RECLAMATION
Managing Water in the West

Friant-Kern Canal Middle Reach Capacity Correction Project

Feasibility Report

January 2020

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

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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Abbreviations and Acronyms

AF	acre-feet
APE	Area of Potential Effect
B-C	benefit cost
CalSim II	California Water Resources Simulation Model
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CER	Canal Enlargement and Realignment
cfs	cubic feet per second
CVP	Central Valley Project
CWC	California Water Commission
DEC	Design Engineering and Cost
D&S	Directives and Standards
DWR	California Department of Water Resources
EA	Environmental Assessment
EIS/R	Environmental Impact Statement/Environmental Impact Report
ESA	Endangered Species Act
FAA	Financial Assistance Agreement
FKC	Friant-Kern Canal
FWA	Friant Water Authority
GSA	groundwater sustainability agency
GSP	groundwater sustainability plan
Guidelines	Guidelines for the Application of Criteria for Financial Assistance for Local Projects under Part III of Public Law 111-11
HGL	Hydraulic Grade Line
ID	Irrigation District
IDC	Interest During Construction
IS	Initial Study
JPA	Joint Powers Authority
MP	Mile Post
MUD	Municipal Utility District
NED	National Economic Development
NEPA	National Environmental Policy Act
NOD	Notice of Determination
NOI	Notice of Intent
NOP	Notice of Preparation
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
O&M	operations and maintenance

OM&R	operations, maintenance, and replacement
OPCC	opinion of probable construction cost
PCA	Project Cooperation Agreement
P.L	Public Law
PR&G	Principles, Requirements, and Guidelines for Federal Investment in Water Resources
Project	Friant-Kern Canal Middle Reach Capacity Correction Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Report	Draft Recommended Plan Report
ROD	Record of Decision
ROW	right of way
RWA	Recovered Water Account
Settlement	Stipulation of Settlement of Natural Resource Defense Council (NRDC) et al. v. Kirk Rodgers et al.
Settlement Act	San Joaquin River Restoration Settlement (Title X, Subtitle A) Provisions of Public Law 111-11
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
State	State of California
Study	FKC Middle Reach Capacity Correction Project Feasibility Study
SWAP	State-Wide Agricultural Production
TAF	thousand acre-feet
TM	technical memorandum
URFs	Unreleased Restoration Flows
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
VERA	Voluntary Emission Reduction Agreement
WD	Water District
WEAT	worker environmental awareness training
WIIN Act	Water Infrastructure Improvements for the Nation Act (P.L. 114-322) of 2016
WSD	Water Storage District

Chapter 1 Introduction

The Friant-Kern Canal (FKC) is a principal feature of the Central Valley Project (CVP) in the eastern portion of California's San Joaquin Valley. It extends approximately 152 miles from Millerton Lake to the Kern River and delivers CVP water supplies to Friant Division long-term contractors. The FKC Middle Reach, an approximately 33-mile section located within Tulare and Kern Counties, has experienced significant capacity loss. The capacity loss is a result of regional land subsidence that has occurred over the past decade, original design deficiency, and other factors that prevent the intended flow capacity. The FKC Middle Reach Capacity Correction Project (Project) is being developed to provide improvements to restore its originally designed and constructed capacity through the Middle Reach of the FKC. The Project will include design features, including sufficient embankment height, pressurized siphons below road crossings and other structures that will maintain design capacity as future land subsidence occurs during the project service life.

The FKC Middle Reach Capacity Correction Project Feasibility Study (Study) was developed by the Friant Water Authority (FWA) in coordination with the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). Progress and results of the Study are being documented in this Feasibility Report which will culminate in a Final Feasibility Report and associated compliance documentation consistent with the National Environmental Policy Act (NEPA), the *Principles, Requirements, and Guidelines for Federal Investment in Water Resources* (PR&G) (CEQ 2013), Reclamation Directives and Standards (D&S) CMP 09-02 for Water and Related Resources Feasibility Studies (2015), and applicable environmental laws.This Report presents the formulation and evaluation of Initial Alternatives, the selection and evaluation of Alternatives, and the identification of a Recommended Plan consistent with the PR&Gs and Reclamation requirements for preparing a feasibility study.

Reclamation is responsible to conduct this Study and is authorized to implement the Recommended Plan. FWA is the non-Federal operating entity of the FKC under an operation, maintenance, repair, and replacement contract with Reclamation. FWA, as the cost share partner, will coordinate with Reclamation on the implementation of the Recommended Plan identified in this Feasibility Report. The following subsections describe Federal, State of California (State), and local authorization and legislation relevant to this Project.

Purpose

Reduced conveyance capacity in the FKC Middle Reach causes several inter-related effects, including:

- Reduced water deliveries to Friant Division long-term contractors under Class 1 and Class 2 contracts, as well as Section 215, Recovered Water Account (RWA), and Unreleased Restoration Flow (URF) water supplies;
- Reduced ability of the FKC to convey flood waters during wet periods;
- Reduced ability to implement provisions of the Water Management Goal as described in Paragraph 16 of the San Joaquin River Restoration Settlement (Settlement); and
- Reduced ability to store and manage the timing and volume of Restoration Flows in Millerton Lake and flood flows at Friant Dam.

The Friant Division of the CVP was developed to improve groundwater storage in a region that had and continues to experience groundwater overdraft. A two-class water contract system is employed to support this objective. Class 1 water contracts are based on the generally reliable annual yield of the Millerton Lake, and Class 2 contracts are based on water supplies available during wet periods that are used to replenish groundwater through direct recharge or delivery in lieu of groundwater pumping. The reduced delivery of water supplies via the FKC reduces the availability of water under Class 2 and Class 1 contracts (in that order) for agricultural, municipal, and industrial uses in the eastern San Joaquin Valley and thereby reduces this conjunctive use capability of the Friant Division. . When water deliveries are impacted because of constrained capacity in the FKC, storage levels in Millerton Lake increase, which in turn decreases the ability to manage the timing and volume of Restoration Flows in Millerton Lake and increases flood releases from Friant Dam.

The purpose of the Project is to restore the conveyance capacity of the FKC Middle Reach to such capacity as previously designed and constructed by Reclamation, as provided for in the San Joaquin River Restoration Settlement Act (Public Law 111-11, Title X, Part III(a)(1)). The purpose of this Study is to formulate, evaluate, and compare alternatives that address Project planning objectives and identify a Recommended Plan consistent with Federal authorizations and requirements. Information developed through the Study will be used in preparation of required environmental compliance documentation.

Planning Objective

The planning objective is to restore the capacity of the FKC in the Middle Reach from Mile Post (MP) 88.2 to MP 121.5 to address the subsidence-induced and original design deficiency capacity reductions. Capacity reductions from subsidence and original design deficiency are described in Chapter 2. The FKC was designed to convey water at a normal capacity for the delivery of water under CVP contracts, and maximum capacity for the short-term conveyance of flood flows to aid in storage and control of flood waters behind Friant Dam. Both design capacity requirements are to be achieved, consistent with current Reclamation design requirements. The planning objective also is to include design features in the Recommended Plan that will maintain the design capacity of the FKC as anticipated future subsidence occurs during the project service life.

Organization of this Report

This report is organized as follows:

- **Chapter 1** provides background information about the study and related studies, projects, and programs.
- **Chapter 2** provides an overview of the water and related resources, problems, opportunities, and constraints.
- **Chapter 3** describes the initial alternative formulation process.
- **Chapter 4** presents the No Action Alternative and the two Alternatives in terms of major features, costs, and other defining characteristics.
- **Chapter 5** presents benefit cost analyses of the Alternatives and identifies a Recommended Plan.
- **Chapter 6** describes the Recommended Plan and findings.
- **Chapter 7** presents recommendations.
- **Chapter 8** provides a list of sources consulted in preparation of this report.

This report is supported by appendices, attachments, and exhibits that provide greater technical detail, as shown in the organization hierarchy (Figure 1-1).

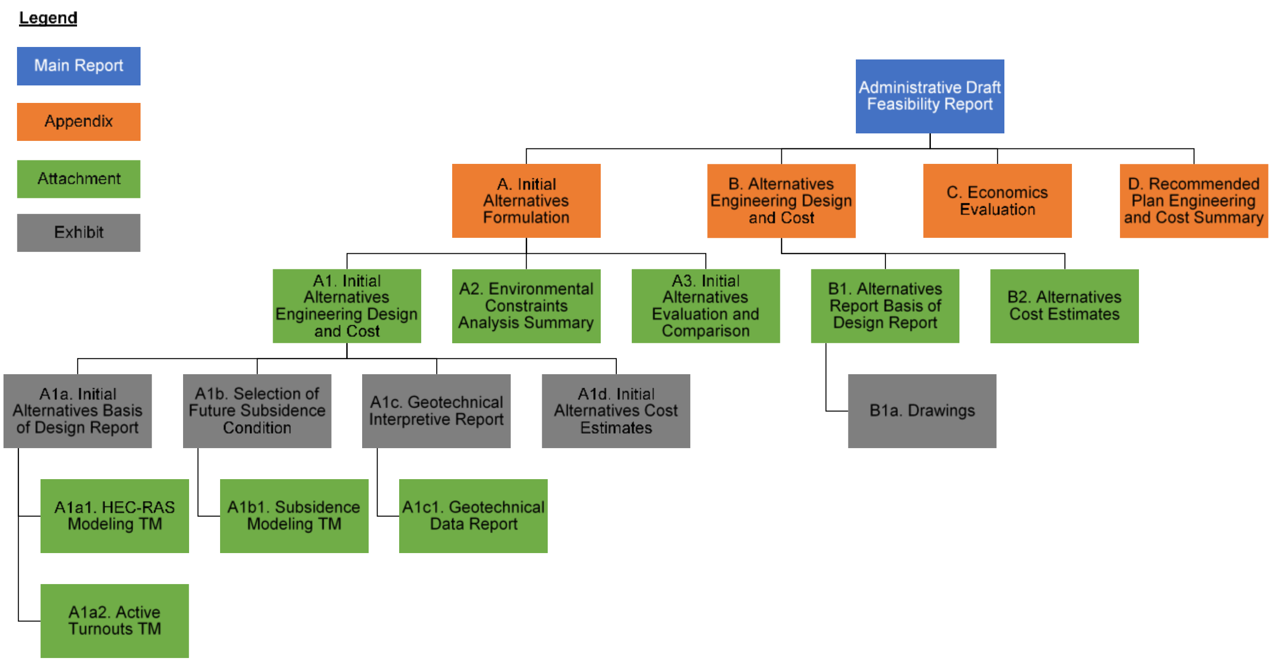

Figure 1-1. Feasibility Report Document Hierarchy

Federal Authorities

The Study is being prepared to support feasibility determinations in accordance with the following Federal authorities:

- San Joaquin River Restoration Settlement (Title X, Subtitle A) provisions of Public Law [P.L.] 111-11 (Settlement Act), the Omnibus Public Land Management Act of 2009;
- Section 9603, Extraordinary Operation and Maintenance Work Performed by the Secretary, of P.L. 111-11; and
- The Water Infrastructure Improvements for the Nation Act (WIIN Act) (P.L. 114-322) of 2016.

P.L. 111-11

Part III of the Settlement Act authorizes the restoration of the FKC to such capacity as previously designed and constructed by the Bureau of Reclamation (PL 111-11, sec. 10201).

> *Section 10201:*
>
> *"(a) The Secretary of the Interior (hereafter referred to as the 'Secretary') is authorized and directed to conduct feasibility studies in coordination with appropriate Federal, State, regional, and local authorities on the following*

improvements and facilities in the Friant Division, Central Valley Project, California:

> *(1) Restoration of the capacity of the Friant-Kern and Madera Canal to such capacity as previously designed and constructed by the Bureau of Reclamation...*

(b) Upon completion of and consistent with the applicable feasibility studies, the Secretary is authorized to construct the improvements and facilities identified in subsection (a) in accordance with applicable Federal and State laws.

Section 10201(a)(1) directs Reclamation to conduct a feasibility study that includes a recommended plan that restores the capacity of the FKC as originally intended by Reclamation. The FKC was designed in accordance with engineering practice at the time to provide the intended capacity, however the constructed canal did not provide the designed capacity because of deficiencies in design assumptions. If funding for construction is limited, a sequencing approach may be applied in which the project could be designed and constructed in discrete portions in a manner that would not preclude future modifications to achieve the original designed and constructed capacity.

In addition to providing authorization for both studies and construction, Section 10203 provides funding to conduct studies and construct projects identified in Part III of the Settlement Act. While funds made available under this section are not sufficient to complete this project, in conjunction with other Federal, State, and local sources of funding the projects under this section could be deemed financially feasible and proceed to construction under this authorization in compliance with Federal, State, and local laws.

Project construction is also authorized under PL 111-11 Section 9603, which addresses Extraordinary Operation and Maintenance Work Performed by the Secretary.

9603 (a) IN GENERAL.—The Secretary or the transferred works operating entity may carry out, in accordance with subsection (b) and consistent with existing transfer contracts, any extraordinary operation and maintenance work on a project facility that the Secretary determines to be reasonably required to preserve the structural safety of the project facility.

> *(b) REIMBURSEMENT OF COSTS ARISING FROM EXTRAORDINARY OPERATION AND MAINTENANCE WORK.—*

> *(1) TREATMENT OF COSTS.—For reserved works, costs incurred by the Secretary in conducting extraordinary operation and maintenance work will be allocated to the authorized reimbursable purposes of the project and shall be repaid within 50 years, with interest, from the year in which work undertaken pursuant to this subtitle is substantially complete.*

> *(2) AUTHORITY OF SECRETARY.—For transferred works, the Secretary is authorized to advance the costs incurred by the transferred works operating entity in conducting extraordinary operation and maintenance work and negotiate appropriate 50-year repayment contracts with project beneficiaries providing for the return of reimbursable costs, with interest, under this subsection: Provided, however, That no contract entered into pursuant to this subtitle shall be deemed to be a new or amended contract for the purposes of section 203(a) of the Reclamation Reform Act of 1982 (43 U.S.C. 390cc(a)).*

WIIN Act

Authorization and funding for planning has been provided under authority of Section 4007 of the WIIN Act. The WIIN Act addresses the needs of the nation's harbors, locks, dams, flood protection, and other water resources infrastructure critical to the economic growth, health, and competitiveness. WIIN authorizes the Secretary to enter into agreements with "*…any State, or public department, agency, or subdivision of a state…*" on behalf of the United States for the "*…design, study, and construction or expansion of any federally owned storage project…"* The WIIN Act authorizes the Secretary to participate in a Federally owned storage project in an amount equal to not more than 50% of the total cost of the Federally owned storage project.

Unless directed otherwise by Congress, all costs for studies, report preparation, and review that falls under the WIIN Act authorization must be shared with a non-Federal cost-sharing partner. Costs will be accounted for and in-kind services valued in accordance with *Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards* (2 CFR 200). Cost-sharing must be in the form of in-kind services, cash payments, or a combination of the two. Unless authorizing legislation specifies a cost-share formula, the Federal cost-share will be up to 50 percent of the project study costs.

For a project to be considered for funding under the WIIN Act, proponents must demonstrate that the project constitutes either construction or expansion of water storage in a Federal- or State-led project. Pursuant to the provisions provided under Section 4007, the Project qualifies as a Federally-led Storage project because the FKC and the benefiting storage facility, Friant Dam and Millerton Lake, are owned by the federal government. The reduction in FKC capacity has diminished storage capabilities in Millerton Lake; restoration of FKC capacity will improve Reclamation's storage capabilities and improve benefits to authorized purposes.

Flood benefits provided by Millerton Lake result from the management of flood flows in authorized flood management storage space operated by the US Army Corps of Engineers (USACE), and the availability of non-flood storage capacity that fills before authorized flood space becomes encroached. Water that cannot be delivered because of constrained capacity in the FKC is temporarily stored in non-flood storage space in Millerton Lake until it can be delivered at a later time or until storage levels in Millerton Lake encroach into authorized flood control space and it must be released as flood flows from Friant Dam to the San Joaquin River.

As FKC canal capacity diminishes over time due to localized ground subsidence, the volume of water that can be delivered to Friant Division long-term contractors will continue to be reduced and authorized flood control space will be encroached upon more frequently, and for greater durations, including during periods that historically have not included flood releases, such as critically dry water years. Less available non-flood storage space results in increased frequency and magnitude of flood storage space encroachments, and increases the frequency, magnitude, and duration of flood flow releases to the San Joaquin River that would otherwise be delivered as Class 1, Class 2, RWA, or WRF water but for the reduced canal capacity due to subsidence. Restoration of the capacity of the Middle Reach of the FKC will restore the availability of non-flood storage capacity in Millerton Lake to manage authorized water supplies, thereby qualifying the project as a Federal "Storage" project under WIIN Act provisions.

In order to commence construction on a Federally owned storage project authorized by the WIIN Act, the Secretary must:

> *"A) determine(s) that the proposed federally owned storage project is feasible in accordance with reclamation laws;*
>
> *B) Secure(s) an agreement providing upfront funding as is necessary to pay the non-Federal share of the capital costs; and*
>
> *C) determine(s) that, in return for the Federal cost-share investment in the federally owned storage project, at least a proportionate share of the project benefits are Federal benefits, including water supplies dedicated to specific purposes such as environmental enhancement and wildlife refuges."*

Local Authorities

The FWA is a Joint Powers Authority (JPA) public agency formed through its members under California law to operate and maintain the FKC and to represent its members in policy, political, and operational decisions that could affect the Friant Division of the CVP. FWA was formed in 2004 as the successor agency to the Friant Water Users Authority (FWUA), which began FKC operations and maintenance (O&M) under agreement with Reclamation in 1986.

FWA maintains a professional staff with expertise in project operations, finance, and technical services that perform all on-going services related to the FKC O&M and represent their member entities. During the past 25 years, FWA and FWUA conducted several O&M actions along the FKC, including panel replacements, canal embankment seepage control, gate maintenance and repairs, automated monitoring, and control systems implementation.

As the responsible O&M entity for the FKC, FWA is leading the planning, permitting and design of the Project in coordination with Reclamation. FWA is the lead agency for environmental compliance pursuant to CEQA.

Study Area

The study area, shown in Figure 1-2, encompasses the FKC from MP 88.2 (Fifth Avenue check) to MP 121.5 (Lake Woollomes check), the service areas of six[1] Friant Division long-term contractors that can experience water supply reductions as a result of capacity restrictions in this reach, and areas that would be directly affected by construction-related activities.

[1] The six affected Friant Division long-term contractors include: Arvin-Edison Water Storage District, Delano-Earlimart Irrigation District, Kern-Tulare Water District, Saucelito Irrigation District, Shafter-Wasco Irrigation District, and Southern San Joaquin Municipal Utility District.

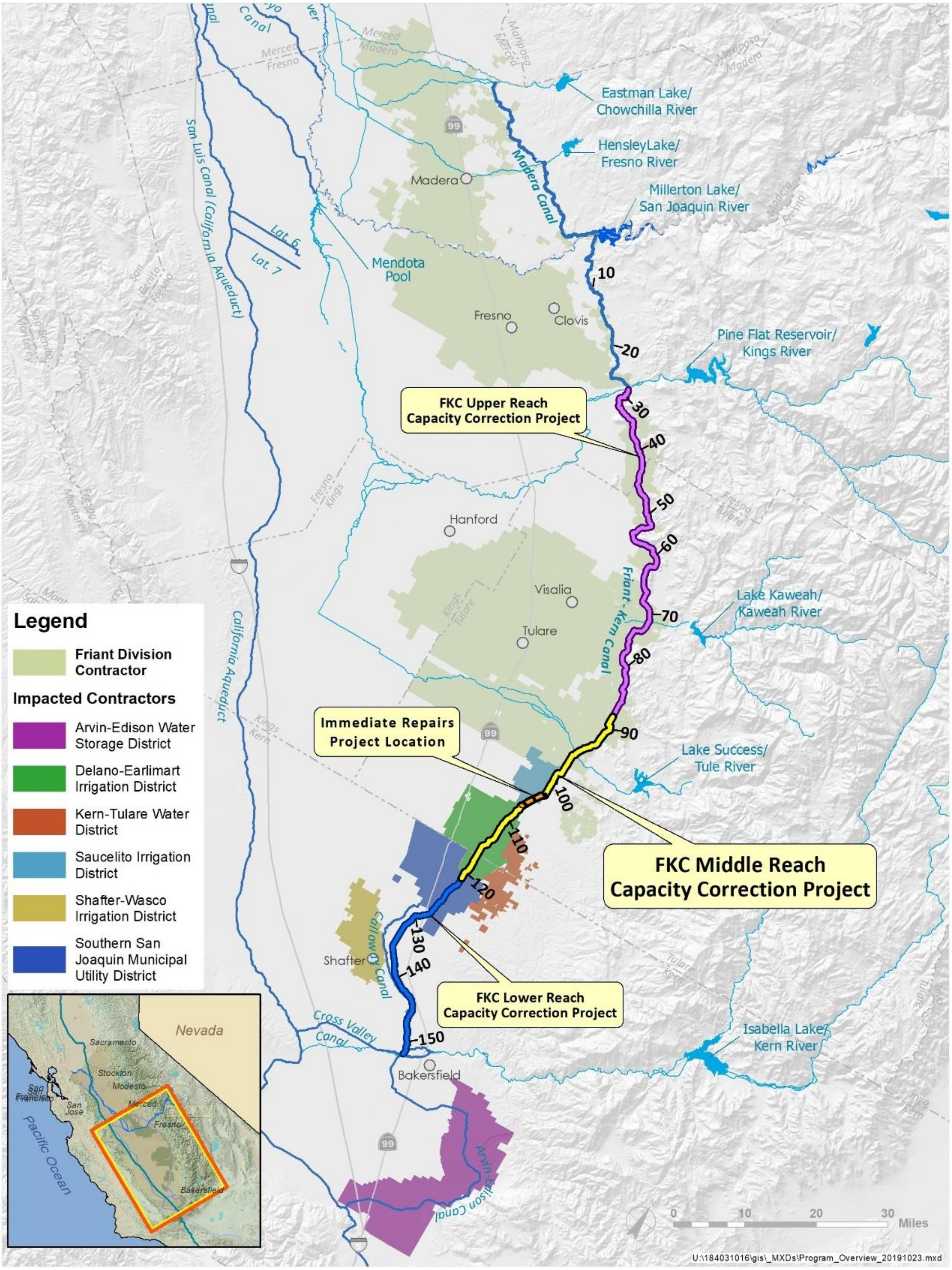

Figure 1-2. Study Area

Background

The FKC has a maximum design capacity of 5,300 cubic feet per second (cfs), gradually decreasing to 2,500 cfs to accommodate conveyance for downstream water demand. However, the maximum conveyance capacity has not been actualized due to several factors. Original design assumptions regarding the roughness or Manning's "n" value were found inaccurate shortly following construction completion. As a result, the FKC operating capacity is less than designed. Capacity has been further reduced by additional canal surface roughness with age, vegetation within canal sections, changes in water delivery patterns, localized seepage through embankments, and regional land subsidence.

In conjunction with the adjacent land, the canal has subsided. The FKC was designed with a relatively flat gradient, approximately 6 inches per mile, which makes it vulnerable to capacity reductions from subsidence. In particular, the section from MP 99 to MP 116 has subsided the most, with a significant localized depression between MP 103 and MP 107 that experienced subsidence greater than 10 feet since the FKC was constructed.

Over the decades, several efforts have been made to restore the canal capacity. In the late 1970s, Reclamation addressed subsidence-associated capacity reduction between MP 99 and MP 116 by raising the concrete lining on the canal. In the 1980s, Reclamation performed a subsequent lining raise between MP 0.0 and MP 28.5 that increased the canal capacity from 5,000 cfs to the design capacity of 5,300 cfs. While these efforts were successful, capacity restrictions continue to limit water deliveries throughout most of the canal.

The Settlement Act authorized the Secretary of the Interior to study, construct, and fund FKC capacity restoration to the original designed and constructed capacity. Under this authorization, Reclamation, identified four alternatives to restore the capacity of the entire FKC. However, the cost of all alternatives exceeded the available funding, which led to a focus on first restoring the Upper Reach from MP 29.14 to MP 88.2. Alternatives to restore capacity in the Upper Reach also exceeded the available funding. Reclamation presented the estimated costs to restore capacity of the Upper Reach to a group of Friant Division long-term contractors and FWA staff in September 2015. From that meeting, the contractors determined they would take the lead in identifying a path forward and report back to Reclamation.

In February 2017, FWA observed that a flow of 1,900 cfs was encroaching on the top of the liner and the lower chords of some bridges in the portions of the FKC Middle Reach (MP 88.2 to MP 121.5). In December 2017, FWA, on behalf of the Friant Division long-term contractors, provided their recommendations to Reclamation to complete appropriate feasibility, design, and compliance documents for the FKC Middle Reach. To temporarily reduce capacity constraints in the Middle Reach of the FKC before the Project is constructed, FWA also implemented an Immediate Repairs Project which installed a temporarily liner between 103.85 to MP 106.32 in the winter of 2018-2019.

The Project is part of the larger strategy to restore the design capacity of the entire FKC. The approach will be implemented through projects located in three reaches of the FKC, based on the operational characteristics of the canal as well as the nature of the corrective actions to be accomplished. Reaches with the greatest capacity reduction will be prioritized, and all reaches will be designed to restore the original design capacity of the FKC:

- Upper Reach Capacity Correction Project – this project will address design capacity reduction in the FKC from approximately MP 29 (Downstream Kings River Siphon) to MP 88 (Fifth Avenue Check). As noted above, this project was previously evaluated by Reclamation and has an estimated cost of $140 million in 2014 dollars;

- Middle Reach Capacity Correction Project – this project, which is the subject of this Report, will address design and subsidence capacity reduction in the FKC from approximately MP 88 (Fifth Avenue Check) to MP 121 (Woollomes Check). The Project includes the Immediate Repairs Project (MP 103.6 to MP 107.3). If the Project includes modifications at the same location, the Immediate Repair improvements will be removed and replaced with Project actions. The Project will be coordinated with the FKC Pump-back Project, also authorized by the SJRRS Act, to the extent possible to identify infrastructure affected by both projects in the Middle Reach; and

- Lower Reach Capacity Correction Project – this project will address capacity reduction in the FKC from approximately MP 121 to the canal terminus at MP 152. The project will also coordinate with FKC Pump-back Project for affected infrastructure in the Lower Reach. The extent of work required in the Lower Reach has not been evaluated at this time and does not impact the Project.

As of December 2018, Reclamation and the FWA finalized a Financial Assistance Agreement (FAA) for the FKC Capacity Correction Project (R19AC00013). The FAA describes authorized federal funding sources including the Settlement Act and the WIIN Act.

