is 0.78%.

Subsidence Buffer

The fishway does not contain an area of zero slope at the upstream end. This results in no subsidence buffer.

It should be noted that if a subsidence buffer is required, the invert slope of the entire fishway could be increased slightly to create this area of zero slope.

River Side Improvements

Near the headworks structure, grouted riprap is placed to protect the headworks, and also to connect the headworks to the existing dam abutment.

On the downstream end of the fishway, grouted riprap would be used to stabilize the channel against flood velocities.

Cost Estimate

Escalated field costs for Alternative 3 are summarized in Table 11 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-9.

Table 11. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 3

8150 Alternative 3 & 8311 Alternative G2 Sub-Total	**$6,297,700**
Mobilization (5%) +/-	$310,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,592,300
Construction Contingencies (25%) +/-	$2,300,000
Escalation to Notice to Proceed	$500,000
Total Field Cost* (July 2022)	**$11,000,000**

* Field costs do not include non-contract costs in support of the project.

Fish Passage Alternative 4

Brief Description

Alternative 4 uses a roughened channel for fish passage. It has an invert slope of 0.78%. The option impacts the levees and will require replacement / relocation of levee sections. Additionally, the levee access road will be impacted, and will follow a new path along the fishway, adding several bends to the existing road.

Note on Alternative Alignment

Alternative 4 is the same as Alternative 3, except for how the fishway interacts with the levee and access road. In Alternative 3, bridges are placed for crossing the fishway, and in Alternative 4 the levee and access road are relocated.

Headworks Structure

The headworks is the same as described in the "Fishway Common Components" section above.

Roughened Channel Fishway

The fishway consists of a roughened channel as described in the "Fishway Common Components" section above.

The invert slope for this alternative is 0.78%.

Subsidence Buffer

The fishway does not contain an area of zero slope at the upstream end. This results in no subsidence buffer.

It should be noted that if a subsidence buffer is required, the invert slope of the entire fishway could be increased slightly to create this area of zero slope.

River Side Improvements
Near the headworks structure, grouted riprap is placed to protect the headworks, and also to connect the headworks to the existing dam abutment.

On the downstream end of the fishway, grouted riprap would be used to stabilize the channel against flood velocities.

Cost Estimate
Escalated field costs for Alternative 4 are summarized in Table 12 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-10.

Table 12. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 4

8150 Alternative 4 & 8311 Alternative G2 Sub-Total	**$4,977,700**
Mobilization (5%) +/-	$250,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,272,300
Construction Contingencies (25%) +/-	$1,700,000
Escalation to Notice to Proceed	$500,000
Total Field Cost* (July 2022)	**$8,700,000**

* Field costs do not include non-contract costs in support of the project.

Fish Passage Alternative 5

Brief Description
Alternative 5 uses a boulder weir fishway for fish passage. It has an invert slope of 3%. The increased slope also allows for a larger subsidence buffer to be present. The option stays completely within the levees.

Headworks Structure
The headworks is the same as described in the "Fishway Common Components" section above.

Boulder Weir Fishway
The fishway consists of a boulder fishway as described in the "Fishway Common Components" section above.

The invert slope for this alternative is 3.00%.

Subsidence Buffer
The fishway only has a 115-foot section of zero slope at the upstream end. This results in a subsidence buffer of 3.45 ft.

It should be noted that if a larger subsidence buffer is required, the invert slope of the entire fishway could be increased slightly, or the length increased.

River Side Improvements

Near the headworks structure, grouted riprap is placed to protect the headworks. Because the fish exit is relocated upstream in the river significantly, the grouted riprap will only be in the vicinity of the headworks and will not extend all the way down to the existing dam abutment.

On the downstream end of the fishway, grouted riprap would be used to stabilize the channel against flood velocities.

Cost Estimate

Escalated field costs for Alternative 5 are summarized in Table 13 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-11.

Table 13. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 5

8150 Alternative 5 & 8311 Alternative G2 Sub-Total	**$4,202,100**
Mobilization (5%) +/-	$210,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,087,900
Construction Contingencies (25%) +/-	$1,400,000
Escalation to Notice to Proceed	$400,000
Total Field Cost* (July 2022)	**$7,300,000**

* Field costs do not include non-contract costs in support of the project.

Fish Passage Alternative 6

Brief Description

Alternative 6 is similar to Alternative 6 but adds a river bypass on the outside of the fishway. This will provide additional flow to the fishway under many flow conditions.

Headworks Structure

The headworks is the same as described in the "Fishway Common Components" section above.

Boulder Weir Fishway

The fishway consists of a boulder fishway as described in the "Fishway Common Components" section above.

The invert slope for this alternative is 3.00%.