Related Studies, Projects, and Programs

The following is a summary of pertinent previous studies and current activities that affect the Study.

1960s – Reclamation Technical Memorandum No. 661

In the 1940s and 1950s, Reclamation constructed several large concrete canals and subsequently found they were incapable of conveying the flows specified in the original designs. In response, Reclamation conducted a technical investigation of several canals, including the FKC, to determine the cause of conveyance limitations in canals and published its findings in Technical Memorandum No. 661 – Analyses and Descriptions of Capacity Tests in Large Concrete-Lined Canals (Reclamation 1964). A major conclusion from the Technical Memorandum No. 661 was that the basic hydraulic loss formulas used during the design of the large concrete canals required adjustment. Specifically, the original designs for the FKC used a Manning's "n-value" (or friction coefficient) of 0.014 for concrete-lined sections. Results from the Technical Memorandum No. 661 demonstrated that the friction coefficient for concrete-lined sections ranges from 0.015 to 0.019.

1970s – Reclamation Friant-Kern Canal Liner Raise

In the late 1970s, Reclamation addressed subsidence problems along the FKC between MP 99 to MP 116. In the 16.5-mile stretch, the concrete lining was raised between 1 foot and 4.5 feet above the top-of-canal lining. To accommodate the canal lining raise, Reclamation raised four concrete bridges approximately 3 feet (Ave. 112, Ave. 88, Ave. 80, and Road 192) and reconstructed and raised a farm bridge by 4.5 feet. When raising the bridges, Reclamation also modified attached utility pipe crossings. In conjunction with the liner raise and bridge work, Reclamation adjusted several turnouts, drain inlets, check structures, and culverts.

1980 – Reclamation Upper Reach Work

Between 1977 and 1980, Reclamation authorized, designed, and constructed a lining raise between the FKC headworks at MP 0.00 and the Kings River Check at MP 28.50. This work was necessitated by an increase in water demand and operational control. Thus, the initial maximum capacity of the FKC was increased from 5,000 cfs to 5,300 cfs and the design deficiency in this reach was corrected. The details for this construction can be found in Reclamation specification DC-7295.

2002 – FWA Liner Raise

In 2002, FWA installed an 18-inch concrete liner raise, from MP 75.77 (Spruce Bridge) to just downstream of MP 76.37 (Marinette Bridge). The purpose of this project was to both address subsidence and increase the flow capacity from 3,950 cfs to 4,300 cfs.

2018-2019 – Immediate Repairs

During the winter of 2018 to 2019, FWA undertook a series of repairs to increase the capacity of the Middle Reach to the extent possible while the Project is implemented. FWA installed a 0.045-inch-thick reinforced polypropylene liner between MP 103.85 and MP 106.32, coated five bridges with a protective sealant, repaired or reinforced utility supports spanning bridges, and mud-jacked as necessary to control seepage.

San Joaquin River Restoration Program

The Settlement Act, included in Public Law 111-11 and signed into law on March 30, 2009, authorizes and directs the Secretary of the Interior to implement the Stipulation of Settlement of Natural Resource Defense Council (NRDC) et al. v. Kirk Rodgers et al. (Settlement), which ended an 18-year legal dispute over the operation of Friant Dam and resolved longstanding legal claims brought by a coalition of conservation and fishing groups led by the NRDC. Reclamation is the Federal lead agency for the San Joaquin River Restoration Program (SJRRP). Along with

Reclamation, the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), California Department of Water Resources (DWR), and California Department of Fish and Wildlife (CDFW) are implementing agencies.

The Settlement establishes two goals: (1) the Restoration Goal is 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, and (2) the Water Management Goal is 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.

To achieve the Water Management Goal, Paragraph 16 of the Settlement and Part III of the Settlement Act provide for actions to recapture Restoration Flows and increase access to water supply during wet hydrologic conditions, including restoration of the capacity of the FKC and Madera Canal. The reduced capacity of the FKC constrains Reclamation's ability to implement actions to achieve the Water Management Goal.

Interim Flows for experimental purposes began in 2009, and Restoration Flows began January 1, 2014. Current channel capacity constraints limit the ability to release full Restoration Flows. The flows will increase gradually over the next several years as channel capacity is increased through the implementation of SJRRP actions.

Friant-Kern Canal Capacity Restoration Feasibility Study

Part III of the Settlement Act authorizes Reclamation to conduct feasibility studies on restoration of the designed and constructed capacity of the FKC and Madera Canal. In 2011, Reclamation completed a Draft Feasibility Report for the FKC with the planning objective to improve the water deliveries and reliability within a funding constraint of $25,000,000. Estimated costs to restore the original designed and constructed capacity of the entire FKC exceeded the available funding. Therefore, the feasibility study alternative focused on raising the canal lining in the Upper Reach from the Kings River Siphon outlet (MP 29.14) to the 5th Avenue Check (MP 88.2). Based on the Draft Feasibility Report recommendations, Reclamation prepared a 60 percent design and cost estimate for the Upper Reach of the FKC, which found the project formulation was not feasible within the funding authorized in the Settlement Act.

Part III Financial Assistance for Local Projects

Part III of the Settlement Act authorizes Reclamation to provide financial assistance to local agencies within the Friant Division of the CVP for the planning, design, environmental compliance, and construction of local facilities to bank water underground or recharge groundwater. A project will be eligible if all or a portion of the project is designed to reduce, avoid, or offset the quantity of expected water supply impacts to Friant Division long-term contractors caused by Restoration Flows in the San Joaquin River released pursuant to the Settlement.

Reclamation completed Guidelines for the Application of Criteria for Financial Assistance for Local Projects under Part III of Public Law 111-11 (Guidelines) in consultation with Friant

Division long-term contractors. The Guidelines provide a framework for obtaining Federal financial assistance for Friant Division groundwater recharge and/or banking projects as authorized by Part III. Consistent with statutory requirements of Part III of the Settlement Act, Office of Management and Budget cost principles and Reclamation policy, the Guidelines address the contents of a complete Planning Report and cost-share agreement.

Several Part III Projects have been constructed and are in operation in the Study Area and result in an increased ability to recharge groundwater. This increase in recharge capability can increase demand during wet hydrologic periods when FKC flows are typically highest. The reduced capacity of the FKC constrains the ability to deliver water to Part III projects.

Friant-Kern Canal Reverse Flow Pump-back Project

In September 2016, Reclamation and FWA entered into FAA Number R16AC00106 for the Friant-Kern Canal Reverse Flow Pump-back Project whereby FWA will perform the planning, environmental compliance documentation, and design and construction of Reverse Flow Pump-back Facilities. Reclamation initially studied permanent pump-back facilities along the southern portion of the FKC as part of the SJRRP. Reclamation evaluated permanently increasing pumping capacities to 200 cfs at the Shafter Check Structure and 75 cfs at the Lake Woollomes and Deer Creek Check structures. Building on the appraisal study, FWA is considering sizing the Reverse Flow Pump-back to improve water management during drought conditions. The MRCCP involves coordination with the Pump-Back Facilities Project.

Sustainable Groundwater Management Act

A three-bill package, known as the Sustainable Groundwater Management Act (SGMA), was passed by the California legislature and signed into law by Governor Edmund G. Brown in 2014. This legislation, amended in 2015, allows local agencies to customize groundwater sustainability plans to their regional economic and environmental needs, and creates a framework for sustainable, local groundwater management. The act defines sustainable groundwater management as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" such as land subsidence and water quality degradation.

The Study Area includes several groundwater basins designated under SGMA as high-priority due to the severity of groundwater overdraft. As a result of this designation, the managing agencies or Groundwater Sustainability Agencies (GSA) in the area are required to adopt Groundwater Sustainability Plans (GSP) by January 31, 2020. The GSAs have twenty years to implement their GSPs and achieve their sustainability goal in the basin by 2040.

Chapter 2 Water Resources and Related Conditions

One of the most important elements of any water resources evaluation is defining existing conditions in the study area, the associated problems and opportunities, and how these conditions may change in the future. This chapter describes these critical topics which will provide guidance for the solutions presented in subsequent chapters.

Existing Conditions in Study Area

The existing and likely future conditions are used to establish the basis of comparing potential alternative plans, a process consistent with PR&G, NEPA, CEQA, and Reclamation D&S Standards. This section briefly discusses existing conditions in the study area.

Surface Water

The major surface water resources in the study area are the San Joaquin River and its tributaries. The San Joaquin River is the second longest river in California. It originates in the Sierra Nevada mountain range at an elevation of approximately 12,000 feet above mean sea level and carries snowmelt from mountain meadows to the valley floor before turning north and becoming the backbone of tributaries draining into the San Joaquin Valley. The San Joaquin River discharges to the Sacramento-San Joaquin Delta from the south and, ultimately, to the Pacific Ocean through San Francisco Bay.

Groundwater

The San Joaquin Valley Groundwater Basin, Figure 2-1, makes up the southern two-thirds of the 400-mile-long, northwest-trending, asymmetric trough of the Central Valley regional aquifer system (Page 1986). The study area overlies two main hydrologic regions within the San Joaquin Valley Groundwater Basin: The San Joaquin River Hydrologic Region and the Tulare Lake Hydrologic Region.

The San Joaquin River Hydrologic Region consists of surface-water basins that drain into the San Joaquin River system, from the Cosumnes River basin in the north through the southern boundary of the San Joaquin River watershed (DWR 1999). Aquifers in the San Joaquin Valley Groundwater Basin typically extend to depths of 800 feet. The San Joaquin River Hydrologic Region relies heavily on groundwater, accounting for approximately 30 percent of the region’s annual water supply for agricultural and urban uses (DWR 2003).

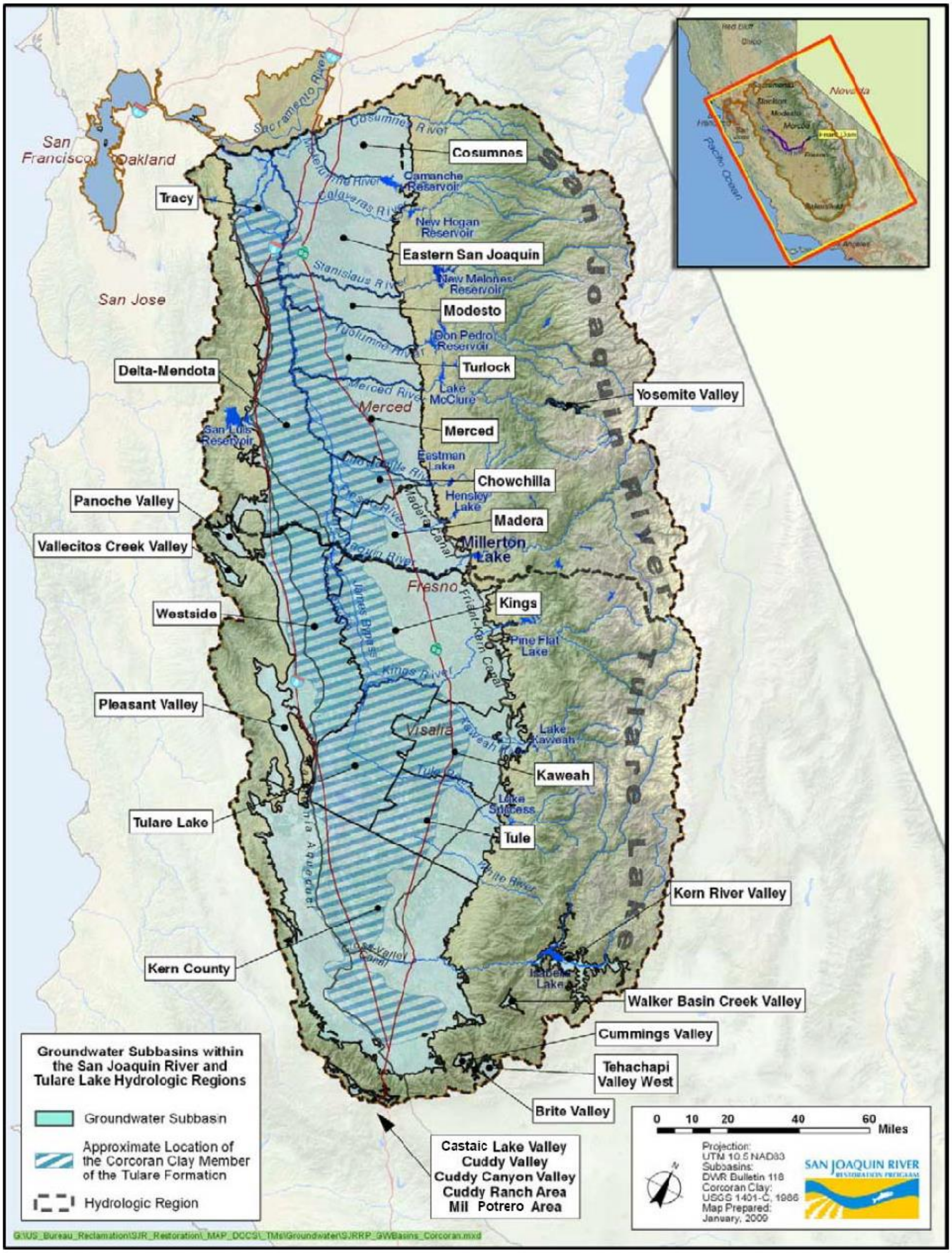

Figure 2-1. San Joaquin Valley Groundwater Basin and Sub-basins

The Tulare Lake Hydrologic Region is a closed drainage basin at the south end of the San Joaquin Valley, and encompasses the Kings, Westside, Pleasant Valley, Kaweah, Tulare Lake, Tule, and Kern County groundwater sub-basins. In the hydrologic region, the primary aquifer extends 1,000 feet below the surface (DWR 2003). The Tulare Lake Hydrologic Region also relies heavily on groundwater supplies; groundwater use has historically accounted for 41 percent of the total annual water supply within the region and for 35 percent of all groundwater use in California. Groundwater use in this hydrologic region represents approximately 10 percent of the state's total agricultural and urban water use (DWR 1998).

Friant Division of the Central Valley Project

The Friant Division of the CVP provides water to over one million acres of irrigated land on the east side of the southern San Joaquin Valley. Principal features of the Friant Division include Friant Dam and Millerton Lake, and the Madera and Friant-Kern canals.

Friant Dam and Millerton Lake

Friant Dam is a concrete gravity dam that impounds Millerton Lake on the San Joaquin River, located about 16 miles northeast of Fresno near the community of Friant. The dam, owned and operated by Reclamation, began releasing water from Millerton Lake in 1942. The lake has a capacity of 524 thousand acre-feet (TAF) which is typically filled during late spring and early summer from snowmelt. Prior to SJRRP implementation, annual water allocations draw down the reservoir storage to minimum levels by the end of September. Post-SJRRP implementation, the reservoir will reach minimum storage levels during late fall to early winter.

Friant Dam releases water deliveries to the Friant-Kern and Madera canal through outlet works. Outlets to the Madera Canal are located on the right side of the dam and outlets to the Friant-Kern Canal are located on the left. There is also a river outlet works located to the left of the spillway within the lower portion of the dam. The Friant Power Authority owns and operates powerhouses located on the FKC and Friant Dam river outlets that have a combined capacity of about 30 megawatts.

Madera Canal

The Madera Canal, operated and maintained by the Madera and Chowchilla Water and Power Authority, is a 36-mile-long canal that begins at Millerton Lake and terminates at the Chowchilla River. The canal was designed with an initial capacity of 1,000 cfs at the headworks, decreasing to 625 cfs at the Chowchilla River. In 1965, the canal lining was raised from the headworks to MP 2.09, increasing the capacity in that reach to 1,250 cfs.

Friant-Kern Canal

The FKC, operated and maintained by FWA, is a 152-mile, gravity canal that spans from Friant Dam south to the Kern River. The FKC has a maximum design capacity of 5,300 cfs, gradually decreasing to 2,500 cfs to accommodate conveyance for downstream water demand. However, maximum design capacity has not been actualized. Original design assumptions regarding the roughness or Manning's "n" value were found inaccurate shortly following completion of the canal, resulting in capacity reductions. The capacity has been further reduced because of increased canal surface roughness with age, vegetation within canal sections, changes in water delivery patterns, localized seepage through canal embankments, and land subsidence. As described in Chapter 1, the Project focuses on the FKC Middle Reach, from MP 88.2 to MP 121.5, which comprises four segments, as described below. The features and structures of the FKC Middle Reach are depicted on a single-line diagram in Figure 2-2A and 2-2B and summarized in Table 2-1. For more detail, refer to Appendix B Feasibility Alternatives Engineering Design and Cost.

Segment 1: 5th Ave. to Tule River The first (most upstream) segment of the Project is about 13 miles long and extends from the 5th Ave. Check (MP 88.2) to the Tule River (MP 95.6). It was designed for a normal flow of 3,500 cfs and a design maximum flow of 4,500 cfs. Sixteen state/county bridges cross the FKC in this segment and one bridge runs parallel to a siphon. In addition, this segment includes seven turnouts, three siphons, one wasteway, and one weir.

Segment 2: Tule River to Deer Creek The second segment is about seven miles long and extends from Tule River (MP 95.6) to Deer Creek (MP 102.7). It was designed for a normal flow of 3,000 cfs and a maximum flow of 4,000 cfs. Six state/county bridges one farm bridge, and one bridge parallel to a siphon cross the FKC in this segment. In addition, this segment includes ten turnouts and one siphon.

Segment 3: Deer Creek to White River The third segment is about 10 miles long and extends from Deer Creek (MP 102.7) to White River (MP 112.9). It was designed for a normal flow of 3,000 cfs and a maximum flow of 4,000 cfs. Ten state/county bridges and two farm bridges cross the FKC in this segment. In addition, this segment includes, nine turnouts, one siphon, and one wasteway in this segment.

Segment 4: White River to Woollomes The fourth segment is about eight miles long and extends from White River (MP 112.9) to Lake Woollomes (MP 121.5). It was designed for a normal flow of 2,500 cfs and a design maximum flow of 3,000 cfs. Eight state or county bridges, two farm bridges, and one abandoned railroad bridge cross the FKC in this segment. In addition, this segment includes 12 turnouts, one siphon, and one reservoir structure (Lake Woollomes). The downstream limit of the Project is MP 121.5.

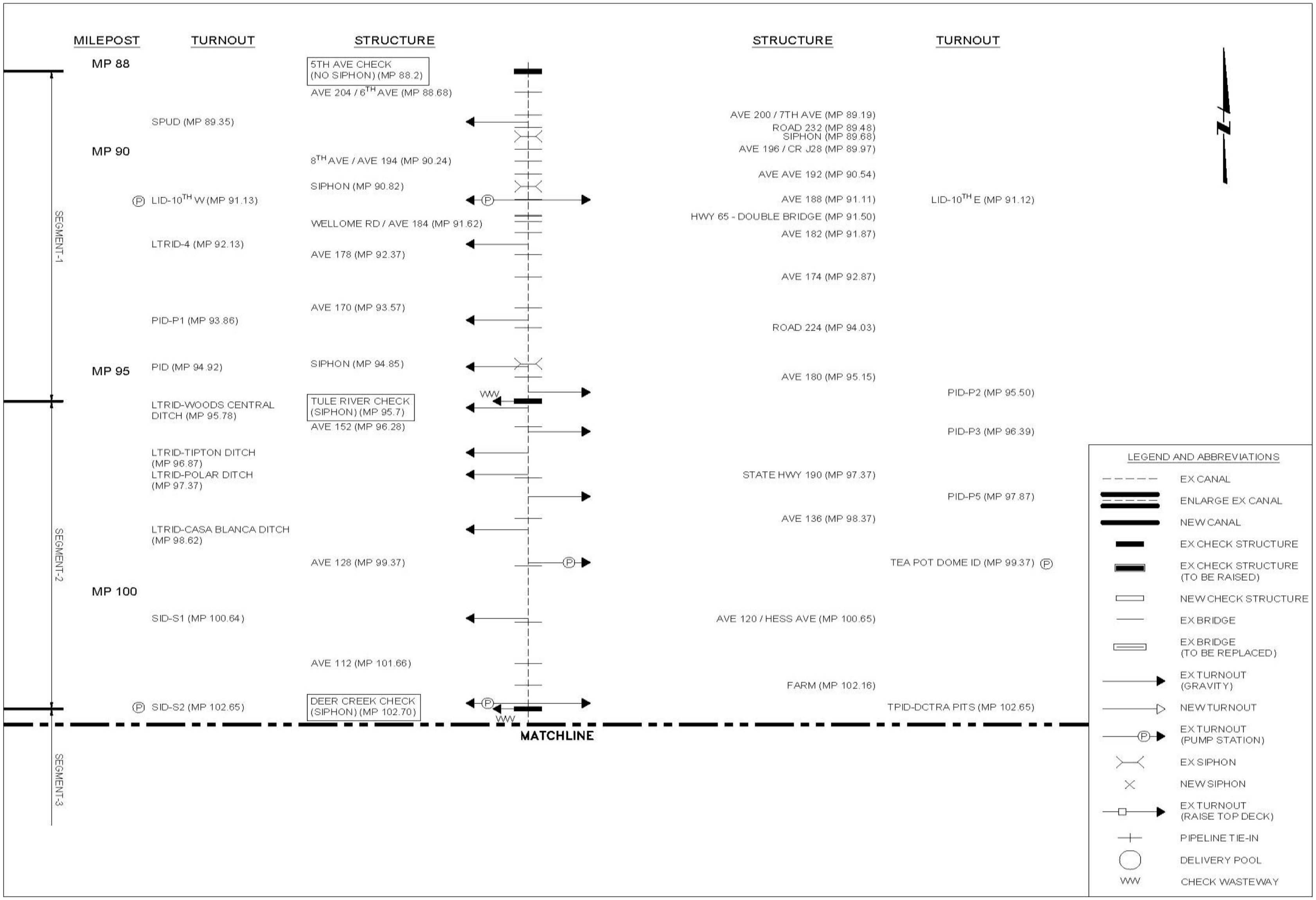

Figure 2-2A. Existing Canal Single-Line Diagram of Segments 1 and 2

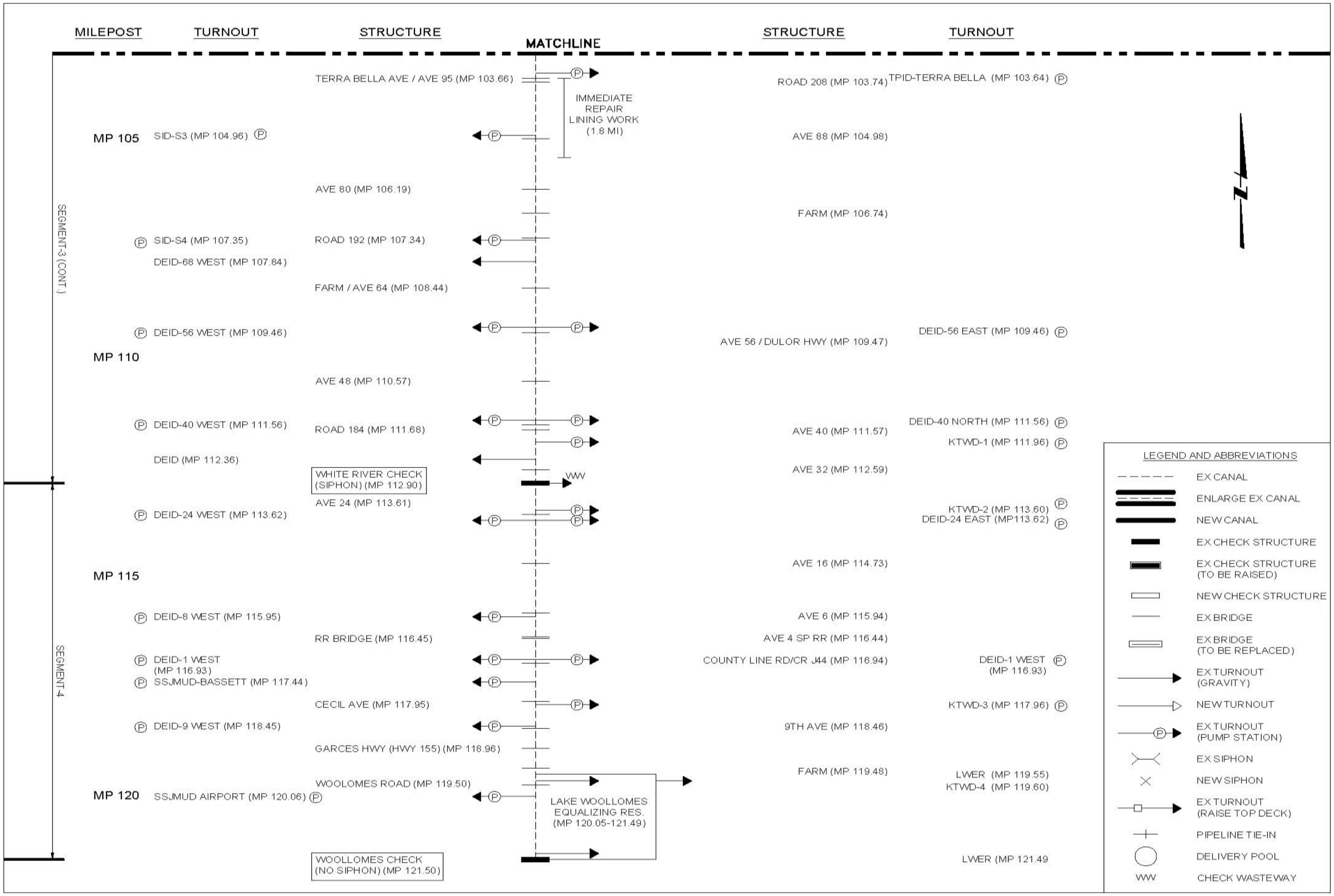

Figure 2-2B. Existing Canal Single-Line Diagram of Segments 3 and 4

Table 2-1. Friant-Kern Canal Structures by Segment

Structures	Segment 1 5th Ave. to Tule River (MP 88.2 – 95.6)	Segment 2 Tule River. to Deer Creek (MP 95.6 – 102.7)	Segment 3 Deer Creek to White River (MP 102.7 – 112.9)	Segment 4 White River. to Woollomes (MP 112.9 – 121.5)
Bridges, State/County	16	6	10	8
Bridges, Farm	0	1	2	2
Bridges, Other	1	1	0	1
Turnouts	7	10	9	12
Siphons	3	1	1	1
Other Structures	1 Wasteway, 1 Weir	0	1 Wasteway	1 Reservoir Structure

Note: Bridges, Other refers to the bridges parallel to siphons or the abandoned railroad bridge.