River Bypass Weir

A weir will be constructed upstream of the headworks structure. The crest length of the weir would be approximately 50 feet. The weir would consist of a concrete weir with a cutoff and downstream apron. The weir would be set to approximately the diversion elevation used by HMRD. As the water rises, signaling either a higher river flowrate or decreased diversion, water would begin to spill over the weir and into the bypass.

This bypass would connect to the fishway. Above the typical low flow fishway section will be a step that contains the higher flow/ higher velocity bypass. Due to hydraulic differences between the rough fishway and smooth bypass, the fishway would continue to be passable. The river bypass may allow for additional passage opportunities as well.

As river flows grew significantly larger, a large portion of the river flow could be bypassed through this structure.

Subsidence Buffer

The fishway only has a 115-foot section of zero slope at the upstream end. This results in a subsidence buffer of 3.45 ft.

It should be noted that if a larger subsidence buffer is required, the invert slope of the entire fishway could be increased slightly, or the length increased.

River Side Improvements

Near the headworks structure, grouted riprap is placed to protect the headworks. Because the fish exit is relocated upstream in the river significantly, the grouted riprap will only be in the vicinity of the headworks and will not extend all the way down to the existing dam abutment.

On the downstream end of the fishway, grouted riprap would be used to stabilize the channel against flood velocities.

Cost Estimate

Escalated field costs for Alternative 6 are summarized in Table 14 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-12.

Table 14. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 6

8150 Alternative 6 & 8311 Alternative G2 Sub-Total	**$4,611,970**
Mobilization (5%) +/-	$230,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,258,030
Construction Contingencies (25%) +/-	$1,500,000
Escalation to Notice to Proceed	$500,000
Total Field Cost* (July 2022)	**$8,100,000**

* Field costs do not include non-contract costs in support of the project.

Fish Passage Alternative 7

Brief Description

Alternative 7 is similar to Alternative 5, except for the control of water and excavation design for the headworks foundation. Alternative 7 includes the use of steel sheet piles as a cofferdam cell, groundwater cutoff, and excavation support; whereas Alternatives 1 through 6 include a supersack cofferdam within the river and well point dewatering system surrounding the headworks structure, with a sloped excavation. All other components remain the same as for Alternative 5. These options for control of water are further discussed in a preceding section title “Upstream Cofferdam”. The combined costs for the headworks structure control of water and excavation are less expensive for Alternative 7 than for Alternative 5.

Cost Estimate

Escalated field costs for Alternative 7 are summarized in Table 15 below; details of quantity and cost estimates are presented on the Estimate Worksheets included in Appendix B-13.

Table 15. Breakdown of Appraisal Field Cost Estimate for Fish Passage Alternative 7

8150 Alternative 7 (same as 8150 Alternative 5) & Alternative G1 Sub-Total	**$3,979,140**
Mobilization (5%) +/-	$200,000
Contract Cost Allowances for Design Contingencies (20%) and APS (5%) +/-	$1,020,860
Construction Contingencies (25%) +/-	$1,300,000
Escalation to Notice to Proceed	$400,000
Total Field Cost* (July 2022)	**$6,900,000**

* Field costs do not include non-contract costs in support of the project.

Comparison of Fish Passage Alternatives

In order to provide a consolidated comparison, several tables have been developed and are shown below.

Table 16. Comparison of Alternatives

Alt. #	Fishway Type	Fishway Slope	Flat slope length	Subsidence buffer	Notes
1	Roughened channel	1% for 940 ft	20 ft	0.20 ft	Slope could be steepened to allow for buffer to exist
2	Boulder Weir Fishway	2% for 470 ft	100 ft	2.00 ft	Slope could be steepened to allow for buffer to exist
3	Roughened channel	0.78% for 1,039 ft	0 ft	none	Slope could be steepened to allow for buffer to exist
4	Roughened channel	0.78% for 1,039 ft	0 ft	none	Slope could be steepened to allow for buffer to exist
5	Boulder Weir Fishway	3% for 313 ft	115 ft	3.45 ft	Slope could be steepened to allow for buffer to exist
6	Boulder Weir Fishway, High Flow river bypass	3% for 313 ft	115 ft	3.45 ft	Slope could be steepened to allow for buffer to exist
7	Boulder Weir Fishway	3% for 313 ft	115 ft	3.45 ft	Similar to #5, but with a different headworks foundation

Table 17. Alternative cost comparison

Alt. #	Contract Cost	Field Cost	Construction Cost
1	$6,800,000	$9,000,000	TBD by Project Office
2	$5,500,000	$7,300,000	TBD by Project Office
3	$8,200,000	$11,000,000	TBD by Project Office
4	$6,500,000	$8,700,000	TBD by Project Office
5	$5,500,000	$7,300,000	TBD by Project Office
6	$6,100,000	$8,100,000	TBD by Project Office
7	$5,200,000	$6,900,000	TBD by Project Office

Notes: Field cost includes cost escalation to July 2020. The construction cost is the field cost plus non-contract costs. Non-contract costs shall be determined by the responsible office.