Friant Division Water Contracts

Reclamation holds most of the water rights on the San Joaquin River, allowing diversions at Friant Dam through purchase and exchange agreements with entities, or long-term contractors. Thirty-two Friant Division long-term contractors in Madera, Fresno, Kings, Tulare and Kern counties supply water to over 1.2 million acres of irrigated land, several small rural communities, and large urban areas.

Reclamation employs a two-class system of water contracts in the Friant Division. Class 1 contracts total 800 TAF and are dependable water supply and are generally assigned to agricultural and urban water users who have limited access to good quality groundwater. Class 2 contracts total approximately 1,401 TAF and, because of its uncertainty as to availability and timing, Class 2 contracts are considered undependable in nature and are applicable only when Reclamation makes available. Class 2 contracts support regional conjunctive use and are the basis to provide water supplies for groundwater replenishment during wetter years. Contract amounts for all Friant Division long-term contractors are listed in Table 2-2 and locations are shown in Figure 2-3.

Table 2-2. Friant Division Long-Term Contractors and Friant Water Authority Membership

Friant Division Long-Term Contractor[1]	FWA Membership		Class 1 Contract		Class 2 Contract		Total Contract	
	FKC O&M Membership	Representation Membership	(AF)	(% of Total)	(AF)	(% of Total)	(AF)	(% of Total)
Chowchilla WD		X	55,000	6.9	160,000	11.4	215,000	9.8
Madera ID		X	85,000	10.6	186,000	13.3	271,000	12.3
Gravelly Ford WD			-	0.0	14,000	1.0	14,000	0.6
Madera County			200	0.0	-	0.0	200	0.0
Fresno County			150	0.0	-	0.0	150	0.0
Garfield WD	X		3,500	0.4	-	0.0	3,500	0.2
International WD	X		1,200	0.2	-	0.0	1,200	0.1
City of Fresno	X	X	60,000	7.5	-	0.0	60,000	2.7
Fresno ID	X	X	-	0.0	75,000	5.4	75,000	3.4
Tri-Valley WD	X		400	0.1	-	0.0	400	0.0
Hills Valley ID	X	X	1,250	0.2	-	0.0	1,250	0.1
City of Orange Cove	X		1,400	0.2	-	0.0	1,400	0.1
Orange Cove ID	X	X	39,200	4.9	-	0.0	39,200	1.8
Stone Corral ID	X		10,000	1.3	-	0.0	10,000	0.5
Ivanhoe ID	X		6,500	0.8	500	0.0	7,000	0.3
Kaweah Delta Water Conservation District	X	X	1,200	0.2	7,400	0.5	8,600	0.4
Tulare ID	X	X	30,000	3.8	141,000	10.1	171,000	7.8
Exeter ID	X		11,100	1.4	19,000	1.4	30,100	1.4
Lewis Creek WD	X		1,200	0.2	-	0.0	1,200	0.1
City of Lindsay	X		2,500	0.3	-	0.0	2,500	0.1
Lindsay-Strathmore ID	X	X	27,500	3.4	-	0.0	27,500	1.2
Lindmore ID	X	X	33,000	4.1	22,000	1.6	55,000	2.5
Lower Tule River ID	X		61,200	7.7	238,000	17.0	299,200	13.6
Porterville ID	X	X	15,000	1.9	30,000	2.1	45,000	2.0
Saucelito ID	X	X	21,500	2.7	32,800	2.3	54,300	2.5
Terra Bella ID	X	X	29,000	3.6	-	0.0	29,000	1.3
Tea Pot Dome WD	X		7,200	0.9	-	0.0	7,200	0.3
Delano-Earlimart ID	X		108,800	13.6	74,500	5.3	183,300	8.3
Kern-Tulare WD	X	X	-	0.0	5,000	0.4	5,000	0.2
Southern San Joaquin MUD	X		97,000	12.1	45,000	3.2	142,000	6.5
Shafter-Wasco ID	X		50,000	6.3	39,600	2.8	89,600	4.1
Arvin-Edison Water Storage District	X	X	40,000	5.0	311,675	22.2	351,675	16.0
Total Contract (AF)	**800,000**			**1,401,475**		**2,201,475**		

Note: [1]Contractors listed in a north to south orientation
Key:
AF = acre-feet
FKC = Friant-Kern Canal
FWA = Friant Water Authority
ID = irrigation district
MUD = municipal utility district
O&M = operations and maintenance
WD = water district

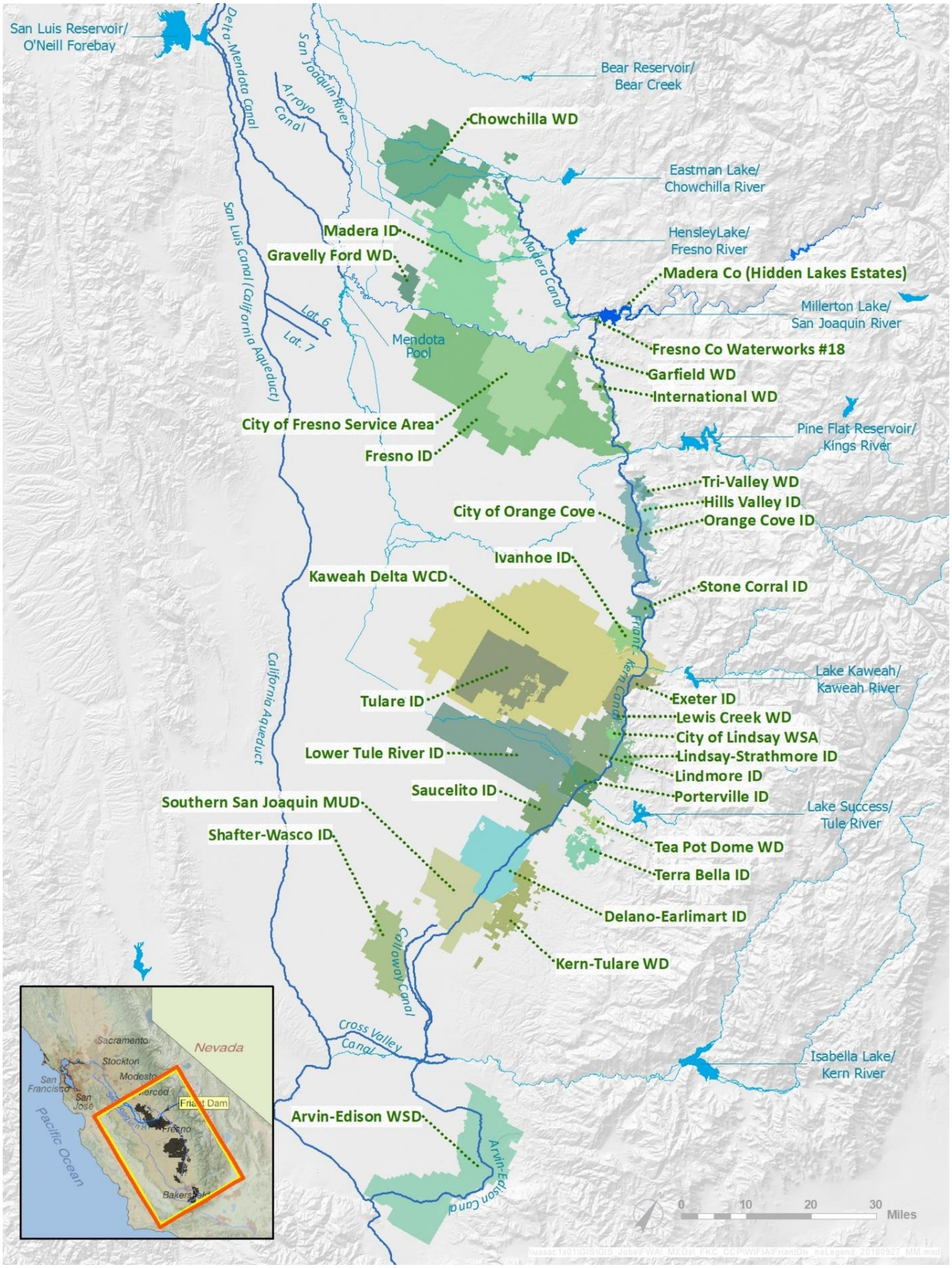

Figure 2-3. Friant Division Long-Term Contractors

In addition, Friant Division long-term contractors can obtain surface water in accordance with Section 215 of the Reclamation Reform Act of 1982 and under the provisions of Paragraph 16(b) of the Settlement. Section 215 authorizes Reclamation to deliver water that cannot be stored and otherwise would be released in accordance with flood management criteria or unmanaged flood flows. Delivery of Section 215 water has enabled the replenishment of San Joaquin Valley groundwater at higher levels than otherwise could be supported with Class 1 and Class 2 contract deliveries. Paragraph 16(b) provides for the delivery of water during wet hydrologic conditions at a cost of $10 per acre-foot, when water is not needed for Restoration Flows.

Friant Division long-term contractors schedule deliveries through daily water orders to Reclamation at Friant Dam. Due to long-standing irrigation practices, water delivery amounts vary by day of the week; water delivery demands are generally higher mid-week and lower on weekends. A review of historical releases at the FKC headworks from 2000 to 2017 demonstrates that daily demand can vary by week, month, and water year type. During a week, daily demand can vary by as much as 30 percent during July, at the peak of the irrigation season . The magnitude and timing of the variations fluctuate in accordance with the water year type; the largest variations occur during the peak irrigation months of dryer years and late irrigation months of wet years, as shown in Figure 2-4.

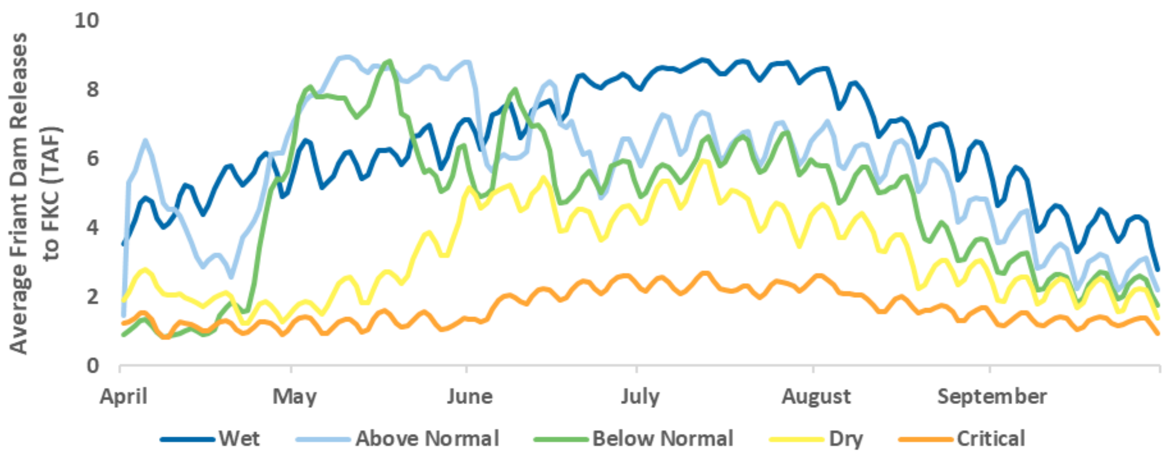

Figure 2-4. Average Daily Distribution Pattern by Water Year Type from 1921-2003

Land Use and Agricultural Resources

The Friant Division of the CVP contains some of the most productive lands in California, with the study area containing the top three agricultural producing counties in the nation (USDA 2007). The primary land uses in the study area are agriculture, urban, and open space; agriculture accounts for the majority of land use, with urban and open space accounting for only a small percentage. Table 2-3 shows the acreages of land use by the Friant Division long-term contractors that receive water deliveries from the FKC.

Table 2-3. Existing Land Uses in the Friant Division

Friant Division Long-Term Contractor	Land Use (acres)			
	Agricultural	Open Space	Urban	Total
Chowchilla ID	85,869	0	2,250	88,119
Madera ID	123,830	1	6,882	130,713
Gravelly Ford WD	8,431	0	0	8,431
Madera County*	0	0	154	154
Fresno County WW No. 18	251	2	0	253
Garfield WD	1,813	0	0	1,813
International WD	724	0	0	724
City of Fresno	0	1,210	88,790	90,000
Fresno ID	187,489	64	60,336	247,889
Tri Valley WD*	1,800	2,700	0	4,500
Hills Valley ID*	3,500	800	0	4,300
City of Orange Cove	286	0	674	960
Orange Cove ID	29,163	0	116	29,279
Stone Corral ID	6,882	0	0	6,882
Ivanhoe ID	10,983	0	0	10,983
Kaweah Delta Water Conservation District*	299,000	11,000	30,000	340,000
Tulare ID	69,293	0	4,220	73,513
Exeter ID	14,078	0	1,136	15,214
Lewis Creek WD	1,297	0	0	1,297
City of Lindsay	415	0	1,113	1,528
Lindsay-Strathmore ID	15,628	0	492	16,120
Lindmore ID	27,483	0	214	27,697
Lower Tule River ID	102,159	932	185	103,276
Porterville ID	15,842	0	1,194	17,036
Saucelito ID	19,826	0	0	19,826
Terra Bella ID	13,642	0	272	13,914
Tea Pot Dome WD	3,581	0	0	3,581
Delano-Earlimart ID	56,264	0	353	56,617
Kern-Tulare WD	17,433	2,639	0	20,082
Southern San Joaquin MUD	56,233	79	5,308	61,620
Shafter-Wasco ID	36,042	0	2,952	38,994
Arvin-Edison WSD	128,941	220	3,691	132,852
Total	**1,338,178**	**19,647**	**210,332**	**1,568,157**

Source: Draft SJRRP PEIS/R.
* *Friant Division Atlas*
Key:
ID = Irrigation District
MUD = Municipal Utility District
WD = Water District
WSD = Water Storage District

Problems, Needs, and Opportunities

Four predominant problems in the study area impact Friant Division water supply delivery and reliability: FKC design deficiency, groundwater overdraft, subsidence, and reduced canal capacity. The proceeding conditions are described below in the order they occurred in time. These problems can be addressed through the Settlement Act, other provisions of P.L. 111-11, the WIIN Act, and the local implementation of SGMA.

Friant-Kern Canal Design Deficiency

The FKC was built prior to the development of Reclamation's current Design Standards No. 3, Release No. DS-3-5, dated 1967, and revised in 1994. As such, assumptions used in the original design led to an inability to achieve design conveyance capacity.

The design deficiency was recognized in the 1940s and 1950s when Reclamation observed that many large concrete canals were incapable of conveying flows specified in the original designs. This problem prompted a study on several canals in the 1950s, including the FKC. Reclamation documented the conclusions and results of this study in their early 1960s Technical Memorandum No. 661 – Analyses and Descriptions of Capacity Tests in Large Concrete-Lined Canals. Through Part III of the Settlement Act, Reclamation is authorized to restore the original design capacity.

Groundwater Overdraft

Groundwater overdraft is a regional problem that directly impacts FKC water deliveries. Overdraft occurs when use exceeds the recharge rate of an aquifer. Through an extensive evaluation process, the State classified which groundwater basins are subject to critical conditions of overdraft.[1] According to Bulletin 118 (DWR 2016), five subbasins in the Tulare Lake Hydrologic Region (Kings, Tulare Lake, Kern County, Kaweah, and Tule) and three subbasins in the San Joaquin River Hydrologic Region (Chowchilla, Eastern San Joaquin, and Madera) are subject to critical conditions of overdraft.

These eight subbasins are subject to critical conditions of overdraft as a result of limited access to surface water during dry hydrologic periods and widespread agricultural land use. The reduced FKC capacity, as a result of subsidence, affects Friant Division water deliveries to lands in some of these subbasins. As FKC capacity decreases, Friant Division contractors will likely meet their water needs with additional groundwater, causing groundwater levels to further decline. As groundwater levels decrease, the risk grows for impaired water quality, reduced water storage, and increased subsidence. To mitigate these risks, GSAs are developing GSPs under SGMA requirements. As the plans go into effect, it is likely that water users will adopt water

[1] Bulletin 118, Update 1980 defines a groundwater basin subject to critical conditions of overdraft "when continuation of present water management practices would probably result in significant adverse overdraft related environmental, social, or economic impacts."

management practices that include greater conservation of groundwater and surface water, yet their ability to implement these actions will be limited due to reduced capacity in the FKC.

Subsidence

Subsidence is a consequence associated with groundwater overdraft. When groundwater is extracted faster than the natural rate of replenishment, the water suspending fine-grained sediments are removed and the sediments compact, resulting in subsidence.

Subsidence is an ongoing regional issue, which was exacerbated during the 2012 to 2016 drought. Data from an interferometric synthetic aperture radar shows regional land subsidence from May 2015 to September 2016 lowered the land surface elevation by as much as 25 inches; within the FKC Middle Reach, the land subsided between 5 and 20 inches during this 16-month period (Figure 2-5).

The FKC is located over the eastern portion of the regionally subsided area. As of July 2018, it is estimated that the FKC is approximately 12 feet below the original constructed elevation, creating a significant low point in the Middle Reach between MP 103 and MP 107 (Figure 2-6). Subsidence, and its consequences for the FKC, can be minimized through implementation of both SGMA and the Settlement Act. With the implementation of GSPs, it is expected that subsidence will lessen over time. While the GSPs address the root cause of subsidence, the Settlement Act provides the authority to restore the original design capacity of the FKC. To minimize the potential recurrence of this problem, design improvements should include features to accommodate future subsidence.

The alternatives for the project considered in this report include design features that work to mitigate or accommodate the impact of future subsidence impacts to the FKC. Design considerations to accommodate future subsidence are described in Chapter 4, and include:

1. Additional embankment height – to allow the FKC to be operated at the required hydraulic grade line and provide design capacity as future subsidence occurs;

2. Road Crossing Siphons – designed to be function under increased water pressure associated with greater submergence resulting from future subsidence with no loss of conveyance capacity or risk of overtopping;

3. Structural Modifications – turnouts, siphon walls, and check structures designed to operate at the design hydraulic grade line without future modifications as future subsidence occurs.

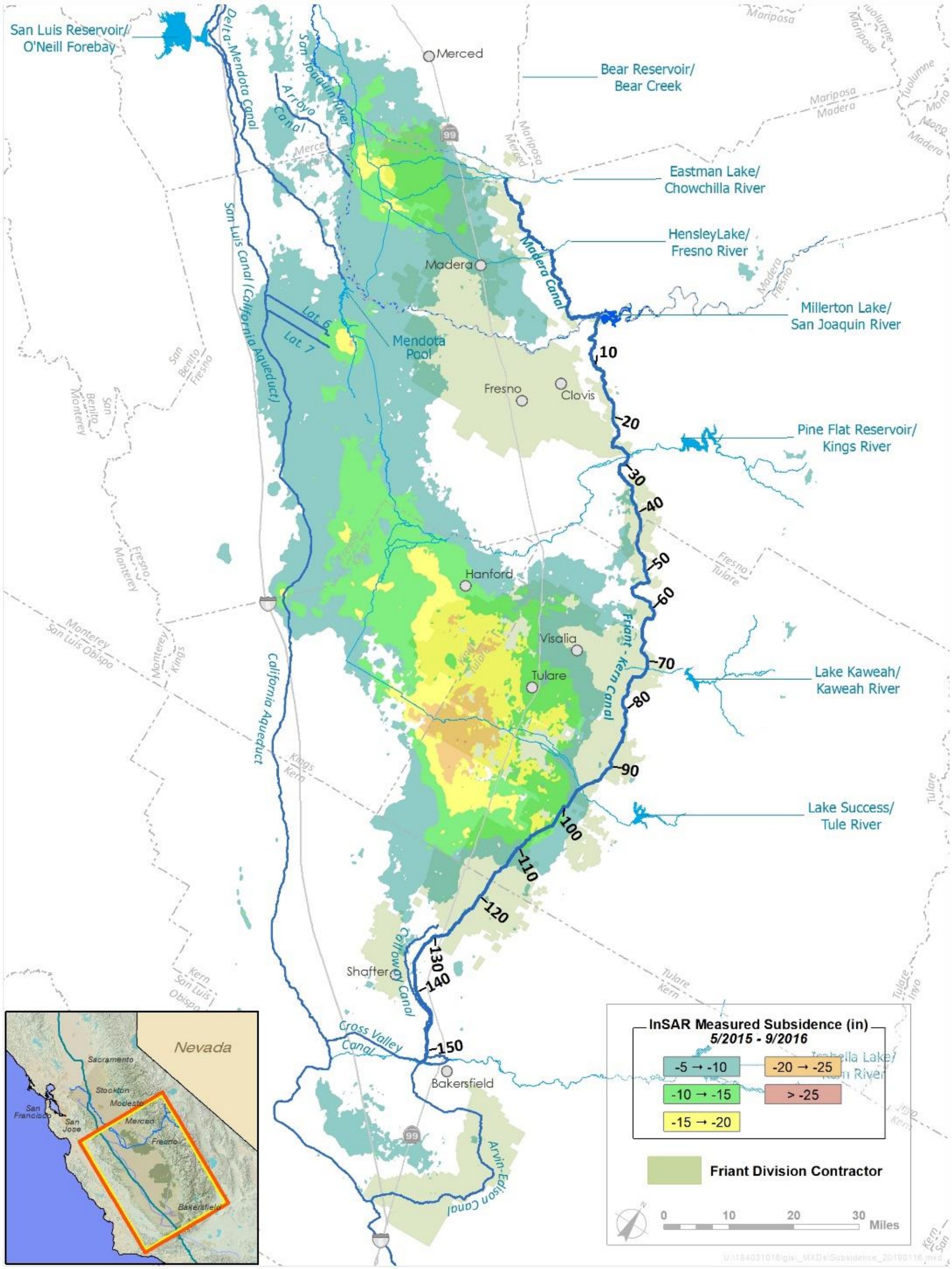

Figure 2-5. Recent Subsidence in the Friant Division

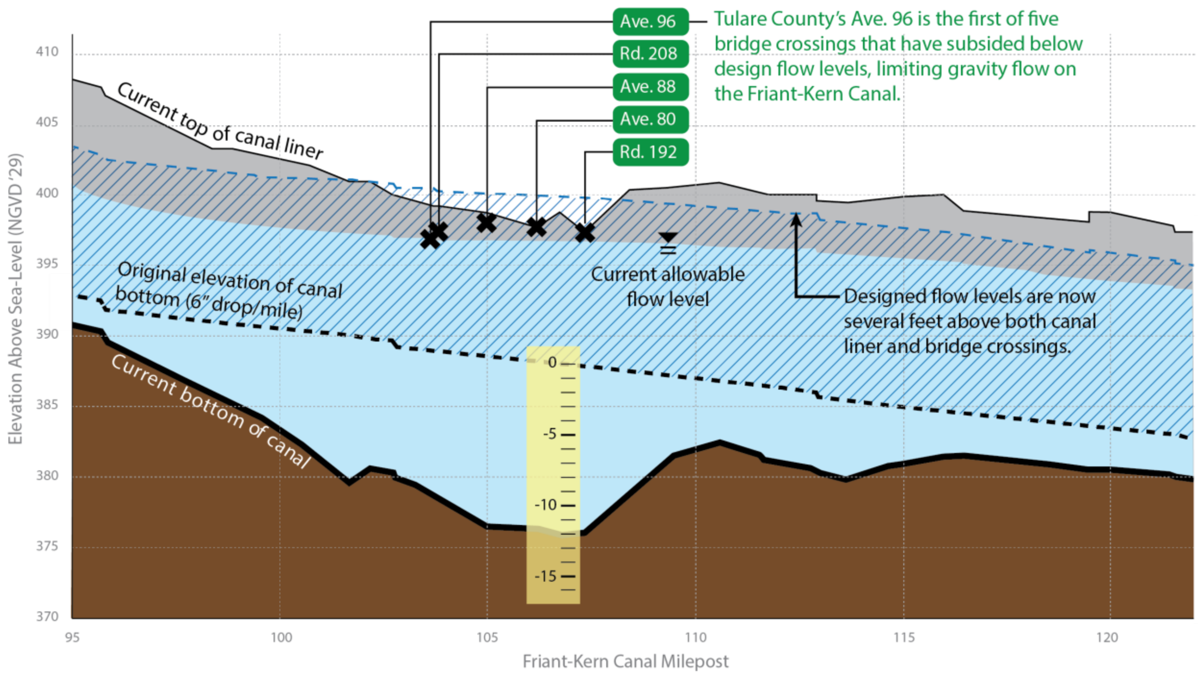

Figure 2-6. Schematic Illustration Along Friant-Kern Canal

Reduced Canal Capacity

As shown in Figure 2-7, the canal capacity is well below its designed maximum flow. The capacity reduction causes the water surface to encroach upon the operating freeboard and, at times, approach the top of the existing concrete liner. Operating canals at reduced freeboard increases seepage, which can damage the liner and increase risk of embankment failure. Higher water surface elevations can also adversely affect bridges, utilities, and other infrastructure.

During wet years, the reduced canal capacity limits the delivery of surface water supplies that would be used for groundwater replenishment, thereby creating an even greater reliance on groundwater supply. During dry years, contractors in the Friant Division conjunctive use area rely more on groundwater than surface water. The increased groundwater pumping reduces groundwater levels, which can further exacerbate subsidence and reduce the FKC capability to deliver surface water.

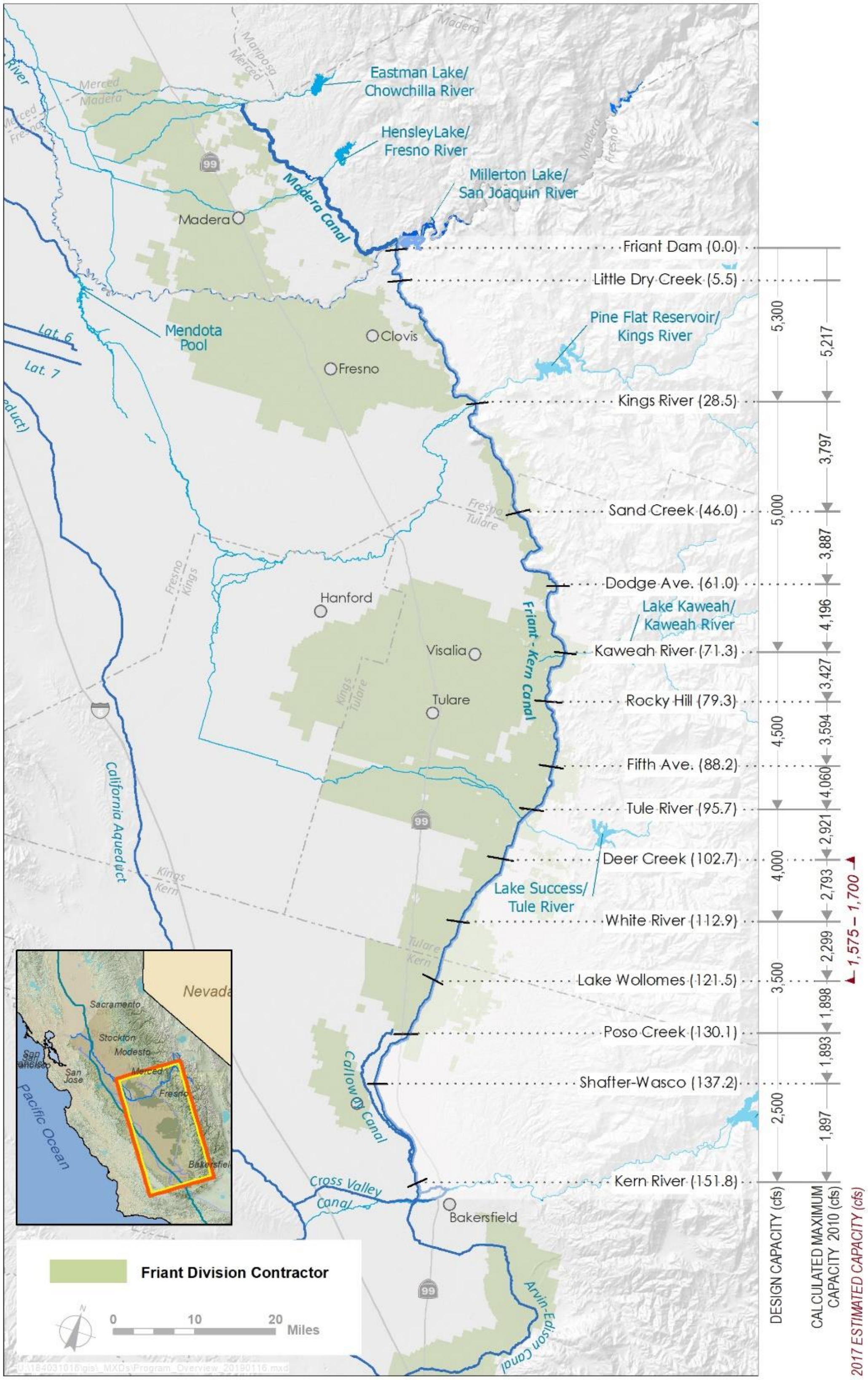

Figure 2-7. Estimated Capacity of the Friant-Kern Canal in 2017

Likely Future Without-Project Conditions Summary

The magnitude of potential water resources and related problems, needs, and opportunities is based not only on the existing conditions described above, but also on how these conditions may change in the future. Predicting future conditions is complicated by a variety of factors, including uncertainty regarding future regulatory requirements, ongoing programs and projects in the study area, future land subsidence, SGMA implementation, and future hydrologic conditions. The likely future without-project conditions represent the No Action Alternative, as discussed further in Chapter 4.

San Joaquin River Restoration Program Implementation

Physical changes to the San Joaquin River from Friant Dam to the Merced River are being implemented by the SJRRP and are assumed to be in place in the future without-project condition. These changes include levee modifications associated with incorporating new floodplain and related riparian habitat in the San Joaquin River, structure modifications to ensure fish passage, and channel capacity changes to accommodate Restoration Flows. The release of Restoration Flows will result in reductions to Friant Division water supplies.

Implementation of the SJRRP is progressing more slowly than planned due to unforeseen conditions and funding limitations. Currently, the release of full Restoration Flows is not possible due to downstream channel capacity constraints. As a result, URFs have been identified and made available to Friant Contractors. The availability of URFs will decrease as channel improvements enable greater releases of Restoration Flow volumes. Stage 1 SJRRP Implementation is scheduled to be completed by 2024 (SJRRP, 2018). The SJRRP anticipates project implementation would enable the release of full Restoration Flow volumes up to a maximum flow rate of 2,500 cubic feet per second (cfs) by the year 2025. When that occurs, water deliveries to Friant Division contractors will decrease to levels anticipated by the SJRRS.

SGMA Implementation

SGMA will be implemented by several GSAs to achieve compliance in the Study Area by 2040. During the past few years, GSAs in the Study Area have been estimating the extent of groundwater overdraft within their portion of the groundwater basins, identifying criteria to achieve sustainability, identifying potential actions that may be implemented, and preparing draft GSPs. The GSPs are still under development and specific projects, programs, and anticipated timelines are not yet finalized and therefore could not be included in this Study. Draft GSPs indicate that planned reductions in groundwater pumping will begin to be implemented in 2020. It is likely that SGMA implementation will result in changes in agricultural practices and cropping patterns, reduced irrigated acreage, and implementation of local and regional water management programs.

Future Subsidence

Subsidence projection studies relevant to the FKC Middle Reach are being developed in support of the Eastern Tule Basin GSA using the Tule Subbasins Groundwater Model. The Tule Subbasin model was developed using MODFLOW. MODFLOW is a block centered, finite difference groundwater flow modeling code developed by the United States Geological Survey (USGS) for simulating groundwater flow. MODFLOW is widely used and among the most accepted model codes available. The version of MODFLOW utilized for the Tule Subbasin Groundwater Model is the USGS One Water Hydrologic Flow Model, which integrates both surface water and groundwater processes. The model includes a subsidence and aquifer system compaction package, which was utilized for the analysis of subsidence.

It is generally recognized that future groundwater pumping for agricultural irrigation in the Tule Subbasin will need to be reduced in order to comply with SGMA. The timing of this reduction in pumping, however, has not been determined. Many GSAs in the area of the affected FKC have discussed a transitional reduction in groundwater pumping.

To support evaluations presented in this Study, four groundwater pumping scenarios were developed to identify potential future subsidence along the alignment of the FKC Middle Reach in response to changes in groundwater pumping. The scenarios reflect a range of potential future groundwater pumping “ramp-down” conditions between 2020 and 2040 to achieve SGMA compliance by the year 2040. All scenarios also include residual subsidence continuing to the year 2070 with no subsidence thereafter. The scenarios also incorporate variation of hydrological conditions, which could also impact groundwater levels and, thus, subsidence. Each scenario was run for 50 years into the future to represent a 20-year period to comply with SGMA by 2040, and a 30-year period following the achievement of sustainable conditions.

Because it is not practical to evaluate the performance of project alternatives over all subsidence projections (4 scenarios with 50-year simulation periods), it was necessary to define a small number of potential conditions that represent a reasonable range of future outcomes. Subsidence profiles for each scenario at decade intervals (2030, 2040, 2050, 2060, and 2070) were selected and those simulations that produced similar results were combined into four groups. The results for simulations in each group were averaged to establish the subsidence profiles along the FKC Middle Reach for groups, as presented in Figure 2-8. The four groups generally represent the following potential future subsidence conditions:

- Group 1. Minimal Mid-Term Subsidence Condition;
- Group 2. Moderate Mid-Term Subsidence Condition;
- Group 3. Severe Mid-Term Subsidence Condition; and
- Group 4. Severe Long-Term Subsidence Condition.

Both Groups 1 and 2 represent conditions that are similar to today's groundwater pumping and may come to fruition by the time the Project is constructed with little addition subsidence thereafter. Group 4 represents a worst-case scenario in terms of both hydrology and timeframe to achieve SGMA compliance and is thus unlikely. Therefore, the future subsidence condition described by Group 3, Severe Mid-Term Subsidence Condition, was selected as most representative for use in the evaluation of Project alternatives.

The results of Group 3 indicate that about 8.5 feet of additional subsidence could occur in the FKC Middle Reach by the year 2070. For a detailed explanation of the evaluated scenarios and basis for selection of Group 3, please refer to Appendix A Initial Alternatives Formulation, Attachment 1b Selection of Future Subsidence Condition.

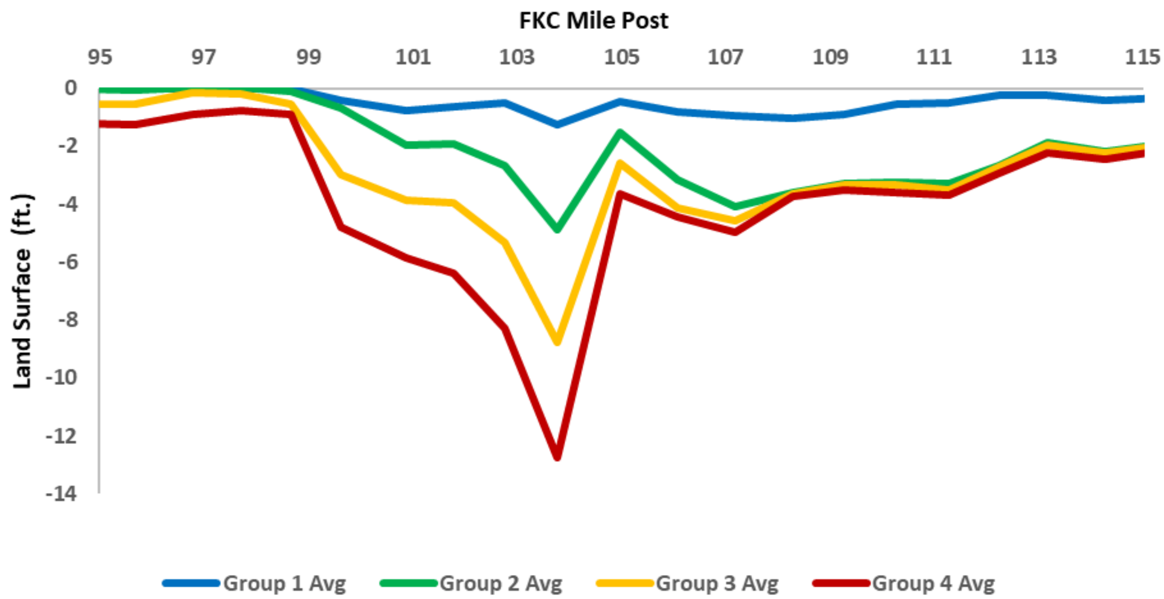

Figure 2-8. FKC Profiles Under Future Subsidence Scenarios

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Chapter 3 Initial Alternatives

The plan formulation process to the Study is based on the PR&G (CEQ 2013) and consists of the following deliberate and iterative steps:

1. Specify the water and related land resources problems and opportunities associated with the Federal objective and specific State and local concerns.
2. Inventory, forecast, and analyze existing and projected future resources conditions in the study area.
3. Formulate alternative plans.
4. Evaluate the potential effects of alternative plans.
5. Compare alternative plans.
6. Select a recommended plan to decision makers based on the comparison of alternatives.

Alternatives formulation was accomplished through a two-step approach: The Initial Alternative evaluation and Alternative evaluation. This chapter describes the formulation, evaluation and comparison of Initial Alternatives and the selection of alternatives to be carried forward for further evaluation. Information in this chapter is supported with additional detail provided in Appendix A Initial Alternatives Formulation.

Project Planning Horizon

The Project is intended to be integrated into a long-term solution to restore capacity of the entire FKC, as part of the Reclamation approach to restore the design capacity of the entire FKC. The planning horizon is 100 years, consistent with the expected service life of large civil projects.

Planning and Resource Constraints

The primary constraints are funding availability and physical boundary conditions.

Funding Constraints

Two Federal funding sources are currently available for the Project. These include SJRRP non-reimbursable funds of about $30.8 million and 2019 WIIN Act appropriations of about $2.2 million. As described in Chapter 1, the WIIN Act is also applicable to construction costs, and requires that total Federal expenditures do not exceed 50 percent of total construction costs.

Boundary Conditions

When designing either a new canal or modifications to an existing canal, the first step is to identify the boundary conditions, or the required (design) water levels at each end of the system. Boundary conditions may be difficult to define, especially since they can change significantly with relatively minor changes to the Project. Although the upstream and downstream limits for this Project are the 5th Avenue Check and the Lake Woollomes Check, hydraulics were analyzed from the 5th Avenue Check through the canal terminus at the Kern River Check. The boundary condition was considered the Kern River Check because the Project needs to be compatible with any future modifications in the Lower Reach. From the analysis, it was determined that the hydraulic head varies about 25 feet between 5th Avenue Check and the Kern River. Of this, approximately 20 feet is required for the canal gradient and the remaining 5 feet is required to accommodate for losses at canal structures, including bridges, turnouts, checks, and siphons.

The boundary conditions, along with the Project objectives, were used to establish a proposed hydraulic grade line (HGL). The proposed HGL was set as low as possible to minimize embankment raise requirements and the need to modify bridges. All management measures considered, and subsequent Project alternatives, are based on the proposed HGL. The proposed HGL is shown in Figure 3-1.

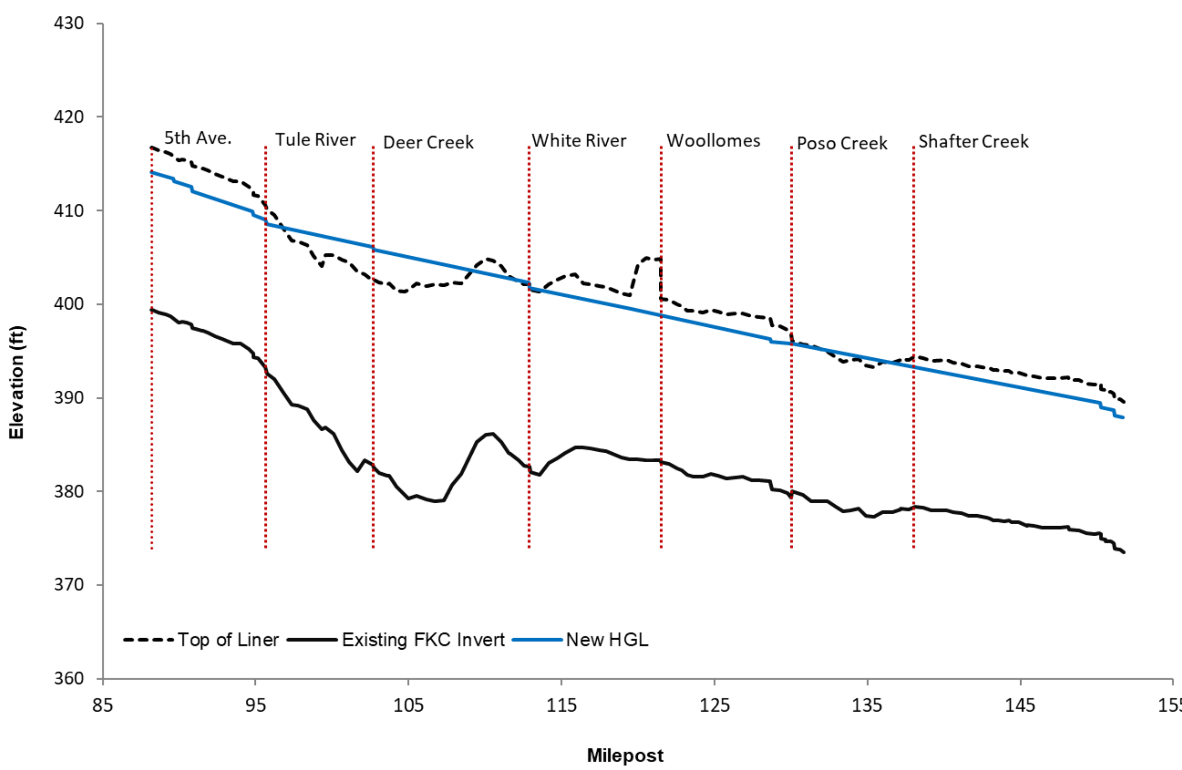

Figure 3-1. Canal Profile with Proposed Hydraulic Grade Line

Initial Alternatives Formulation

The Initial Alternatives Formulation describes the development, evaluation, and comparison of a set of seven Initial Alternatives. From the evaluation, two Initial Alternatives were selected for further development in this Study. For more detail, refer to Appendix A Initial Alternatives Formulation.

Measures Considered

In formulating Initial Alternatives, several structural measures were identified that could contribute to the Project objective of restoring the original designed and constructed capacity of the FKC. Structural measures were organized into the following categories: canal enlargement, pumping plant, new canal, bridge modification, and other. One nonstructural measure, the re-scheduling of affected water deliveries in Millerton Lake, was identified for consideration. While this measure would not contribute the Project objective of restoring the design capacity of the FKC, it will be included in the No Action Alternative and combined with structural measures in action alternatives to reduce water delivery impacts. Of the measures identified, several were retained for inclusion in Initial Alternatives (Table 3-1).

Table 3-1. Measures to Restore Friant-Kern Canal Capacity

Resource Management Measure	Status	Rationale
Canal Enlargement		
Raise Canal	Retained	Raising the canal would contribute to the Project objectives.
Raise and Widen Entire Cross Section	Removed	This measure is cost prohibitive and raises constructability concerns. Dropped from further consideration.
Raise and Widen Upper Portion of Cross Section	Retained	Enlarging the canal would contribute to Project objectives.
Pumping Plant		
Pumping Plant	Retained	The addition of a pumping plant would help restore capacity, thus contributing to Project objectives.
New Canal		
Bypass Canal	Retained	A bypass canal would restore capacity, though not in the original FKC.
Parallel Canal	Retained	A parallel canal would restore capacity, though not in the original FKC.
Bridge Modification		
Bridge Raise	Retained	A bridge raise does not sufficiently meet Project objectives but is an operational requirement.
Bridge Replacement	Retained	A bridge replacement does not sufficiently meet Project objectives but is an operational requirement to be included.
Other		
Pipeline	Removed	Initial hydraulic analysis indicated that head losses would exceed available head, requiring a pump station(s) to move water through the Middle Reach consistent with the boundary conditions. This would be more costly than other available options.
Nonstructural Measures		
Reschedule affected deliveries in Millerton Lake	Retained	Water deliveries affected by reduced FKC capacity could be re-scheduled in available conservation space in Millerton Lake as allowable by water rights, contracts, and Reclamation policy.

Capacity Restoration Objectives for Initial Alternatives

The objective of the Project is to restore the designed and constructed capacity of the FKC, consistent with SJRRS Act authority. This involves restoring the original design capacity of the FKC consistent with current Reclamation design standards for Normal and Design Maximum flow rates, and including design features in the Recommended Plan to accommodate future subsidence without reducing FKC capacity.

The design of all Initial Alternatives was based on a canal capacity equal to the Design Maximum Flow Rate (Table 3-2). Canal lining depths were based on the normal depths at the Design Maximum Flow Rates plus the lined freeboard criteria for normal operations. The design flow rates were used to develop the HGL profiles for the Initial Alternatives. This approach is considered conservative and is inclusive of potential flow and freeboard design requirements that may be considered in future evaluations.

Table 3-2. Design Flow Rates for Initial Alternatives

Canal Section No.	Canal Segment (MP to MP)	Description (Check to Check)	Normal Flow Rate (cfs)	Design Maximum Flow Rate (cfs)
4	88 to 95.67	5th Avenue to Tule	3,500	4,500
5	95.67 to 112.90	Tule to White River	3,000	4,000
6.1	112.90 to 128.69	White River to HWY 99	2,500	3,500
6.2	128.69 to 130.03	HWY 99 to Poso	2,500	3,000

Key:
cfs = cubic feet per second
HWY = highway
MP = mile post

Initial Alternatives

Seven Initial Alternatives were developed using various combinations of retained structural measures. All Initial Alternatives also include the retained nonstructural measure of rescheduling affected water supplies in Millerton Lake. A nonstructural alternative was not considered because the SJRRS Act requires the restoration of the originally designed and constructed capacity, which cannot be achieved through the implementation of nonstructural actions. A brief overview of each alternative is provided below. A summary of features of each Initial Alternative is provided in Table 3-3.

Initial Alternative 1: Canal Enlargement

Initial Alternative 1 would increase the capacity of the FKC by either raising the embankments and the concrete liner or raising and widening the embankments and liner. To raise and widen the canal, a portion of the existing liner would be removed, a bench would be cut into the existing grade, the embankment would be widened, and liner would be extended on the bench and the raised embankment. This approach would minimize land acquisition requirements; however, 67 miles of embankment would be modified.

Initial Alternative 2: Pump Station at MP 109

Initial Alternative 2 would change the FKC from a gravity canal to a pumped canal. When flows are high and cannot be conveyed by gravity, water would be diverted from the original canal at MP 109, into a forebay, then pumped back into the original canal. The initial pump station design includes eight 250-cfs pumps. In the event of a power failure, water would be directed into a 400-acre emergency reservoir to prevent a surge.

Initial Alternative 3: Pump to Woollomes

In Initial Alternative 3, capacity restoration would be achieved by moving water from the original canal into an approximately 10-mile-long bypass canal and pumping it into Lake Woollomes. The existing canal would be used to maintain deliveries within the bypassed section.

Initial Alternative 4A: Bypass Canal-Tule River to White River

Alternative 4A is an offset bypass canal that would move water into a new canal at the Tule River and connect back into the existing canal at White River. The existing canal would be used solely to maintain deliveries between the two checks.

Initial Alternative 4B: Bypass Canal-Tule River to Woollomes

Initial Alternative 4B is the same as Initial Alternative 4A but extends to Lake Woollomes.

Initial Alternative 5A: Parallel Canal-Tule River to White River

Initial Alternative 5A is a combination of the canal enlargement and parallel canal measures. The parallel canal would run from Tule River to White River. The existing canal would be used solely to maintain deliveries between the two checks.

Initial Alternative 5B: Parallel Canal-Tule River to Woollomes

Initial Alternative 5B is the same as Initial Alternative 5A but extends to Lake Woollomes.

Table 3-3. Initial Alternative Features Summary

Alternative	Capital Cost (M)	Present Worth Additional OM&R (M)	Material Balance[1] (1,000 yd^3)	ROW Required (acres)[2]	Bridge Modification[3]	Stream Crossing	Embankment Modification (mi)
1: Canal Enlargement	$290	$0.3	-1,550	170	17	0	66
2: Pump Station at MP 109	$270	$3.1	+542	522	14	0	52
3: Pump to Woollomes	$380	$3.5	+945	622	23	1	27
4A: Bypass Canal—Tule River to White River	$300	$1	+1,750	508	18	1	32
4B: Bypass Canal—Tule River to Woollomes	$320	$1.4	+2,418	650	24	2	20
5A: Parallel Canal—Tule River to White River	$300	$0.9	Balanced	321	18	0	49
5B: Parallel Canal—Tule River to Woollomes	$300	$1.3	Balanced	390	24	0	43

Notes:
[1] Negative values indicate borrow and positive values indicate surplus.
[2] ROW required is the additional ROW needed outside the existing Reclamation ROW.
[3] Modifications can be a raise, replace, or new bridge. Farm bridge modifications are not included in this count.
Key:
M = million dollars
mi =miles
MP = mile post
OM&R = operations, maintenance, and replacement
yd^3 = cubic yard

Evaluation and Comparison of Initial Alternatives

The seven Initial Alternatives were evaluated and scored based on five criteria and several related sub-criteria, as listed in Table 3-4. The criteria addressed: (1) constructability, (2) operational requirements and flexibility, (3) cost, (4) schedule, and (5) environmental compliance and permitting. The evaluation and scoring considered both 2018 survey and projected future land surface elevations. Scoring results were evaluated as unweighted and weighted based on Project priorities of cost and schedule. A summary of the ranking results based on existing land surface is shown in Figure 3-2. The results from this analysis, as well as an analysis that considered potential future subsidence, revealed that Alternatives 1 and 5 consistently ranked highest. On the basis of these findings, Alternatives 1 and 5 were selected for further evaluation. Additional information on the Initial Alternatives evaluation can be found in Appendix A Initial Alternatives Formulation.

Table 3-4. Initial Alternatives Evaluation Criteria and Sub-Criteria

I. Constructability	II. Operational Requirements and Flexibility	III. Cost	IV. Schedule	V. Environmental Compliance and Permitting
CON-1. Complexity to Maintain Water Deliveries during Construction	OPS-1. Additional O&M Requirements and Expertise of FWA Staff	COST-1. Construction Cost*	SCH-1. Time to Start Construction	ENV-1. Complexity of Required Environmental Compliance
CON-2. Ability to O&M during Construction	OPS-2. Operations of District Turnouts	COST-2. Non-contract Cost*	SCH-2. Construction Duration	ENV-2. Number of Stream Crossings*
CON-3. Temporary Bypasses and Tie-Ins Needed to Construct the Project*	OPS-3. Ability to Accommodate Power Outages	COST-3. Present Worth Additional OM&R Costs*	SCH-3. Time Until Benefits Realized	ENV-3. Number of Bridges*
CON-4. Extent of Dewatering			SCH-4. Potential to Phase Construction	ENV- 4. Length of Modified Existing Embankment*
CON-5. Material Balance*			SCH-5. Land Acquisition*	
			SCH-6. Schedule Risk	

Note:
*Qualitative sub-criterion
Key:
O&M = operations and maintenance
OM&R = operations, maintenance, and replacement

UNWEIGHTED

ID	Alternative Name	Alternative Type	Constructability (20%)	Operational Requirments and Flexibility (20%)	Cost (20%)	Schedule (20%)	Environmental Compliance and Permitting (20%)	Composite Score (UNWEIGHTED)	Alternative Ranking (UNWEIGHTED)
1	Canal Enlargement	G	1.8	5.0	4.7	4.8	2.6	3.8	1
2	Pump Station at MP 109	PS	2.7	2.3	3.4	2.8	2.9	2.8	5
3	Woollomes Pump Station	PS	2.8	2.0	1.0	1.9	1.7	1.9	7
4A	Bypass Canal: Tule River to White River	G	4.1	3.7	3.8	2.0	2.3	3.2	4
4B	Bypass Canal: Tule River to Woollomes	G	4.2	3.0	2.1	1.2	1.6	2.4	6
5A	Parallel Canal: Tule River to White River	G	4.2	4.3	3.9	3.0	2.4	3.6	2
5B	Parallel Canal: Tule River to Woollomes	G	4.5	3.7	3.4	2.4	2.0	3.2	3

COST

ID	Constructability (10%)	Operational Requirments and Flexibility (15%)	Cost (50%)	Schedule (10%)	Environmental Compliance and Permitting (15%)	Composite Score (COST)	Alternative Ranking (COST)
1	1.8	5.0	4.7	4.8	2.6	4.1	1
2	2.7	2.3	3.4	2.8	2.9	3.0	5
3	2.8	2.0	1.0	1.9	1.7	1.5	7
4A	4.1	3.7	3.8	2.0	2.3	3.4	3
4B	4.2	3.0	2.1	1.2	1.6	2.3	6
5A	4.2	4.3	3.9	3.0	2.4	3.7	2
5B	4.5	3.7	3.4	2.4	2.0	3.2	4

SCHEDULE

ID	Constructability (10%)	Operational Requirments and Flexibility (15%)	Cost (10%)	Schedule (50%)	Environmental Compliance and Permitting (15%)	Composite Score (SCHEDULE)	Alternative Ranking (SCHEDULE)
1	1.8	5.0	4.7	4.8	2.6	4.2	1
2	2.7	2.3	3.4	2.8	2.9	2.8	4
3	2.8	2.0	1.0	1.9	1.7	1.9	7
4A	4.1	3.7	3.8	2.0	2.3	2.7	5
4B	4.2	3.0	2.1	1.2	1.6	1.9	6
5A	4.2	4.3	3.9	3.0	2.4	3.3	2
5B	4.5	3.7	3.4	2.4	2.0	2.8	3

Figure 3-2. Evaluation and Comparison of Initial Alternatives

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Chapter 4 Alternatives

This chapter provides a description of the No Action Alternative and the two Alternatives. The physical features of the Alternatives, as well as the costs and anticipated permitting requirements, are summarized below and evaluated further in Chapter 5.