Options to be taken to 30% Design

The TSC design team recommends that Alternative 5 and Alternative 7 be taken to the 30% Design Level. These two represent options that will meet the project objectives for the lowest cost.

Alternative 6 may be considered if a river bypass system is needed.

Next Steps

Review of 10 % Design Documents

The project team would request that all stakeholders review the updated 10% Design Report and its appendices. Written comments will ensure all questions/ concerns/ comments are addressed. A comment form is provided at the end of this report. A similar form should be used and provided electronically to Emily Thomas by April 16, 2021.

10% Design Review Meeting

Goals

The review meeting will have the following goals:

- Assemble stakeholders for a review
- Allow stakeholders to review each other’s comments
- Review 10% design drawings for fish screens
- Review fish screen design considerations

- Review fish screen alternative costs
- Allow for stakeholders to have the ability to comment on the screening designs
- Determine the alternative(s) to carry to 30% design
- Review 10% design drawings for fish passage
- Review fish passage design considerations
- Review fish passage alternative costs
- Allow for stakeholders to have the ability to comment on the fish passage designs
- Determine approximate timelines for 30% design package and reviews

Format

Due to COVID restrictions, the review will be done at least partially remotely. Stakeholders near the project may assemble as allowed, but much of the TSC will need to present and attend remotely. Details for the meeting will be forthcoming.

After the review has concluded, the project team should consult to discuss the schedule for the following:

- TSC Design Team site visit
- Value Planning and Value Engineering studies
- 30% Design completion
- 30% Design review
- Other stakeholder meetings as needed

Project Schedule / Future Tasks

Value Planning Study

A Value Planning study is performed before a preferred alternative has been selected (or even thought of) usually concentrates on identifying project objectives and developing functional components and general approaches to meet project objectives. Value planning studies are appropriate for most projects, programs, or activities at a very early stage of design or development.

This study provides a creative problem-solving process for a construction or O&M project. It attacks problems from many angles to simplify solutions without sacrificing key functions. During this review, a five- to seven-member Value Study Team follows a systematic Job Plan that meets U.S. Department of the Interior (DOI) requirements.

The team develops proposals and cost estimates that support informed decision making for projects ranging from construction to administration. The team generates and develops solutions that fulfill the necessary functions while improving performance.

At Sack Dam, this process could help determine the optimal structure of the construction contracts. With the fish screen also being built, this study could evaluate the benefits and risks of combining the fishway and fish screen contracts, as well as the benefits and risks of doing them individually. These conclusions would help decision makers make informed decisions on the best path to meet the project goals.

30% Design Review

The goals of the 30% design review will be to choose the single preferred alternative and identify constraints and requirements that must be taken into consideration in the next level of design.

The structure of the review will be similar to the 10% Design Review.

The 30% Design Review has not been scheduled.

Value Engineering Study

A Value Engineering study is performed for a construction or O&M project after design alternatives have been developed, and often a preferred alternative has been selected. Team members will typically focus their time and use many techniques to quantify and compare alternatives for selected project components. Because more is known about a project as the design process advances, the level of detail reached in engineering studies is greater than in planning studies.

Physical and Computational Hydraulic Modeling

Reclamation's Hydraulics Laboratory at the Technical Service Center conducts physical hydraulic modeling and computational fluid dynamics modeling in the areas of environmental hydraulics, hydraulic structures and equipment, infrastructure safety, water conservation and management, and water measurement and field testing.

Physical hydraulic modeling of the SJRRP Reach 2 Compact Bypass Channel at the Delta Mendota Pool started in 2016 and is ongoing. The primary objective of the physical model is to optimize fish ladder design and performance at the Compact Bypass control structure. The physical model includes the compact bypass structure, fish ladder, auxiliary flow system, and grade control structures. A physical hydraulic model will be constructed in 2021 to successfully identify any hydraulic issues relating to the Mendota pool fish screen, reverse flow facility, and compact bypass control structure relating to the SJRRP.

If there are uncertainties or concerns regarding final design components or configurations for fish passage at Sack Dam or if new or modified concepts are proposed during the Value Engineering process, physical and/or computational modeling can be used to support design verification and optimization.

Review Comment Sheet

A sample review comment sheet is shown below. This exact form does not need to be used but format your comments similarly. Email your comments to Emily Thomas before April 16, 2021.

10% Design Review **Arroyo Canal Fish Screen**		
Reviewer:		
Organization:		
Comment Date:		
#	Page	Comments
1		
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