No Action Alternative

The No Action Alternative represents a projection of reasonably foreseeable future conditions that could occur if no action is taken to address current and projected future capacity reductions to the FKC (i.e., the future without the proposed Project). Reclamation recommends several criteria for including proposed future actions within the No Action Alternative: proposed actions should be (1) authorized; (2) approved through completion of NEPA, CEQA, Endangered Species Act (ESA), and other compliance processes; (3) funded; and (4) permitted. The No Action Alternative is considered the basis for comparison with the Recommended Plan, consistent with NEPA and the PR&G (CEQ 2013) guidelines. Therefore, if no proposed action is determined feasible, the No Action Alternative is the default option.

Under the No Action Alternative, Reclamation and FWA would not take additional actions towards restoring the capacity of the FKC Middle Reach. However, four foreseeable actions have been identified that affect future conditions: SJRRP implementation, continued subsidence, SGMA implementation, and CVP water delivery rescheduling in Millerton Lake.

SJRRP Implementation

Under the No Action Alternative, water supply availability to Friant Division long-term contractors will decrease as San Joaquin River channel improvements are implemented that allow for increased and ultimately full release of Restoration Flows. As shown in Figure 4-1, simulated long-term average annual Friant Division deliveries under the current level of SJRRP implementation is estimated at 1,119 TAF per year. As of October 2019, release of full Restoration Flows is not possible due to downstream channel capacity constraints.

The SJRRP Funding Constrained Framework for Implementation (SJRRP, 2018) describes planned implementation of actions through 2024 using available funding sources. The Funding Constrained Framework was developed to identify projects that can be implemented with funding available from previous Federal appropriations, Friant capital repayment, appropriations from the State of California and revenue from water sales. Projects that would be implemented with projected expenditures would address increased channel capacity to enable the release of full Restoration Flow volumes up to a flow of 2,500 cfs, fish passage, other priority restoration actions, and projects that could be supported with remaining Part III funds. After these funds are expended, the only funding sources that would remain available for continued implementation of SJRRP restoration actions would be derived from water sales. With full release of Restoration Flow volume to the San Joaquin River, anticipated by 2025, long-term annual average deliveries to the Friant Division would be reduced to about 1,052 TAF.

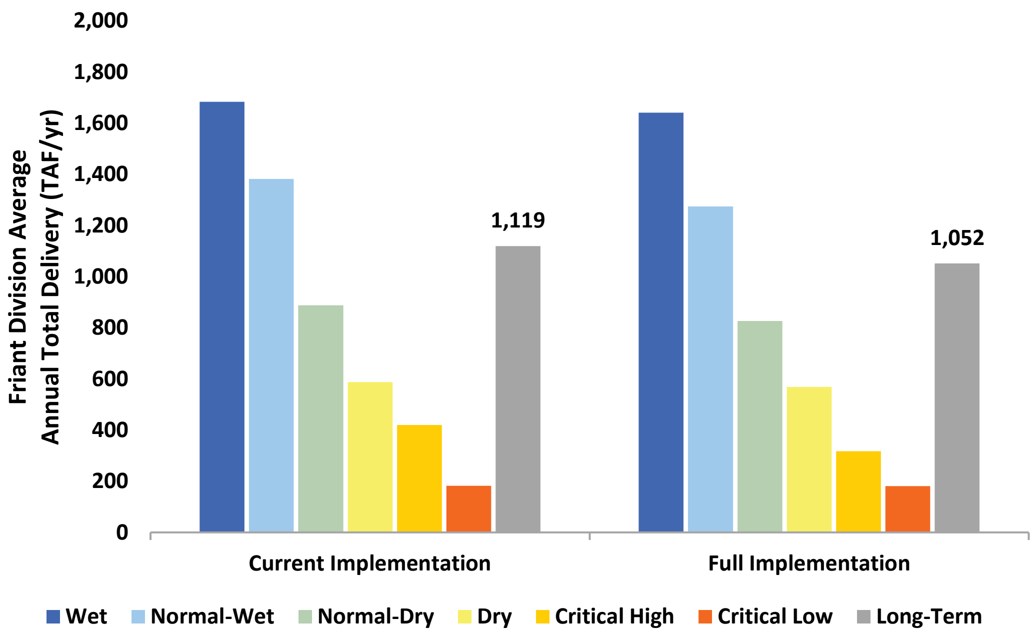

Figure 4-1. Simulated Friant Division Delivery Capability with SJRRP Implementation

Under the No Action Alternative, the current capacity-restricted condition of the FKC would continue to limit affected Friant Division long-term contractors' ability to receive water during periods of peak demand or peak flow. This could impact the ability of the contractors to take delivery of water under Paragraph 16 (b) of the Settlement "for the purpose of reducing or avoiding impacts to water deliveries to all of the Friant Division long-term contractors caused by the Interim and Restoration Flows," thus limiting the Secretary of the Interior's ability to achieve the Water Management Goal in the Settlement. As subsidence continues, water delivery impacts associated with decreased canal capacity would increase.

As described in the Funding Constrained Framework, available funding for implementation of the SJRRS would be limited to revenue from water sales, as follows:

- Recovered Water Account (RWA) revenue – Paragraph 16(b) of the Settlement directs Reclamation to make water available to all of the Friant Division long-term contractors who are impacted by the Settlement's Interim and Restoration flows at a total cost of $10 per acre-foot. Water is to be made available only in wet hydrologic conditions.

- Friant Surcharge revenue – The Friant surcharge is the continuation of and the dedication of an environmental fee of $7 per acre-foot charged pursuant to the CVP Improvement Act for CVP project water delivered to Friant contractors, except for RWA water. This Funding Constrained Framework assumes that the surcharge would remain at $7 per acre-foot.

- Unreleased Restoration Flow (URF) revenue is also provided through the sale of URFs pursuant to Paragraph 13(i) of the Settlement; this revenue is expected to be minimal after the projects described in the Funding Constrained Framework are completed and would only occur under extraordinary conditions.

Reduced delivery of RWA and CVP project water supplies to Friant Division long-term contractors in the No Action Alternative will reducing revenue to the SJRRA Fund. The Funding Constrained Framework anticipates that RWA sales and Friant Surcharge revenue would be used to implement actions pursuant to Paragraph 12 of the Settlement to enhance fish and wildlife restoration. Reduced revenue from water sales to the SJRRA Fund would reduce improvements in in the San Joaquin River toward achieving the Restoration Goal of the Settlement.

Future Subsidence

Under the No Action Alternative subsidence is expected to continue throughout the project area. As described in Chapter 2, a groundwater model of the Tule Subbasin was developed to simulate potential future groundwater and land subsidence conditions in support of planning for SGMA compliance. The Severe Mid-Term Subsidence condition was selected for use in Project evaluations, resulting in the maximum total subsidence displacement from the current condition of each year described in Table 4-1.

Table 4-1. Maximum Simulated Additional Subsidence in the FKC Middle Reach

Year	Displacement from Current Condition (feet)
2025	3.9
2030	6.7
2040	8.5
2070	9.5

SGMA Implementation

In response to reduced deliveries from Friant Dam as a result of SJRRP implementation and FKC capacity reduction, affected Friant Division long-term contractors would likely increase groundwater pumping. However, SGMA implementation is expected to limit allowable groundwater pumping to amounts less than historical and current amounts. SGMA requires that actions to achieve sustainable groundwater management be in place no later than 2040. Therefore, it is assumed that no increased groundwater pumping would result as a response to surface water reductions.

Rescheduling Affected Water Deliveries in Millerton Lake

As described in Chapter 2, it is reasonable to expect the Friant Division long-term contractors would reduce water delivery shortages by rescheduling affected water deliveries in available conservation space in Millerton Lake to the extent possible. This action would be considered a nonstructural measure to limit the affected water supply reductions, however it would not contribute to restoring the authorized capacity of the FKC. Opportunities to reschedule affected water deliveries in available conservation space in Millerton Lake would occur to the extent they are foreseeable, could be rescheduled in coordination with other supplies available to affected contractors, and are consistent with water rights, contracts, and Reclamation policy. The potential for rescheduling affected water supplies is based on the following factors:

- Water demands for affected Friant Division contractors that would be served by non-Friant Division water supplies (local surface water, groundwater, or other supplies).
- Available storage capacity in Millerton Lake.
- Available capacity in the FKC to convey rescheduled water supplies.

The potential to reschedule affected Friant Division water deliveries in Millerton Lake was simulated by creating accounts to track the storage of affected water supplies for Class 1, Class 2 and RWA/215 water supplies. Affected Class 1 water supplies would have the highest priority for use of available conservation storage capacity for rescheduling and for rescheduled diversion to the FKC, followed by Class 2, then RWA/215 supplies. Water in the rescheduled water accounts would be the first water subject to spill in reverse order of storage priority to meet the obligations of Friant Dam would under existing priorities. Water would be diverted from rescheduled water storage accounts to the FKC in months when demand that would be served by other supplies is available, as constrained by available conveyance capacity in the FKC.

The analysis assumed that water would remain in the rescheduled storage accounts, including into successive years, until the accounts are evacuated through rescheduling or because of flood releases from Friant Dam to the San Joaquin River. It was further assumed that the rescheduled water supplies would result in a shift in the timing of groundwater pumping and the use of local surface water supplies in a manner that meets water demands in districts that would be affected by the delivery of allocated CVP water supplies due to FKC capacity limitations.

Alternative Plans

As described in Chapter 3, the evaluation and comparison of Initial Alternatives resulted in the selection of Initial Alternative 1 and Initial Alternative 5 for further development and evaluation. The Parallel Canal Alternative was developed based on refinements to Initial Alternative 5. The Parallel Canal Alternative would be a single canal and that would be constructed by replacing a portion of the FKC with a new canal along a parallel alignment and modifying portions of the FKC where possible to convey maximum design flow of the original authorized project. The Canal Enlargement Alternative was developed based on refinements to Initial Alternative 1 and would involve modifying the FKC to convey maximum design flow of the original authorized project. A summary of design capacity and freeboard requirements for the Alternative Plans is provided in Table 4-2.

Table 4-2. Design Capacity and Freeboard Requirements in Alternatives

Segment	Capacity (cfs)	Freeboard (ft)
Segment 1	4,500	1.12
Segment 2	4,000	1.08
Segment 3	4,000	1.08
Segment 4	3,500	1.03

Key:
cfs = cubic feet per second
ft = feet

In refining the retained Initial Alternatives, additional detail was developed regarding turnouts and canal crossings, consideration was given to minimizing ROW requirements, and modifications were made to minimize material hauling requirements. Descriptions of the Alternatives are provided below.

Parallel Canal Alternative

The Parallel Canal Alternative was formulated as an advancement of the Initial Alternative 5 design and incorporates refinements to the alignment, water delivery turnouts, canal cross-section design, road crossings, check structures, utilities, and costs. The Parallel Canal Alternative design is based on providing maximum design flow with flood freeboard at the surveyed 2018 land surface. A single-line diagram showing features included in the Parallel Canal Alternative is provided in Figure 4-2A and Figure 4-2B. As shown, the Parallel Canal Alternative includes a combination of modifications to the existing FKC and the construction of a new replacement canal parallel to and immediately east of the FKC. The selection of canal modification or parallel canal was made based on the extent of modifications that would be required to the FKC. The parallel canal portion would be constructed in reaches where land subsidence has occurred to an extent that raising or raising and widening the FKC to achieve the design capacity is considered less practical. Features of the Parallel Canal Alternative are described in the following sections.

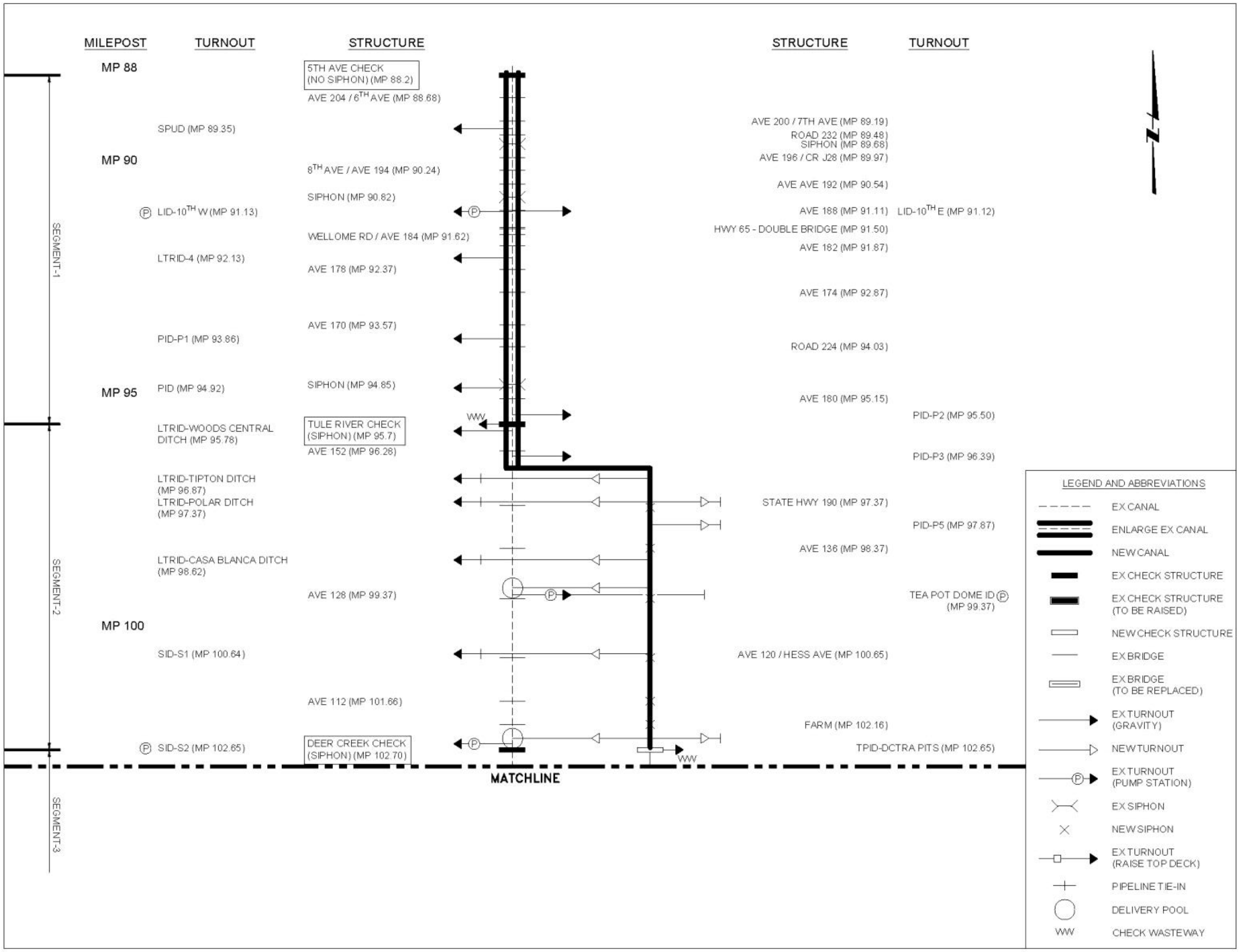

Figure 4-2A. Parallel Canal Alternative Single-Line Diagram of Segments 1 and 2

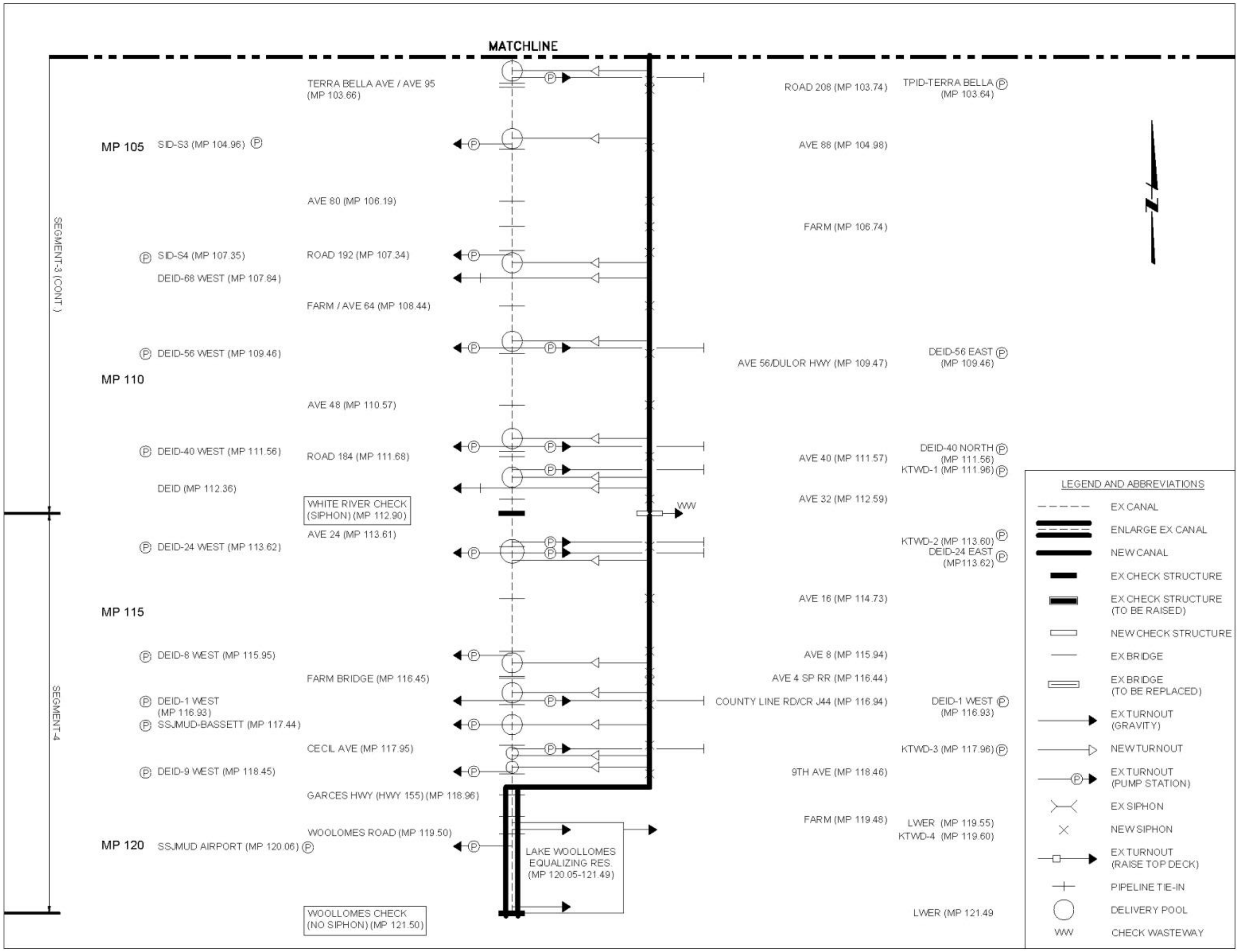

Figure 4-2B. Parallel Canal Alternative Single-Line Diagram of Segments 3 and 4

Canal Alignment and Cross Sections

In comparison to Initial Alternative 5, significant refinements were incorporated in the Parallel Canal Alternative regarding the canal alignment and the cross sections. Initial Alternative 5 was based on a parallel canal from the 5th Avenue Check to either White River or Lake Woollomes, and the continued operation of the existing FKC for deliveries in the bypassed reaches.

Through the refinement process, the length of the parallel canal portion of this alternative was reduced. In some locations, it was found that modifying the FKC to achieve the objective conveyance capacity would be more practical than constructing a parallel canal. It was also determined that retaining long segments of the existing FKC to provide deliveries in the bypassed segments would require modifications to several turnouts. In light of these refinements, the Parallel Canal Alternative was revised to a configuration that includes modifications to the FKC and the construction of a replacement parallel canal.

Where constructed, the parallel canal portion would be the exclusive water conveyance and delivery mechanism and most of the existing FKC in the reach where the parallel canal would be constructed would be demolished, filled in, and taken out of service. This approach was selected due to the numerous benefits it provides; it would reduce ROW acquisition requirements, reduce material hauling during canal earthwork, provide access to existing material, improve constructability, and would provide greater long-term durability.

The Parallel Canal Alternative would include modifications to the current FKC alignment from 5th Ave. Check (MP 88) to Ave. 152 (MP 96.3). Through this reach, the cross section of the existing FKC would be enlarged with a 24-foot bench on either side to increase canal capacity to meet the Design Maximum flow rate of 4,500 cfs in this segment, as shown in Figure 4-3. From 5th Ave. Check (MP 88) to Ave. 152 (MP 96.3) the existing bridges are estimated to be high enough to accommodate the new canal water surface level and the existing turnouts could continue to function without modification. To reduce cost, the enlarged canal would transition into the existing canal prism upstream and downstream from existing bridges and turnouts so that these structures may remain in place without modification.

At MP 96.3, the Parallel Canal Alternative alignment would head east, away from the existing canal centerline, and run on a parallel alignment until it reaches Garces Highway (MP 118.96). In this reach, the Parallel Canal would have a regular trapezoidal shape based on the configuration shown in Figure 4-4. At MP 118.96, the Parallel Canal Alternative would head west and reconnect with the existing alignment of the FKC, which would be enlarged between MP 118.96 to MP 121.5 as described above and shown in Figure 4-3.

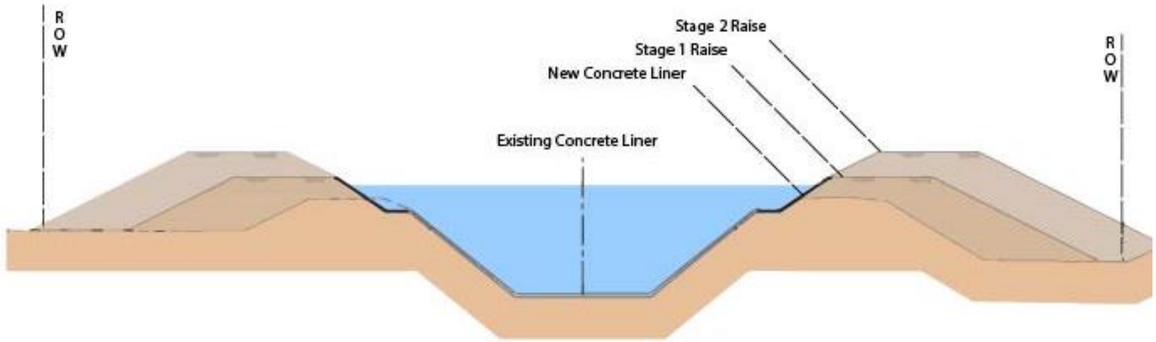

Figure 4-3. Compound Trapezoidal Cross Section in the Parallel Canal Alternative

The Parallel Canal Alternative includes design features to accommodate anticipated future subsidence. For example, the siphon-type road crossings were sized to accommodate future increases in the HGL. In addition, canal embankments were configured such that future actions to raise the embankments and extend the canal lining could be accomplished with minimal interference to the operation of the restored FKC. The Parallel Canal Alternative includes the right of way necessary to accommodate such a future embankment raise.

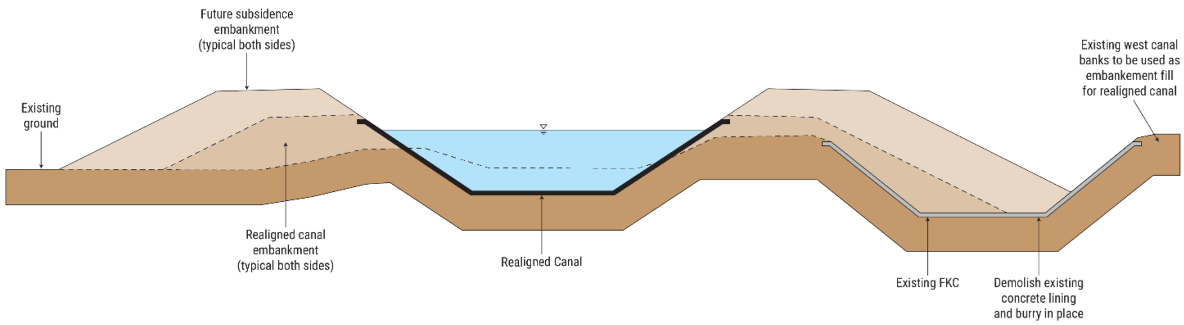

Figure 4-4. Trapezoidal Cross Section in the Parallel Canal Alternative

Construction Sequencing

The parallel canal portion of the Parallel Canal Alternative would be constructed as follows:

1. Partially build the right bank, from existing canal left bank material, while maintaining water deliveries in the existing canal.
2. Excavate the new cross section and use the excavated material to build the left bank. This work could be accomplished while the existing canal is in operation.
3. Put the Parallel Canal into operation and decommission the bypassed portion of the existing FKC.
4. Complete building the Parallel Canal right bank by using the decommissioned FKC right bank material.

Turnouts

The Parallel Canal Alternative includes features to address water delivery at existing turnouts, based, in part, on input provided by Friant Division long-term contractors. The Parallel Canal Alternative incorporates design concepts for pressurized and gravity systems to ensure compatibility between the canal and the contractors' distribution systems, maintain water delivery capability during construction, control overflow, and enhance operational flexibility.

Pressurized Turnout Modifications. In the Middle Reach, many of the 20 pressurized distribution systems have subsided at different rates than the land under the canal, causing varying differential head conditions from those used in the original system designs. All alternatives have been developed to achieve the proposed HGL, which is higher than the current water surface in the FKC. Increasing the HGL would increase head on the suction side of the pumping plants, which would increase the delivery head on district distribution systems. The removal and replacement of current pump stations at a location compatible with the current design was considered and dropped because of significant costs.

The water elevation in the parallel canal would often be above the elevation of the top decks of existing pump stations. If a pump station were to unexpectedly shutdown, the incoming flow from the adjacent canal could overflow the pump station and flood the facility and surrounding land, resulting in equipment and property damage. To avoid the potential risk associated with unexpected shutdowns, the Parallel Canal Alternative includes small delivery pools at each pump station turnout.

As shown in Figure 4-5, the delivery pool would be created by preserving small portions of the existing FKC. Water would flow from the parallel canal through a new pipe to the delivery pool which would serve as a forebay for the existing turnout pump station. The parallel canal alignment would be modified at the location of each pump station turnout and be customized to meet the specific needs of each pressurized delivery system. Proposed modifications to pump station turnouts in the Parallel Canal Alternative are summarized in Table 4-3.

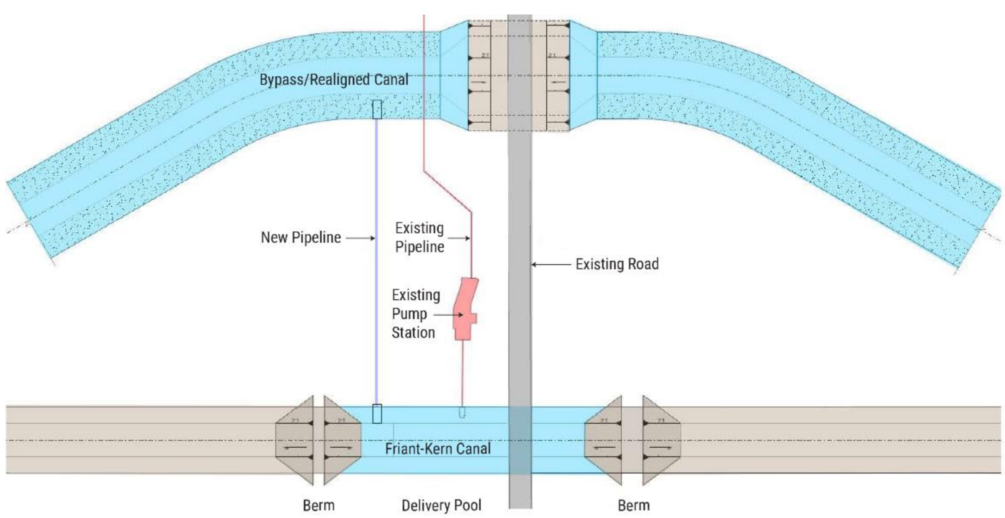

Figure 4-5. Example Pressurized System Turnout Design in the Parallel Canal Alternative

Gravity Turnout Modifications. There are 18 gravity turnouts located in the Middle Reach, each of which were individually analyzed to determine an appropriate design approach. The analysis revealed that all existing gravity turnouts can either be preserved and reused or connected to new turnouts and pipelines on the parallel canal. A summary of modifications at gravity turnouts in the Parallel Canal Alternative is provided in Table 4-3.

Table 4-3. Modifications at Turnouts Under the Parallel Canal Alternative

Segment	Name	Milepost	Canal Side	Type	Modification
1	SPUD-STRATHMORE	89.35	West	G	Unmodified
1	LID-10th E	91.12	East	G	Unmodified
1	LID-10th W	91.12	West	P	Unmodified
1	LTRID-4	92.13	West	G	Unmodified
1	PID-P1	93.85	West	G	Unmodified
1	PID-Porter Slough	94.92	West	G	Unmodified
1	PID-P2	95.50	East	G	Unmodified
2	LTRID-Woods Central Ditch	95.78	East	G	Unmodified
2	PID-P3	96.39	East	G	Build Turnout on Parallel Canal
2	LTRID-Tipton Ditch	96.87	West	G	Build Turnout on Parallel Canal
2	LTRID-Poplar Ditch N&S	97.37	West & East	G	Build Turnout on Parallel Canal
2	PID-P5	97.86	East	G	Build Turnout on Parallel Canal
2	LTRID-Casa Blanca Ditch	98.62	West	G	Build Turnout on Parallel Canal
2	TPDWD-Teapot Dome	99.37	East	P	New Delivery Pool Turnout
2	SID-S1	100.64	West	G	Build Turnout on Parallel Canal
2	TBID-DCTRA Pits	102.65	East	G	Build Turnout on Parallel Canal
2	SID-S2	102.65	West	P	New Delivery Pool Turnout
3	TBID-Terra Bella	103.64	East	P	New Delivery Pool Turnout
3	SID-S3	104.96	West	P	New Delivery Pool Turnout
3	SID-S4	107.35	West	P	New Delivery Pool Turnout
3	DEID-68 West	107.84	West	G	Build Turnout on Parallel Canal
3	DEID-56 West and East	109.46	West & East	P	New Delivery Pool Turnout
3	DEID-40 West and North	111.56	West & East	P	New Delivery Pool Turnout
3	KTWD-1	111.96	East	P	New Delivery Pool Turnout
3	DEID	112.36	West	G	Build Turnout on Parallel Canal
4	KTWD-2	113.60	East	P	New Delivery Pool Turnout
4	DEID-24 West and East	113.62	West & East	P	New Delivery Pool Turnout
4	DEID-8th West	115.95	West	P	New Delivery Pool Turnout
4	DEID-#1 West	116.93	East	P	New Delivery Pool Turnout
4	SSJMUD-Bassett	117.44	West	P	New Delivery Pool Turnout
4	KTWD-3	117.96	East	P	New Delivery Pool Turnout
4	DEID-9th West	118.45	West	P	New Delivery Pool Turnout
4	LWER	119.55	East	G	Unmodified
4	SSJMUD-Airport	120.06	West	P	New Delivery Pool Turnout
4	LWER	121.49	East	G	Unmodified

Key:
G = Gravity
P = Pressurized

Checks and Siphons

In the analysis of Initial Alternative 5, it was assumed that the parallel canal would tie-in to the FKC at the existing check and siphon structures at Deer Creek and White River, and that existing structures and gates would be raised to meet the new canal design objectives. It was expected that continued use of existing structures would reduce cost and environmental consequences. Upon further refinement, it was discovered that this approach would require significant structural modifications to the existing structures, would add two new road crossings (bridges) at the White River check, and ultimately increase the amount of bridge work and overall project cost. Thus, the Parallel Canal Alternative includes new checks and siphons at Deer Creek and White River.

Both replaced check structures require control buildings and associated electrical, mechanical, and control equipment. The buildings would be located adjacent to the radial gate check structure on the canal banks. Utility power would be extended from the power service point at the existing check structures immediately adjacent to the site.

Road Crossings

In the formulation of Initial Alternative 5, bridge modification options included either a raise of the existing bridge or replacement with a new bridge. However, after further analysis it has become apparent that raising or replacing bridges as part of the Parallel Canal Alternative would add complexity and cost.

Designs for raising or replacing existing bridges would require that each bridge design be assessed for current highway and seismic design standards. It is anticipated that significant bridge retrofits would be required should the existing bridge infrastructure remain. In addition, raising or replacing bridges would require approach roadway improvements. It is estimated that up to 1,800 feet of additional road work would be required per bridge, including significant amounts of earthwork to build up the approaches consistent with vertical curve requirements.

Through the refinement process, raised bridges and replacement bridges have been removed from further consideration in the Parallel Canal Alternative in favor of siphon-type crossings that divert canal flow below the existing roadway and allow the road to stay at existing grade. Two typical siphon-type road crossing designs were developed, based on the relative elevation of the existing roadway in comparison to the elevation of the parallel canal. Siphon A would be applied in conditions where the parallel canal water surface elevation would be higher than the existing road elevation at the crossing, as illustrated in Figure 4-6. Siphon B would be applied in conditions where the parallel canal water surface elevation would be lower than the existing road elevation at the crossing, as illustrated in Figure 4-7.

For either application, the existing bridge over the current FKC would be demolished and the abandoned portion of the FKC would be filled to road grade, with the new siphon placed under the new parallel canal. For bridges that fall outside of the parallel canal, no action would be taken. A list of anticipated modifications to bridges in the Parallel Canal Alternative is provided in Table 4-4.

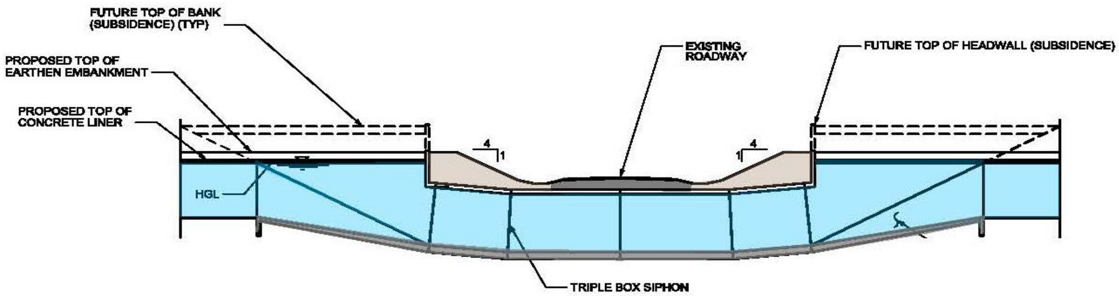

Figure 4-6. Typical Siphon A Road Crossing

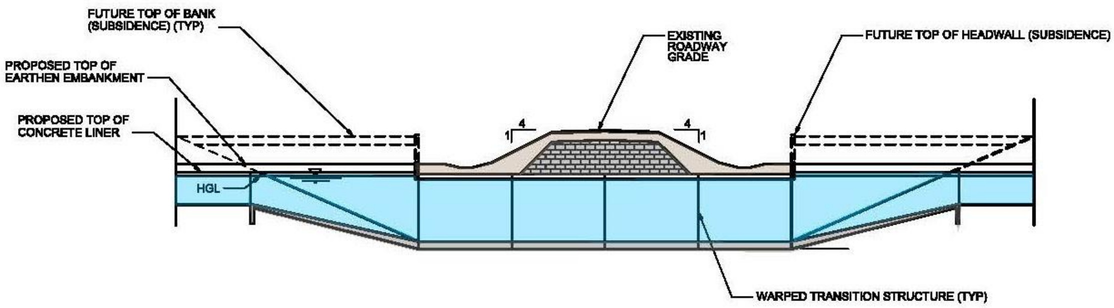

Figure 4-7. Typical Siphon B Road Crossing

Utilities

Numerous utilities located in, along, and across the FKC would be affected by implementation of the Parallel Canal Alternative. The utilities include parallel irrigation canals, fly overs, overhead power lines, adjacent wells, drainage siphons and irrigation crossings under the existing canal, and utilities connected to bridges. Depending on the location and extent of canal modifications, the utilities will either be relocated or entirely replaced, as determined in the final design. A current estimate of potentially affected utilities, based on observations made during a site visit during February 2019, is provided in Table 4-5. It is expected that additional utilities that would be affected by the Parallel Canal Alternative will be identified as design progresses. More detailed information on utilities is provided in Appendix B Engineering Design and Cost.

Table 4-4. Road Crossing Modifications in the Parallel Canal Alternative

Segment	Name	Milepost	Modification
1	6th Avenue Bridge	88.67	Unmodified
1	7th Avenue Bridge	89.17	Unmodified
1	Road 232 Bridge	89.45	Unmodified
1	Frazier Highway 196 Bridge	89.95	Unmodified
1	8th Avenue Bridge	89.95	Unmodified
1	Avenue 192 Bridge	90.23	Unmodified
1	Avenue 188 Bridge	91.10	Unmodified
1	State Highway 65 Northbound Bridge (Double Bridge)	91.51	Unmodified
1	Welcome Avenue Bridge (Avenue 184)	91.60	Unmodified
1	Avenue 182 Bridge	91.85	Unmodified
1	Avenue 178 Bridge	92.35	Unmodified
1	W Linda Vista Avenue	92.85	Unmodified
1	W North Grand Avenue Bridge	93.55	Unmodified
1	N Westwood Street Bridge	94.01	Unmodified
1	W Henderson Avenue Bridge	95.12	Unmodified
2	Avenue 152 Bridge	96.26	Unmodified
2	Avenue 144 Bridge (Highway 190)	97.35	Demo- New Road Crossing/Siphon A
2	Avenue 136 Bridge	98.35	Demo- New Road Crossing/Siphon A
2	Avenue 128 Bridge	99.37	Demo- New Road Crossing/Siphon A
2	Hesse Avenue Bridge	100.64	Demo- New Road Crossing/Siphon A
2	Avenue 112 Bridge	101.64	Demo- New Road Crossing/Siphon A
2	Timber Farm Bridge	102.14	Demo- New Road Crossing/Siphon A
3	Road Terra Bella Avenue (J24)	103.65	Demo- New Road Crossing/Siphon A
3	Road 208 Bridge	103.72	Demo- New Road Crossing/Siphon A
3	Avenue 88 Bridge	104.95	Demo- New Road Crossing/Siphon A
3	Avenue 80 Bridge	106.72	Demo- New Road Crossing/Siphon A
3	Farm Bridge	106.75	Demo- New Road Crossing/Siphon A
3	Road 192 Bridge	107.32	Demo- New Road Crossing/Siphon A
3	Avenue 64 Bridge	108.42	Demo- New Road Crossing/Siphon A
3	Avenue 56 Bridge	109.45	Demo- New Road Crossing/Siphon A
3	Avenue 48 Bridge	110.55	Demo- New Road Crossing/Siphon A
3	Avenue 40 Bridge	111.55	Demo- New Road Crossing/Siphon A
3	Road 184 Bridge	111.66	Demo and Fill
3	Avenue 32 Bridge	112.57	Demo- New Road Crossing/Siphon A
4	Avenue 24 Bridge	113.59	Demo- New Road Crossing/Siphon A
4	Avenue 16 Bridge	114.71	Demo- New Road Crossing/Siphon B
4	Avenue 8 Bridge	115.91	Demo- New Road Crossing/Siphon B
4	Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	Demo- New Road Crossing/Siphon B
4	County Road Avenue 0 Bridge	116.91	Demo- New Road Crossing/Siphon B
4	Cecil Avenue Bridge	117.92	Demo- New Road Crossing/Siphon B
4	9th Avenue Bridge	118.44	Demo- New Road Crossing/Siphon B
4	Garces Highway Bridge	118.94	Unmodified
4	Timber Farm Bridge	119.46	Unmodified
4	Woollomes Avenue Bridge	120.02	Unmodified

Estimated Quantities and Costs

A summary of quantities used in the cost estimate is included in Table 4-5. The cost estimate for the Parallel Canal Alternative is provided in Table 4-6.

Table 4-5. Parallel Canal Alternative Summary of Estimated Quantities

	-	Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Garces Highway	Seg 4: Garces Highway to Woollomes	-
Design Flow (Design Maximum) (cfs)	-	4,500	4,000	4,000	3,500	3,500	-
From MP to MP	-	88.2-96.67	95.67-102.7	102.7-112.9	112.9-118.96	118.96-121.5	-
Total Canal Miles	-	7.47	7.0	10.2	6.06	2.54	-
Description	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
NEW CANAL							
Clearing and grubbing	Acres	-	102	149	95	-	**346**
Excavation	CY	1,050,639	1,896,999	2,710,319	1,761,749	175,558	**7,595,264**
Compacted Canal Embankment construction	CY	530,741	1,939,674	2,748,399	401,363	43,436	**5,663,613**
Spoil Embankment		519,898	-	-	1,319,983	132,437	**1,972,318**
3-1/2" thick concrete lining	SY	384,213	396,505	632,657	366,827	-	**1,780,202**
Ladders	EA	105	99	144	92	-	**440**
Aggregate base O&M road surfacing	SY	105,011	98,653	149	92,245	28,701	**468,565**
CHECK STRUCTURES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
New Check/Siphon Structure	-	-	1	1	-	-	**2**
Existing Check Structures Demolition and Disposal	-	-	1	1	-	-	**2**
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions to Existing Bridges	EA	18	1	-	-	-	**19**
Bridge Replacement (County or State) on Existing Canal	EA	-	-	-	-	-	-
Bridge Replacement (Farm) on Existing Canal	EA	-	-	-	-	-	-
Existing Bridge Demolition	EA	-	6	12	8	-	**26**
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	-	6	11	8	-	**25**
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions on Existing Canal to Existing Turnouts	EA	7	2	-	-	3	**12**
Raise/Modify Existing Turnout Top Deck and Actuators	EA	-	-	-	-	-	-
Turnouts on New Canal	EA	-	9	8	6	-	**23**
Delivery Pools	EA	-	2	6	6	-	**14**

Table 4-5. Parallel Canal Alternative Summary of Estimated Quantities (contd.)

	-	Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Garces Highway	Seg 4: Garces Highway to Woollomes	-
UTILITIES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Parallel Overhead Powerline Relocations	MI	4.5	3.5	3.0	2.5	0.5	**14**
Adjacent Groundwater Well Abandonments	EA	6	4	8	4	1	**23**
Culvert Extensions (Each End)	EA	4	5	4	-	-	**13**
Pipeline Overcrossing Replacements (8" to 12")	EA	-	1	2	4	-	**7**
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	-	4	7	3	-	**14**
LAND ACQUISITION	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Impacted Parcels	EA	69	17	25	20	8	**139**
Permanent Land Acquisition (ROW)	Acres	20	110	260	80	40	**510**

Key:
- = Not Applicable or zero
cfs = cubic feet per second
CY = cubic yard
EA = each
LF = linear feet
LS = lump sum
MI = mile
MP = milepost
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 4-6. Parallel Canal Alternative Cost Estimate

Item	Reference	Cost	Notes/ Inclusions
Segment 1 - 5th Ave to Tule	from estimate	$28,799,642	
Segment 2 - Tule to Deer Creek (New Bypass Canal)	from estimate	$56,507,656	
Segment 3 - Deer Creek to White River (New Bypass Canal)	from estimate	$91,356,060	
Segment 4 - White River to Garces Hwy (New Bypass Canal)	from estimate	$58,590,113	
Segment 5 - Garces Hwy to Woollomes (Widen Existing Canal)	from estimate	$1,943,335	
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$4,001,997	
Subtotal		*$241,198,803*	
Contract Cost Allowance - Design Contingency	17%	$41,003,796	
Contract Cost		**$280,000,000**	Rounded
Construction Contingencies	20%	$56,000,000	
FIELD COST		**$340,000,000**	Rounded
Land Purchase - Construction Phase and ROW		$15,300,000	510 acres at $30,000/acre
Environmental Mitigation	5%	$17,000,000	Calculated as % of Field Cost
Engineering, Permitting, and Construction Management	10%	$34,000,000	Calculated as % of Field Cost
Legal and Administrative	2%	$6,800,000	Calculated as % of Field Cost
Non-Contract Costs		**$73,000,000**	Rounded
TOTAL CONSTRUCTION COST		**$410,000,000**	Rounded
Interest During Construction	2.75% Discount Rate	$17,297,958	3-year construction period
TOTAL CAPITAL COST		**$430,000,000**	Rounded
Annualized Capital Costs		$16,000,000	2.75% (FY20) over 50 years; Rounded
Additional Annualized O&M Costs		$1,000,000	Excludes current O&M costs; (FY20) over 50 years; Rounded
TOTAL ANNUALIZED COST		**$17,000,000**	Rounded

Canal Enlargement Alternative

The Canal Enlargement Alternative was formulated as an advancement of the design evaluated as Initial Alternative 1 and incorporates refinements related to water delivery turnouts, the canal cross-section design, road crossings, check structures, utilities, and costs. The design of the Canal Enlargement Alternative is based on providing maximum design flow with flood freeboard at the surveyed 2018 land surface. A single-line diagram showing features included in the Canal Enlargement Alternative is provided in Figure 4-9A and Figure 4-9B.

Canal Alignment and Cross Section

The Canal Enlargement Alternative would restore the capacity of the FKC by raising and widening the canal embankments and adding concrete lining as needed through the entire 33-mile Middle Reach. This would be accomplished by removing the uppermost extent of the existing concrete lining and, at the level of the demolished lining, excavating a horizontal bench (approximately 14 feet wide on each embankment or a total of 28 feet wide) into the existing grade and constructing new (i.e., wider) upper embankments, which would receive new concrete linings, as shown in Figure 4-8.

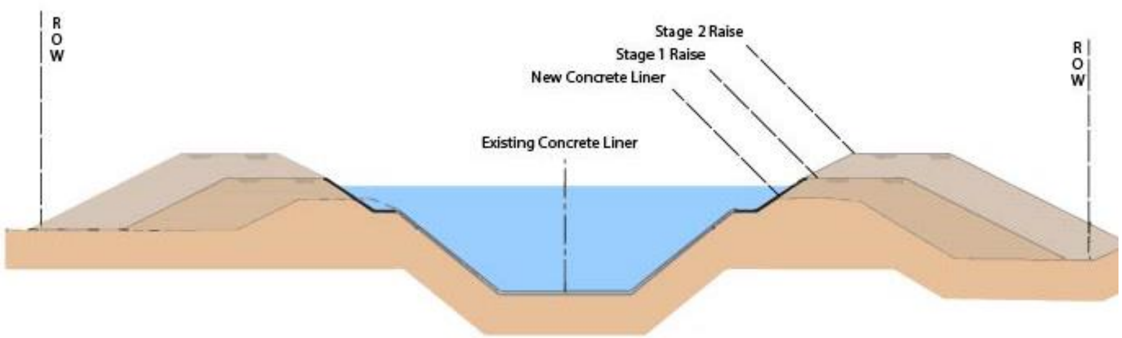

Figure 4-8. Typical Canal Enlargement Cross Section

The Canal Enlargement Alternative includes design features to accommodate anticipated future subsidence. For example, the siphon-type road crossings were sized to accommodate future increases in the HGL. In addition, canal embankments were configured such that future actions to raise the embankments and extend the canal lining could be accomplished with minimal interference to the operation of the restored FKC. The Canal Enlargement Alternative includes the right of way necessary to accommodate such a future embankment raise.

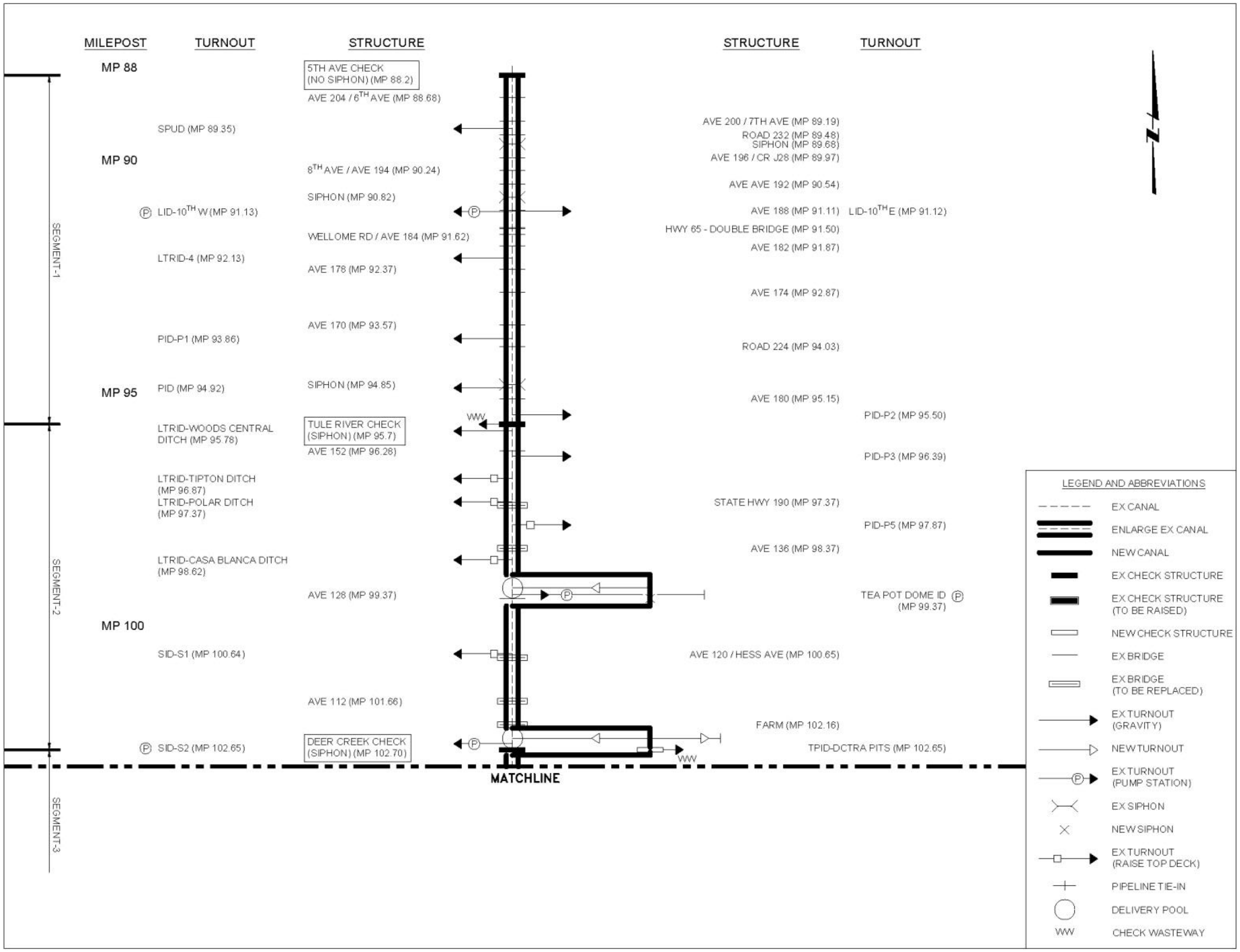

Figure 4-9A. Canal Enlargement Alternative Single-Line Diagram for Segments 1 and 2

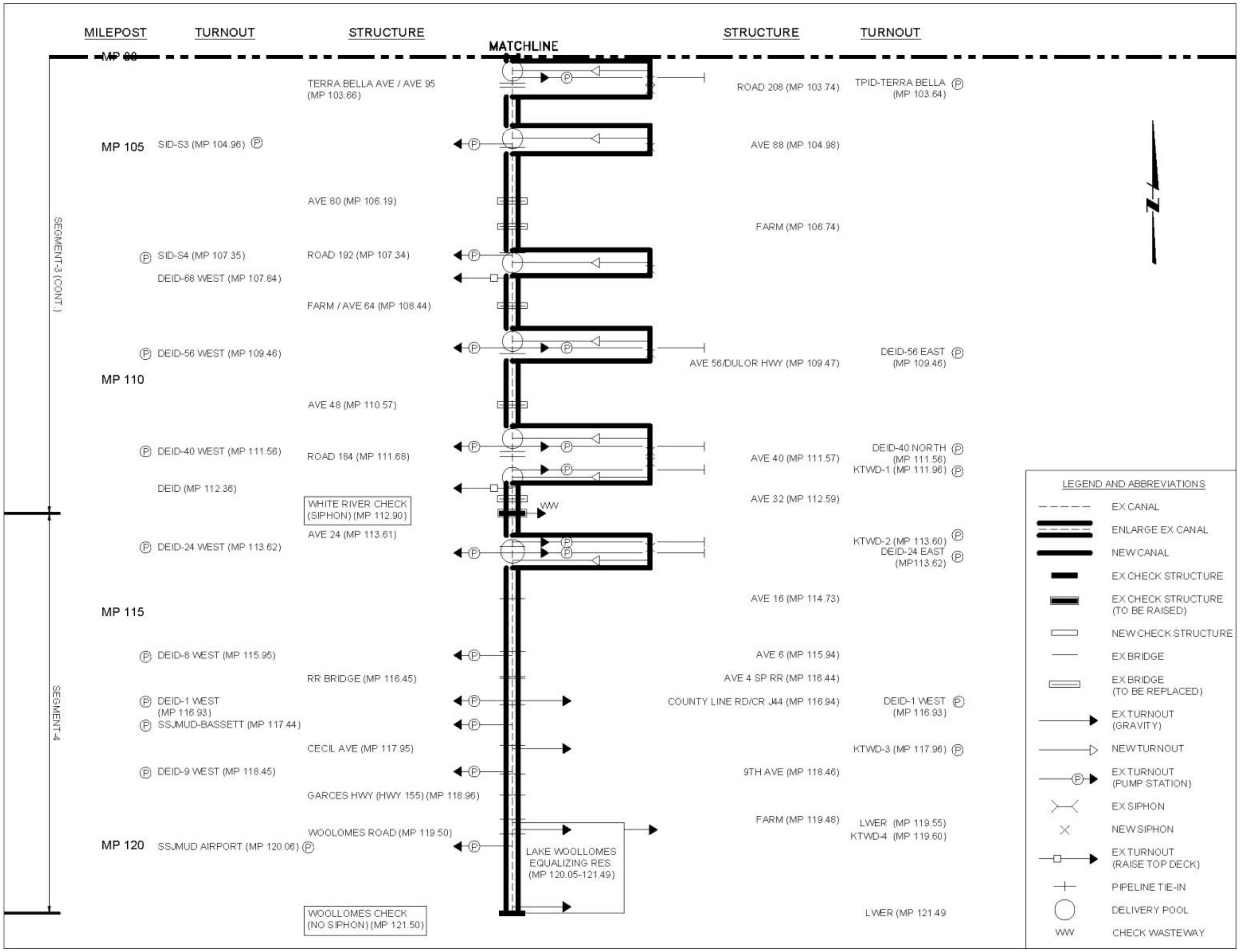

Figure 4-9B. Canal Enlargement Alternative Single-Line Diagram for Segments 3 and 4

As shown in Figures 4-9A and 4-9B, the alignment of the Canal Enlargement Alternative would jog out to the east, away from the existing canal alignment, in the vicinity of several pressurized turnouts. Each jog out would include construction of a new trapezoidal canal similar to the trapezoidal cross section described for the Parallel Canal Alternative and shown in Figure 4-4.

Construction Sequencing

The enlargement of the existing canal would be constructed as follows:

1. During annual canal shutdown periods of up to three months each, the existing FKC would be taken out of service and drained down to a level below the original grade at the toe of the existing canal banks. Existing bank material would be removed, processed, and recompacted with added material sourced offsite to construct the new, taller banks. During this step, the existing canal lining and supporting bank would be left in place for use during the following operational period.

2. The existing canal would be put back into service for use during the operational season. The existing canal would continue to operate at typical water surface elevations. "In-canal" work would cease until the next annual canal shutdown period. Work outside of the existing canal prism, such as parallel canal segments and siphons, would continue during this period.

3. During the next annual canal shutdown period, the existing canal would be taken out of service and drained down to a level below the original grade at the toe of the existing canal banks. The portion of canal that had the bank earthwork completed in Step 1 above would have part of the existing lining removed, a slope stability bench constructed, and new lining installed to the final elevations. This portion of canal would then be ready to operate at the new water surface elevations; however, this could not occur until an entire canal segment (check to check) has been completed and lined.

Turnouts

Similar to the Parallel Canal Alternative, the Canal Enlargement Alternative includes modifications at pressurized and gravity turnouts. Each turnout in the FKC Middle Reach was reviewed to determine modifications that would be required to maintain compatibility between the enlarged canal and district distribution systems, maintain water delivery capability during construction, control overflow, and enhance operational flexibility.

Pressurized Turnout Modifications. The Canal Enlargement Alternative uses the same design for pressurized turnouts that is described under the Parallel Canal Alternative. The Canal Enlargement Alternative would modify a shorter portion of the Middle Reach and therefore fewer pressurized turnout modifications are required. It is estimated that this delivery pool concept would be applied at nine locations for the Canal Enlargement Alternative using the design approach shown in Figure 4-5. A summary of modifications to pressurized turnouts under the Canal Enlargement Alterative is provided in Table 4-7.

Gravity Turnout Modifications. In the portions of the Middle Reach where no modifications would be necessary to convey maximum design flows, existing gravity turnouts would not be modified. In segments 2 and 3, nearly all existing gravity turnouts would require raising the top deck by two to four feet. The extent of the raise at each turnout is dependent upon the lining raise at that location. Raising the top deck of a gravity turnout generally consists of removing the existing top concrete deck, extending the turnout wall height to the new lining height, modifying the existing turnout gates to the new structure height, and rebuilding the top deck and site appurtenances such as retaining walls, railing, and fencing. Apart from the deck raise, two gravity turnouts would only need a new suction pipe. A list of modifications to gravity turnouts in the Canal Enlargement Alternative is provided in Table 4-7 and shown in Figure 4-10. Additional detail is provided in Appendix B Engineering Design and Cost.

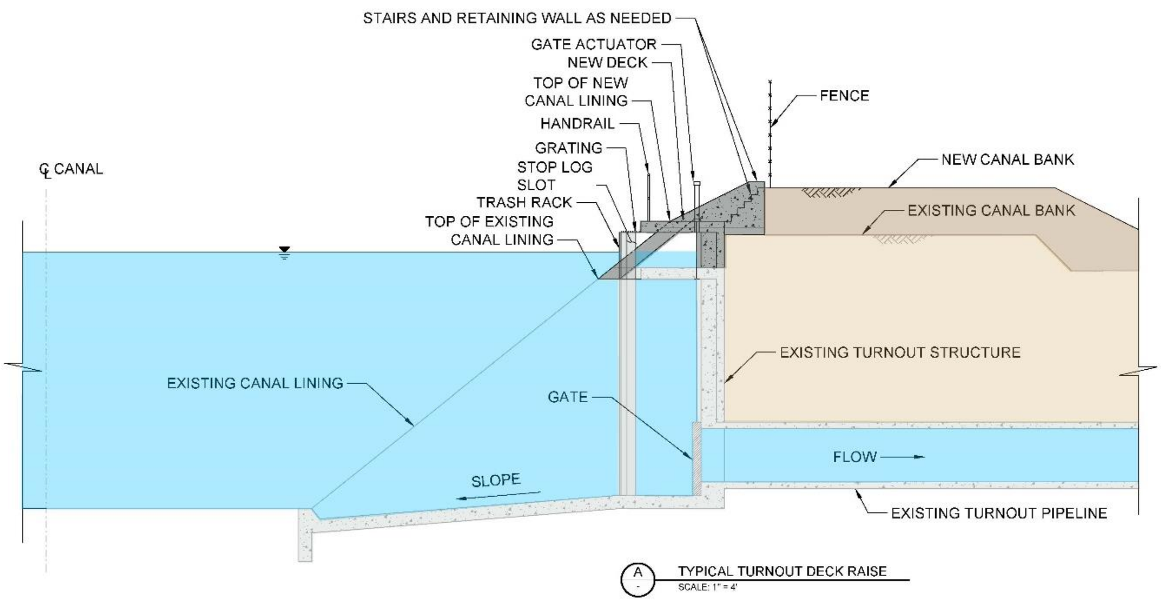

Figure 4-10. Typical Gravity Turnout Deck Raise

Table 4-7. Modifications at Turnouts Under the Canal Enlargement Alternative

Segment	Name	Milepost	Canal Side	Type	Modification
1	SPUD-STRATHMORE	89.35	West	G	None
1	LID-10th E	91.12	East	G	None
1	LID-10th W	91.12	West	P	None
1	LTRID-4	92.13	West	G	None
1	PID-P1	93.85	West	G	None
1	PID-Porter Slough	94.92	West	G	None
1	PID-P2	95.50	East	G	None
2	LTRID-Woods Central Ditch	95.78	East	G	None
2	PID-P3	96.39	East	G	None
2	LTRID-Tipton Ditch	96.87	West	G	1' Top Deck Raise
2	LTRID-Poplar Ditch N&S	97.37	West & East	G	2' Top Deck Raise
2	PID-P5	97.86	East	G	2' Top Deck Raise
2	LTRID-Casa Blanca Ditch	98.62	West	G	3' Top Deck Raise
2	TPDWD-Teapot Dome	99.37	East	P	New Delivery Pool Turnout
2	SID-S1	100.64	West	P	2' Top Deck Raise
2	TBID-DCTRA Pits	102.65	East	G	2' Top Deck Raise
2	SID-S2	102.65	West	P	New Turnout
3	TBID-Terra Bella	103.64	East	P	New Delivery Pool Turnout
3	SID-S3	104.96	West	P	New Delivery Pool Turnout
3	SID-S4	107.35	West	P	New Delivery Pool Turnout
3	DEID-68 West	107.84	West	G	Modification to Pipe
3	DEID-56 West and East	109.46	West & East	P	New Delivery Pool Turnout
3	DEID-40 West and North	111.56	West & East	P	New Delivery Pool Turnout
3	KTWD-1	111.96	East	P	New Delivery Pool Turnout
3	DEID	112.36	West	G	Modification to Pipe
4	KTWD-2	113.60	East	P	New Delivery Pool Turnout
4	DEID-24 West and East	113.62	West & East	P	New Delivery Pool Turnout
4	DEID-8th West	115.95	West	P	None
4	DEID-#1 West	116.93	East	P	None
4	SSJMUD-Bassett	117.44	West	P	None
4	KTWD-3	117.96	East	P	None
4	DEID-9th West	118.45	West	P	None
4	LWER	119.55	East	G	None
4	SSJMUD-Airport	120.06	West	P	None
4	LWER	121.49	East	G	None

Key: G = Gravity P = Pressurized

Checks and Siphons

Similar to the Parallel Canal Alternative, the Canal Enlargement Alternative requires the replacement of check structures, wasteways, and siphons at the Deer Creek and White River crossings. The new check structures and wasteways for the Canal Enlargement Alternative would be constructed within the footprint of the existing canal.

Road Crossings

Modifications at each road crossing would depend on the alignment and cross section modification at that location. Road crossings would either be replaced with a trapezoidal bridge along the existing FKC alignment or filled in and replaced with a siphon where the alignment jogs to the east to accommodate an existing pump station turnout. Siphons would be installed at nine road crossings affected by canal jogs to accommodate pump station turnouts, based on the design. A summary of road crossing modifications in the Canal Enlargement Alternative is provided in Table 4-8. A typical section for a trapezoidal bridge is shown in Figure 4-11

Table 4-8. Road Crossing Modifications in the Canal Enlargement Alternative

Segment	Name	Milepost	Modification
1	6th Avenue Bridge	88.67	Unmodified
1	7th Avenue Bridge	89.17	Unmodified
1	Road 232 Bridge	89.45	Unmodified
1	Frazier Highway 196 Bridge	89.95	Unmodified
1	8th Avenue Bridge	89.95	Unmodified
1	Avenue 192 Bridge	90.23	Unmodified
1	Avenue 188 Bridge	91.10	Unmodified
1	State Highway 65 Northbound Bridge (Double Bridge)	91.51	Unmodified
1	Welcome Avenue Bridge (Avenue 184)	91.60	Unmodified
1	Avenue 182 Bridge	91.85	Unmodified
1	Avenue 178 Bridge	92.35	Unmodified
1	W Linda Vista Avenue	92.85	Unmodified
1	W North Grand Avenue Bridge	93.55	Unmodified
1	N Westwood Street Bridge	94.01	Unmodified
1	W Henderson Avenue Bridge	95.12	Unmodified
2	Avenue 152 Bridge	96.26	Unmodified
2	Avenue 144 Bridge (Highway 190)	97.35	New Trapezoidal Bridge
2	Avenue 136 Bridge	98.35	New Trapezoidal Bridge
2	Avenue 128 Bridge	99.37	Demo- New Road Crossing/Siphon A
2	Hesse Avenue Bridge	100.64	New Trapezoidal Bridge
2	Avenue 112 Bridge	101.64	New Trapezoidal Bridge
2	Timber Farm Bridge	102.14	New Trapezoidal Bridge
3	Road Terra Bella Avenue (J24)	103.65	Demo- New Road Crossing/Siphon A
3	Road 208 Bridge	103.72	Demo- New Road Crossing/Siphon A
3	Avenue 88 Bridge	104.95	Demo- New Road Crossing/Siphon A
3	Avenue 80 Bridge	106.72	New Trapezoidal Bridge
3	Farm Bridge	106.75	New Trapezoidal Bridge
3	Road 192 Bridge	107.32	Demo- New Road Crossing/Siphon A
3	Avenue 64 Bridge	108.42	New Trapezoidal Bridge
3	Avenue 56 Bridge	109.45	Demo- New Road Crossing/Siphon A
3	Avenue 48 Bridge	110.55	New Trapezoidal Bridge
3	Avenue 40 Bridge	111.55	Demo- New Road Crossing/Siphon A
3	Road 184 Bridge	111.66	Demo- New Road Crossing/Siphon A
3	Avenue 32 Bridge	112.57	New Trapezoidal Bridge
4	Avenue 24 Bridge	113.59	Demo- New Road Crossing/Siphon A
4	Avenue 16 Bridge	114.71	New Trapezoidal Bridge
4	Avenue 8 Bridge	115.91	Unmodified
4	Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	Unmodified
4	County Road Avenue 0 Bridge	116.91	Unmodified
4	Cecil Avenue Bridge	117.92	Unmodified
4	9th Avenue Bridge	118.44	Unmodified
4	Garces Highway Bridge	118.94	Unmodified
4	Timber Farm Bridge	119.46	Unmodified
4	Woollomes Avenue Bridge	120.02	Unmodified

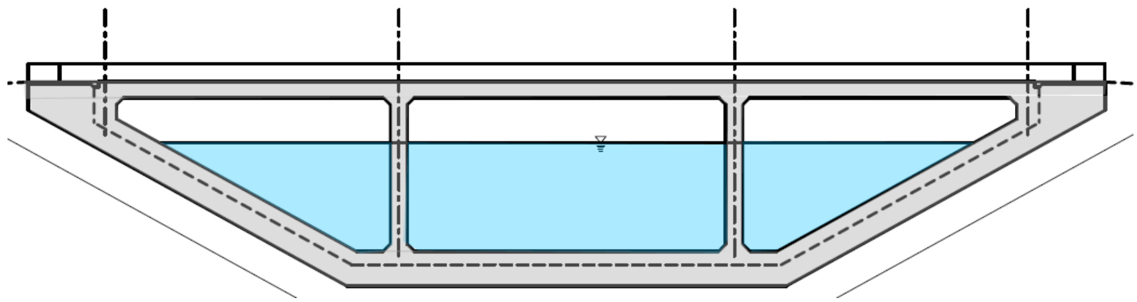

Figure 4-11. Trapezoidal Bridge Typical Section

Utilities

Numerous utilities located in, along, and across the FKC would be affected by implementation of the Canal Enlargement Alternative. The utilities include parallel irrigation canals, fly overs, overhead power lines, adjacent wells, drainage siphons and irrigation crossings under the existing canal, and utilities connected to bridges. Depending on the location and extent of canal modifications, the utilities will either be relocated or entirely replaced, as determined in the final design. A current estimate of potentially affected utilities, based on observations made during a February 2019 site visit, is provided in Table 4-9. It is expected that additional utilities that would be affected by the Parallel Canal Alternative will be identified as design progresses. More detailed information on utilities is provided in Appendix B Engineering Design and Cost.

Estimated Quantities and Costs

A summary of quantities used in the cost estimate is included in Table 4-9. The cost estimate for the Canal Enlargement Alternative is provided in Table 4-10

Table 4-9. Canal Enlargement Alternative Summary of Estimated Quantities

	-	Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Woollomes	-
Design Flow (Design Maximum) (cfs)	-	4,500	4,000	4,000	3,500	-
From MP to MP	-	88.2-96.67	95.67-102.7	102.7-112.9	118.96-121.5	-
Total Canal Miles	-	7.47	7.0	10.2	2.54	-
Description	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
NEW CANAL						
Clearing and grubbing	Acres	41	34	50	14	**139**
Excavation	CY	1,074,246	655,619	912,563	1,372,684	**4,015,112**
Compacted Canal Embankment construction	CY	357,280	1,254,396	2,376,495	370,983	**4,359,154**
Borrow Material	CY	-	598,777	1,463,932	-	**2,062,709**
Spoil Material (Waste)	CY	716,966	-	-	1,001,701	**1,718,667**
3-1/2" thick concrete lining	SY	384,213	361,207	530,071	336,269	**1,611,760**
Ladders	EA	105	100	146	42	**393**
Aggregate base O&M road surfacing	SY	105,011	98,653	143,935	92,245	**439,844**
CHECK STRUCTURES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
New Check/Siphon Structure	-	-	1	1	-	**2**
Existing Check Structures Demolition and Disposal	-	-	1	1	-	2
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions to Existing Bridges	EA	18	-	1	2	**21**
Bridge Replacement (County or State) on Existing Canal	EA	-	5	5	-	**10**
Bridge Replacement (Farm) on Existing Canal	EA	-	1	2	-	**3**
Existing Bridge Demolition	EA	-	1	7	1	**9**
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	-	1	7	1	**9**
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions on Existing Canal to Existing Turnouts	EA	7	10	10	11	**38**
Raise/Modify Existing Turnout Top Deck and Actuators	EA	-	5	2	-	**7**
Turnouts on New Canal	EA	-	3	6	1	**45**
Delivery Pools	EA	-	2	6	1	**9**

Table 4-9. Canal Enlargement Alternative Summary of Estimated Quantities (contd.)

	-	Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Woollomes	-
UTILITIES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Parallel Overhead Powerline Relocations	MI	4.5	3.5	3	1	**12**
Adjacent Groundwater Well Abandonments	EA	6	4	8	-	**18**
Culvert Extensions (Each End)	EA	4	5	4	-	**13**
Pipeline Overcrossing Replacements (8" to 12")	EA	-	1	2	2	**5**
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	-	4	7	1	**12**
LAND ACQUISITION	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Impacted Parcels	EA	69	23	41	9	**142**
Permanent Land Acquisition (ROW)	Acres	20	24	89	11	**144**

Key:
- = Not Applicable or zero
cfs = cubic feet per second
CY = cubic yard
EA = each
MI = mile
MP = milepost
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 4-10. Canal Enlargement Alternative Cost Estimate

Item	Reference	Cost	Notes/ Inclusions
Segment 1 - 5th Ave to Tule	from estimate	$35,842,369	
Segment 2 - Tule to Deer Creek (New Bypass Canal)	from estimate	$67,967,878	
Segment 3 - Deer Creek to White River (New Bypass Canal)	from estimate	$114,292,531	
Segment 4 - White River to Garces Hwy (New Bypass Canal)	from estimate	$29,313,312	
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$8,475,919	
Subtotal		*$255,892,010*	
Contract Cost Allowance - Design Contingency	17%	$43,501,642	
Contract Cost		**$300,000,000**	Rounded
Construction Contingencies	20%	$60,000,000	
FIELD COST		**$360,000,000**	Rounded
Land Purchase - Construction Phase and ROW		$4,300,000	144 acres at $30,000/acre
Environmental Mitigation	5%	$18,000,000	Calculated as % of Field Cost
Engineering, Permitting, and Construction Management	10%	$36,000,000	Calculated as % of Field Cost
Legal and Administrative	2%	$7,200,000	Calculated as % of Field Cost
Non-Contract Costs		**$66,000,000**	Rounded
TOTAL CONSTRUCTION COST		**$430,000,000**	Rounded
Interest During Construction	2.75% Discount Rate	$24,000,459	4-year construction period
TOTAL CAPITAL COST		**$450,000,000**	Rounded
Annualized Capital Costs		$16,500,000	2.75% (FY20) over 50 years; Rounded
Additional Annualized O&M Costs		$1,000,000	Excludes current O&M costs; (FY20) over 50 years; Rounded
TOTAL ANNUALIZED COST		**$17,500,000**	Rounded

Summary

A summary comparison of the quantities and costs for the Parallel Canal and Canal Enlargement alternatives is provided in Table 4-11 and 4-12. The primary distinction between the two alternatives is that the Parallel Canal Alternative involves realigning the existing canal whereas the Canal Enlargement Alternative alignment would be based on the existing canal. This distinction results in differences in earthwork, concrete, borrow requirements, siphon road crossings, delivery pools, and cost.

Table 4-11. Total Quantities Summary of Alternatives

Description	Unit	Parallel Canal Alternative	Canal Enlargement Alternative
NEW CANAL			
Clearing and grubbing	Acres	346	139
Excavation	CY	7,595,264	4,015,112
Compacted Canal Embankment construction	CY	5,663,613	4,359,154
Borrow	CY	-	2,062,709
Spoil to Embankment	CY	1,972,318	-
Spoil to Waste	CY	-	1,718,667
3-1/2" thick concrete lining	SY	1,780,202	1,611,760
Ladders	EA	440	393
Aggregate base O&M road surfacing	SY	468,565	439,844
CHECK STRUCTURES	**Unit**		
New Check/Siphon Structure	-	2	2
Existing Check Structures Demolition and Disposal	-	2	2
ROAD CROSSINGS – BRIDGES	**Unit**		
Canal Transitions to Existing Bridges	EA	19	21
Bridge Replacement (County or State) on Existing Canal	EA	-	10
Bridge Replacement (Farm) on Existing Canal	EA	-	3
Existing Bridge Demolition	EA	26	9
ROAD CROSSINGS - SIPHONS	**Unit**		
Siphon Construction on New Canal	EA	25	9
TURNOUTS	**Unit**		
Canal Transitions on Existing Canal to Existing Turnouts	EA	12	38
Raise/Modify Existing Turnout Top Deck and Actuators	EA	0	7
Turnouts on New Canal	EA	23	45
Delivery Pools	EA	14	9
UTILITIES	**Unit**		
Parallel Overhead Powerline Relocations	MI	14	12
Adjacent Groundwater Well Abandonments	EA	23	18
Culvert Extensions (Each End)	EA	13	13
Pipeline Overcrossing Replacements (8" to 12")	EA	7	5
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	14	12
LAND ACQUISITION	**Unit**		
Impacted Parcels	EA	139	119
Permanent Land Acquisition (ROW)	Acres	510	154

Key:
CY = cubic yard
EA = each
MI = mile
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 4-12. Cost Summary for Alternatives

Item	Reference	Parallel Canal Alternative Costs	Canal Enlargement Costs
Segment 1 - 5th Ave to Tule	from estimate	$28,799,642	$35,842,369
Segment 2 - Tule to Deer Creek	from estimate	$56,507,656	$67,967,878
Segment 3 - Deer Creek to White River	from estimate	$91,356,060	$114,292,531
Segment 4 - White River to Woollomes	from estimate	$60,533,448	$29,313,312
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$4,001,997	$8,475,919.17
Subtotal		*$241,198,803*	*$255,892,010*
Contract Cost Allowance - Design Contingency	17%	$41,003,796	$43,501,642
Contract Cost		**$280,000,000**	**$300,000,000**
Construction Contingencies	20%	$56,000,000	$60,000,000
FIELD COST		**$340,000,000**	**$360,000,000**
Land Purchase - Construction Phase and ROW		$15,300,000	$4,300,000
Environmental Mitigation	5%	$17,000,000	$18,000,000
Engineering, Permitting, and Construction Management	10%	$34,000,000	$36,000,000
Legal and Administrative	2%	$6,800,000	$7,200,000
Non-Contract Costs		**$73,000,000**	**$66,000,000**
TOTAL CONSTRUCTION COST		**$410,000,000**	**$430,000,000**
Interest During Construction	2.75% Discount Rate	$17,297,958	$24,620,190
TOTAL CAPITAL COST		**$430,000,000**	**$450,000,000**
Annualized Capital Costs		$16,000,000	$16,500,000
Additional Annualized O&M Costs		$1,000,000	$1,000,000
TOTAL ANNUALIZED COST		**$17,000,000**	**$17,500,000**

Chapter 5 Evaluation of Alternatives

This chapter presents an evaluation and comparison of the No Action Alternative and the Alternatives described in Chapter 4 with respect to effectiveness, efficiency, completeness, and acceptability and selects a Recommended Plan. This chapter also describes refinements to Recommended Plan that were applied following its selection. Economic comparisons are presented for the inter-dependent effects that result from restoring the capacity of the FKC for the following benefits in comparison to the No Action Alternative:

- Water Supply – through increased delivery of Friant Division water supplies to Friant Division long-term contractors;
- Flood Control – through the provision of additional storage capacity in Millerton Lake to manage flood events before authorized flood storage capacity is encroached;
- Fish and Wildlife Enhancement – through avoided water supply impacts associated with water operations following flood events.

Water Supply Benefits

Because all benefits associated with restoring the capacity of the FKC are associated with water deliveries, the water supply benefits are presented first. Evaluating the benefits of the Alternatives involves consideration of conditions that are expected to change over the 100-year planning horizon. Identified conditions that are expected to change and affect the Project include water supply availability at Friant Dam, and delivery capability of the FKC under the No Action Alternative and action Alternatives in response to future subsidence. The quantification of physical effects associated with water delivery through the subsided FKC, and calculation of monetary water supply benefits was accomplished through a multiple-step process, that included the following:

- Estimate water supply available at Friant Dam through the planning horizon
- Determine the capacity of the existing FKC in the No Action Alternative and the capacity of Alternatives in response to future subsidence over the planning horizon
- Quantify water deliveries affected by reduced canal capacity
- Reschedule affected supplies in Millerton Lake to the extent possible
- Quantify and value lost water supply.

A schematic of the evaluation approach is shown in Figure 5-1 and described in the following sections; additional detail is provided in the Appendix C Economics Evaluation.

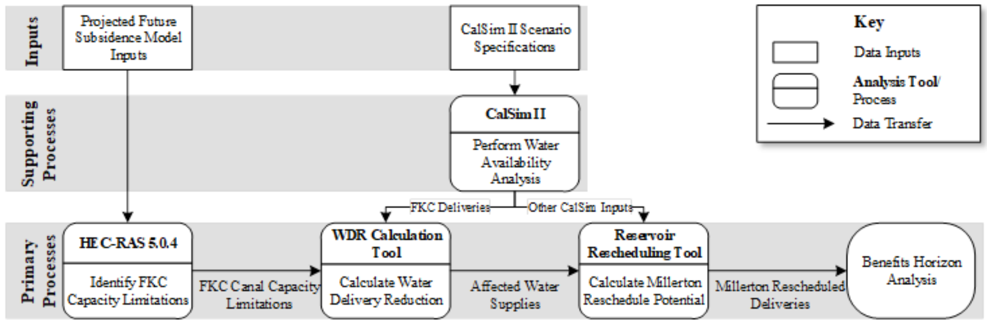

Figure 5-1. Modeling Process for Economics Evaluations

Water Supply Availability at Friant Dam

The California Water Resources Simulation Model (CalSim II) was used to estimate water deliveries from Friant Dam to Friant Division long-term contractors over an 82-year simulation period based on historical hydrologic data for water years 1922 through 2003. The CalSim II model simulates the operation of Millerton Lake to meet a variety of objectives, including the release of flows to the San Joaquin River for water rights and SJRRP Restoration Flows, diversion to the San Joaquin River and Friant-Kern and Madera canals for delivery of water under Friant Division Class 1 and Class 2 contracts and Section 215/other contracts and obligations, and flood operations. Simulated diversions to the Friant-Kern and Madera canals are based on CalSim-estimated water supply allocations under the various contract types, as applied to typical diversion patterns into the canals based on historical data. Only the capacity at the headworks of the canal is considered in the operation of the CalSim II model, meaning the diversions assume no conveyance capacity restrictions due to design deficiencies or subsidence.

For the benefits evaluation, the current implementation of the SJRRP Flow is used for the water supply availability in the year 2019. This amount is projected to linearly decrease to delivery amounts that would occur under conditions that enable the release of full Restoration Flow volume by the year 2025. It is assumed that annual average Friant Division water supply availability would remain constant after 2025.

FKC Capacity Reduction over Planning Horizon

The capacity of the FKC will continue to decrease as land subsides in the future and the decreased capacity will reduce water delivery capability. The rate of land subsidence is assumed to be the same in the No Action Alternative and all action alternatives. Estimates of subsidence along the FKC for Group 3 conditions, as described in Chapter 2, for years 2030, 2040, and 2070 were used in a HEC-RAS model of the FKC, described in Appendix A1a1 HEC-RAS Modeling Technical Memorandum (TM) to determine canal capacity at these dates. The groundwater model results indicate that the greatest amount of future land subsidence is projected occur between 2017 (first year of groundwater model simulation) and 2030, with additional subsidence occurring to 2040 when actions to achieve SGMA requirements would be fully implemented, and additional subsidence occurring to 2070 as a result of 'residual' subsidence of subsurface formations. As shown in Figure 5-2, additional land subsidence will reduce the capacity of the FKC. Similar computations were conducted to estimate the effect of land subsidence on the restored canal capacity at future points in time under the two Alternatives.

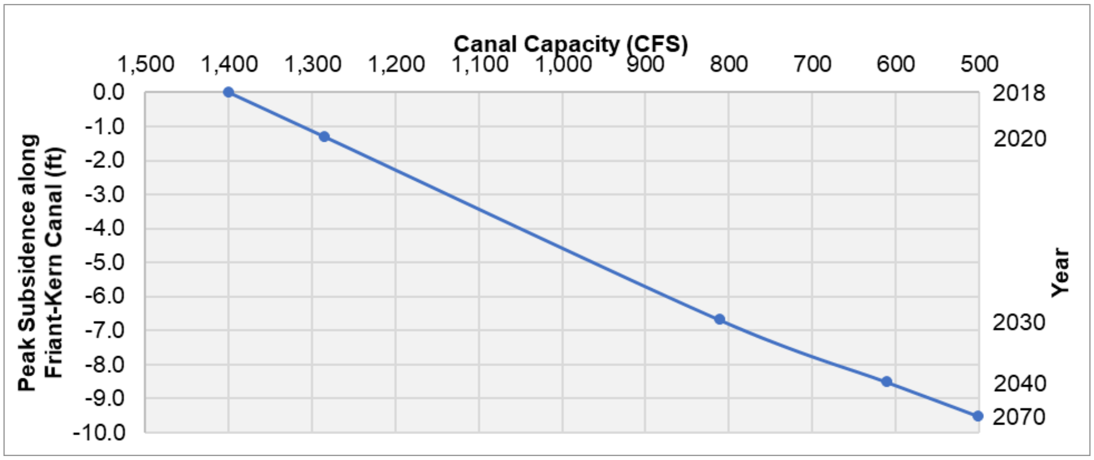

Figure 5-2. Friant-Kern Canal Capacity Under Future Peak Subsidence

Affected Water Deliveries

The modeled canal capacities from HEC-RAS simulations, combined with the variations of water availability, were used in the Water Delivery Reduction Tool to calculate the affected Class 1 and Class 2, and RWA/215 water supply for the Friant Division long-term contractors on the FKC downstream of the subsidence chokepoint. As described in the Economics Evaluation Appendix, the Water Delivery Reduction Tool applies historical patterns of daily diversions to the FKC to estimate water deliveries that would be affected as a result of reduced canal capacity. Evaluations were made for years corresponding to results for simulated ground subsidence during the project planning horizon and interpolated for intervening years. Table 5-1 presents the results of modeled flow capacity, from the HEC-RAS model and the total expected annual affected water deliveries, based on the Water Delivery Reduction Tool described in Appendix C.

Table 5-1. Modeled FKC Capacity and Average Annual Affected Water Supplies

Year	Estimated Minimum Capacity (cfs)	Average Annual Affected Water Supply (AF/yr)
2018	1,400	27,083
2030	810	102,651
2040	610	149,346
2070	500	179,746

Source: Information is from the Water Delivery Reduction Tool Calculation described in Appendix C-Economics Evaluation
Key: cfs = cubic feet per second

The average annual affected water supply quantities listed in Table 5-1 apply to Class 1 and Class 2, and RWA/215 water deliveries, based on information provided in the CalSim II model. RWA/215 water supply is water made delivered pursuant to Paragraph 16(b) of the Settlement "for the purpose of reducing or avoiding impacts to water deliveries to all of the Friant Division long-term contractors caused by the Interim and Restoration Flows."

In the benefits evaluation over the planning horizon, the values of annual estimated capacity of the FKC and corresponding average annual affected water deliveries were linearly interpolated between the evaluation results listed in Table 5-1. Groundwater modeling of a range of potential implementation responses to SGMA reveal that most future subsidence would occur between years 2020 and 2040, with residual subsidence continuing to about the year 2070. Therefore, it is assumed that canal capacity and average annual affected water deliveries would remain constant after 2070.

Rescheduled Water Deliveries

As described in Chapter 4, the No Action Alternative and the Alternatives assume that affected water supplies due to FKC capacity constraints could be rescheduled through Millerton Lake operations to the extent possible. While Millerton Lake is typically operated as an annual reservoir with no long-term carry-over storage objectives, the operation of Millerton Lake provides some opportunities to store water for use in successive periods. The approach used to evaluate rescheduled water deliveries for the Project assumes that all affected deliveries would be rescheduled using available conservation storage capacity in Millerton Lake. Rescheduled water that would cause encroachment into the authorized flood control storage capacity of Millerton Lake would be released as flood flows to the San Joaquin River.

This approach is considered conservative because it represents the maximum opportunity for rescheduling and therefore results in a minimum estimate of lost water supplies. Actual opportunities for rescheduling are expected to be less than evaluated due to several factors, including supply and demand forecasting uncertainty, Millerton Lake operations, the ability of Friant Division long-term contractors to adjust local water uses, water rights, CVP Friant Division contract term requirements and Reclamation policy. The economic analysis assumes that rescheduling of affected water deliveries could be accomplished at no additional cost.

Additional Groundwater Pumping

Affected water supplies that could not be delivered through rescheduling in Millerton Lake would result in water supply reductions to Friant Division long-term contractors. The remaining option for replacement of the water supply reductions would be additional groundwater pumping in the affected districts. However, additional groundwater pumping to replace undeliverable supplies would exceed groundwater pumping reduction targets presented in the draft GSPs that cover the Tule Subbasin. As a result, it is anticipated that groundwater pumping would not increase to replace undeliverable water supplies.

Reduced Deliveries to Friant Division Long-Term Contractors

Affected water supplies that could not be rescheduled in Millerton Lake would be lost as flood releases from Friant Dam to the San Joaquin River and represents a loss of water supply to affected Friant Division long-term contractors. Table 5-2 and Figure 5-3 present the volumes of Class1, Class 2, and RWA/215 water supplies that are lost as flood releases from Friant Dam.

	Annual Average Lost Water Supply by Year Type (TAF/yr)											
	Class 1			Class 2			RWA/215			Total		
	2030	2040	2070	2030	2040	2070	2030	2040	2070	2030	2040	2070
Wet	22	70	105	100	131	146	37	41	44	159	242	295
Above Normal	12	47	83	44	70	80	12	14	16	68	131	179
Below Normal	4	13	23	23	31	37	1	1	1	28	45	61
Dry	5	13	27	22	29	33	0	1	1	27	43	61
Critical	0	0	0	1	6	13	0	0	0	1	6	13
Average Annual	10	34	55	45	63	72	13	15	16	68	112	143

Table 5-2. Average Annual Volume of Lost Water by Contract and Year Type

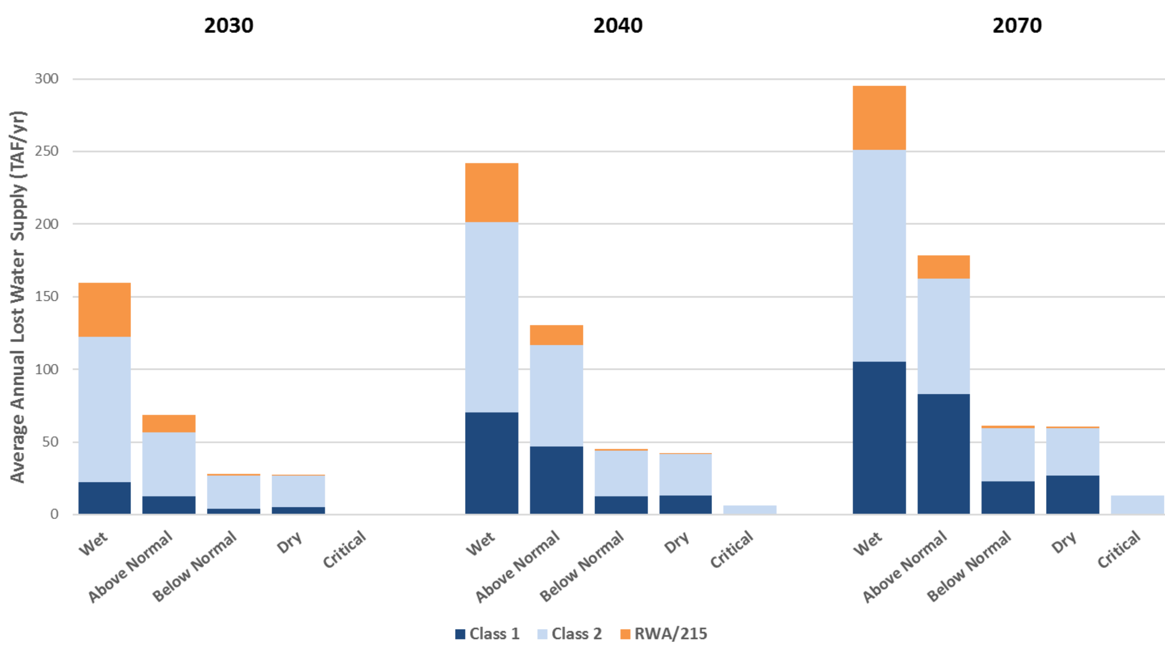

Figure 5-3. Average Annual Volume of Lost Water Supply by Contract and Year Type

Water Supply Monetary Benefits

Water supply benefits are calculated by applying the value of water supply in the eastern San Joaquin Valley to estimated lost water supplies. Water values in the eastern San Joaquin Valley are based on estimates by California Water Commission (CWC) in 2015 under the water rights and regulatory operational requirements in effect at the time. The CWC classified current unit values of water as those corresponding to water operations simulations under a projected 2030 level of development. The values provided by the CWC in 2015, escalated to 2018 price levels using the U.S. Bureau of Economic Analysis GDP Deflator, are shown in Table 5-3.

Table 5-3. Estimated Water Values in the Eastern San Joaquin Valley

Water Year Type	2030 Condition Friant Service Area 2015 Price Value ($/AF of Consumptive Use)	2030 Condition Friant Service Area 2018 Price Value ($/AF of Consumptive Use)
Wet	$200	$211
Above Normal	$251	$265
Below-Normal	$261	$276
Dry	$278	$294
Critical	$324	$342
Weighted Average	$256	$271

Source: CWC WSIP Technical Reference Document

Regional land subsidence will continue through the planning horizon and will cause a decrease in the capacity of the FKC over the planning horizon. This future subsidence will affect water supply deliveries in the No Action Alternative and potentially under project Alternatives. Water supply reductions can result from reduced delivery resulting from land subsidence through the planning horizon, and also delivery impacts that occur during the period of construction for the Alternatives.

Table 5-4 through Table 5-6 show the planning horizon analysis of water supply delivery reductions for the No-Action and Alternatives. Computations are made for each year in the planning horizon. For ease of presentation, the tables report annual results for years 1 through 10 and then every decade following until year 100, the end of the planning horizon. The tables provide the present value of reduced water deliveries over the planning horizon.

Water supply benefits of the Alternatives are based on differences in the present value of reduced water deliveries between project Alternatives and the No Action Alternative, as summarized in Table 5-7.

Table 5-4. Planning Horizon Valuation Analysis of Lost Water Supply Under the No-Action Alternative

	A	B	C	D	E	F	G = D+E+F	H	I = G*H
Year	Average Annual Deliveries (TAF) (A)	Average Annual No Action Affected Water Supply (TAF) (B)	Average Annual Affected Water Supply Rescheduled in Millerton (TAF) (C)	Average Annual Reduction in Class 1 Supply (TAF) (D)	Average Annual Reduction in Class 2 Supply (TAF) (E)	Average Annual Reduction in RWA/215 Supply (TAF) (F)	Average Annual Reduction in Total Water Supply (TAF) (G)	Value of Water Lost ($/AF) (H)	Annual Value of Lost Water ($M) (I)
1	405.9	43.2	16.9	0.0	13.7	12.6	26.3	$271	$7.1
2	402.5	47.5	18.9	0.0	15.9	12.6	28.6	$271	$7.7
3	399.1	51.8	20.9	0.0	18.4	12.4	30.8	$271	$8.3
4	395.7	56.1	22.9	0.0	21.2	11.9	33.1	$271	$9.0
5	392.2	60.4	25.0	0.0	24.2	11.2	35.4	$271	$9.6
6	392.2	68.8	26.6	0.0	30.1	12.1	42.2	$271	$11.4
7	392.2	77.3	28.3	0.0	36.2	12.7	48.9	$271	$13.2
8	392.2	85.7	30.0	0.0	42.6	13.1	55.7	$271	$15.1
9	392.2	94.2	31.7	0.0	49.1	13.4	62.5	$271	$16.9
10	392.2	102.7	33.3	2.0	53.7	13.5	69.2	$271	$18.7
20	392.2	149.3	36.4	31.4	66.1	15.4	112.8	$271	$30.5
30	392.2	159.5	35.7	39.2	68.7	15.9	123.7	$271	$33.5
40	392.2	169.6	34.9	47.2	71.0	16.4	134.7	$271	$36.5
50	392.2	179.7	34.1	55.6	73.1	16.8	145.6	$271	$39.4
60	392.2	179.7	34.1	55.6	73.1	16.8	145.6	$271	$39.4
70	392.2	179.7	34.1	55.6	73.1	16.8	145.6	$271	$39.4
80	392.2	179.7	34.1	55.6	73.1	16.8	145.6	$271	$39.4
90	392.2	179.7	34.1	55.6	73.1	16.8	145.6	$271	$39.4
100	392.2	179.7	34.1	55.6	73.1	16.8	145.6	$271	$39.4
								Present Value	$970

Table 5-5. Planning Horizon Valuation Analysis of Lost Water Supply Under the Parallel Canal Alternative

	A	B	C	D	E	F	G = D+E+F	H	I = G*H
Year	Average Annual Deliveries (TAF) (A)	Average Annual No Action Affected Water Supply (TAF) (B)	Average Annual Affected Water Supply Rescheduled in Millerton (TAF) (C)	Average Annual Reduction in Class 1 Supply (TAF) (D)	Average Annual Reduction in Class 2 Supply (TAF) (E)	Average Annual Reduction in RWA/215 Supply (TAF) (F)	Average Annual Reduction in Total Water Supply (TAF) (G)	Value of Water Lost ($/AF) (H)	Annual Value of Lost Water ($M) (I)
1	405.9	43.2	16.9	0.0	13.7	12.6	26.3	$271	$7.1
2	402.5	47.5	18.9	0.0	15.9	12.6	28.6	$271	$7.7
3	399.1	51.8	20.9	0.0	18.4	12.4	30.8	$271	$8.3
4	395.7	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
5	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
6	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
7	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
8	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
9	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
10	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
20	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
30	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
40	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
50	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
60	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
70	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
80	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
90	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
100	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
								Present Value	$23

Table 5-6. Planning Horizon Valuation Analysis of Lost Water Supply Under the Canal Enlargement Alternative

	A	B	C	D	E	F	G = D+E+F	H	I = G*H
Year	**Average Annual Deliveries (TAF) (A)**	**Average Annual No Action Affected Water Supply (TAF) (B)**	**Average Annual Affected Water Supply Rescheduled in Millerton (TAF) (C)**	**Average Annual Reduction in Class 1 Supply (TAF) (D)**	**Average Annual Reduction in Class 2 Supply (TAF) (E)**	**Average Annual Reduction in RWA/215 Supply (TAF) (F)**	**Average Annual Reduction in Total Water Supply (TAF) (G)**	**Value of Water Lost ($/AF) (H)**	**Annual Value of Lost Water ($M) (I)**
1	405.9	43.2	16.9	0.0	13.7	12.6	26.3	$271	$7.1
2	402.5	47.5	18.9	0.0	15.9	12.6	28.6	$271	$7.7
3	399.1	51.8	20.9	0.0	18.4	12.4	30.8	$271	$8.3
4	395.7	56.1	22.9	0.0	21.2	11.9	33.1	$271	$9.0
5	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
6	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
7	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
8	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
9	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
10	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
20	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
30	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
40	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
50	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
60	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
70	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
80	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
90	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
100	392.2	0.0	0.0	0.0	0.0	0.0	0.0	$271	$-
								Present Value	$31

Table 5-7. Summary of Water Supply Benefits

Item	Canal Enlargement Alternative	Parallel Canal Alternative
Value of reduced water delivery in the No Action Alternative[1,2]	$970	$970
Value of reduced water delivery in the Project Alternative[1,2]	$31	$23
Water Supply Benefit[1,2]	$939	$947

Notes:
[1] All costs are in millions of dollars
[2] Net Present Value based on 100-year planning horizon

Flood Control Benefits

Flood benefits provided by Millerton Lake result from the management of flood flows in authorized flood management storage space operated by the USACE, and the availability of non-flood storage capacity that fills before authorized flood space becomes encroached. Water that cannot be delivered because of constrained capacity in the FKC is temporarily stored in non-flood storage space in Millerton Lake until it can be delivered at a later time or until storage levels in Millerton Lake encroach into authorized flood control space and it must be released as flood flows from Friant Dam to the San Joaquin River.

As FKC canal capacity diminishes over time due to localized ground subsidence, the volume of water that can be delivered to Friant Division long-term contractors will continue to be reduced and authorized flood control space will be encroached more frequently, and for greater durations, including during periods that historically have not included flood releases, such as critically dry water years. Less available non-flood storage space results in increased frequency and magnitude of flood storage space encroachments, and increases the frequency, magnitude, and duration of flood flow releases to the San Joaquin River. Increased frequency, magnitude and duration of flood flows to the San Joaquin River increases the potential for flood damages. Restoration of the capacity of the Middle Reach of the FKC will restore the availability of non-flood storage capacity in Millerton Lake to manage authorized water supplies.

Flood benefits were estimated using a basin-wide flood damage analysis framework and associated suite of technical tools that were originally developed as part of the USACE Sacramento and San Joaquin River Basins Comprehensive Study (Comprehensive Study) (USACE 2002). The Comprehensive Study economic analysis was based on the P&G. A primary objective of the analysis was to quantify estimated annual flood damages along each reach of the San Joaquin River that would result from alternative plans. The flood damage reduction benefit of an alternative is quantified as difference in estimated flood damages resulting from the alternative plan and the flood damages that would occur under the no action alternative. Analytical tools developed for the Comprehensive Study were designed to support evaluations of flood management actions for the entire San Joaquin River basin, and include:

- The USACE HEC-5 model was used for hydrologic modeling of flood operations at all reservoir in the San Joaquin River Basin that are operated for flood control purposes. Hydrologic data included inflows to all major reservoirs operated for flood management, ranging from Pine Flat Reservoir on the Kings River in the south to New Hogan Reservoir on the Calaveras River in the north. At each reservoir, flood scenarios were simulated for standard return-frequency events (2-year, 10-year, 25-year 50-year, 100-year, 200-year, and 500-year). Storm centering analysis was used to combine the standard return-frequency events at a given reservoir with interpreted return frequency hydrologic conditions at all other reservoirs in the basin. The results include flood releases that would occur from each reservoir for a return frequency event at any one reservoir. This process was repeated for each reservoir to produce flood flows under a wide range of return-frequency events at multiple locations in the basin, thereby providing a basin-wide representation of flood conditions.

- The USACE HEC-HMS UNET unsteady state hydraulic model was used to simulate flood routing through the San Joaquin River flood control system. The hydraulic model included all floodways, river channels (leveed and non-leveed reaches) and flood bypasses that convey flood flows in the system. The UNET model simulated levee breaks at defined locations that would occur when river stage levels exceed levels that would trigger probable failure, as determined based on geotechnical data. All return-frequency events were simulated for each storm centering in the San Joaquin River Basin. The resulting maximum river stage for a given return-frequency event was selected as the representative river stage for that event.

- Economic analysis of flood damage reduction was calculated using the USACE HEC Flood Damage Assessment (HEC-FDA) model. The HEC-FDA model represents damageable property in all areas subject to flooding from major flood management and conveyance systems in the entire San Joaquin River basin. The HEC-FDA model integrates hydrologic, hydraulic, and geotechnical engineering and economic data, and incorporates uncertainty for risk analysis using a Monte Carlo simulation procedure. The output of the HEC-FDA model is expressed in terms of estimated annual damage (EAD), which represents the long-term average annual flood damage expected for a given area. Computation of EAD takes into account interrelated hydrologic, hydraulic, geotechnical, and economic information and associated uncertainties. Specifically, EAD is determined by combining the discharge-frequency, stage-discharge (or frequency), and stage-damage functions and integrating the resulting damage-frequency function. Uncertainties are present for each of these functions and are carried forth into the EAD computation.

Flood Control Benefits Associated with Additional Storage Capacity

In support of the Upper San Joaquin River Basin Storage Investigation (USJRBSI), several scenarios were evaluated using the Comprehensive Study framework and tools to quantify the effects that increased available storage capacity Millerton Lake would have on flood damages in the San Joaquin River Basin (Reclamation and DWR 2005b, Flood Damage Reduction Technical

Appendix). These scenarios evaluated the EAD that would result from the operation of the currently authorized flood control space in Millerton Lake of 170 TAF, plus increments of additional available storage capacity. Results are shown in Table 5-8, indexed to July 2018 price levels.

Table 5-8. Total Expected Annual Damages in the San Joaquin River Basin Associated with Additional Storage Capacity at Millerton Lake

Total Available Storage for Flood Management (TAF)	Additional Storage Capacity above Authorized Millerton Lake Flood Capacity (TAF)	EAD ($ millions)	Reduction in EAD Resulting from Additional Storage Capacity ($ millions)
170	0	$40.0	$0
210	40	$38.2	$1.8
250	80	$37.5	$2.5
340	170	$36.5	$3.5
500	330	$34.9	$5.1
1,000	830	$31.6	$8.4

Source: U.S. Department of the Interior, Bureau of Reclamation and California Department of Water Resources. 2005b. Upper San Joaquin River Basin Storage Investigation, Initial Alternatives Information Report. Flood Damage Reduction Technical Appendix. June.

Notes:

[1] Dollar values are expressed in July 2018 price levels.

[2] The expected annual damage associated with 1,000 TAF of flood storage was not assessed with the HEC-FDA model. Instead, it was calculated by fitting a curve defined by a logarithmic function to the data points associated with smaller flood storage values, and using this curve to estimate the expected annual damage associated with 1,000 TAF of flood storage.

Key:
n/a = not applicable
TAF = thousand acre-feet

Flood Control Benefits of Additional Storage Capacity Provided by Alternatives

In the No Action Alternative and project Alternatives, flood control benefits result from the management of authorized flood control space in Millerton Lake plus available storage capacity that would fill before the authorized flood control space would be encroached. Flood benefits of restoring the capacity of the FKC are based on the difference in EAD that would result in the No Action Alternative and the EAD that would result from the Project Alternatives.

The EAD for the No Action Alternative and project Alternatives is based on managing floods using the authorized flood control space plus the additional capacity in Millerton Lake that would be available at the 90 percent exceedence for each month with flood control requirements. For each applicable calendar month, the 90 percent exceedance storage space is calculated as the amount of storage space that is available in that month during at least 90 percent of the years modeled. The 90 percent exceedance storage space was determined for each month of the modeled period under a variety of projected subsidence conditions (2020, 2030, 2040, and 2070).

Flood control benefits for the No Action Alternative and project Alternatives were calculated for each month from October through March, and the result for each month was factored based on the number of days in the month relative to the total number of days in the flood operation period. An example of differences in the monthly storage capacity available for flood management for the projected subsidence conditions in 2030 is shown in Table 5-9.

Table 5-9. Total Storage Capacity Available for Flood Management for the No Action Alternative and Project Alternatives for Project Subsidence in 2030

Month	Number of Days Applicable to Flood Control	Storage Capacity Available for Flood Management (TAF)			Total EAD ($ millions)		
		No Action Alternative	Project Alternatives	Difference	No Action Alternative	Project Alternatives	Difference
October	15	127	214	87	$42.5	$38.1	$4.4
November	30	177	269	92	$39.7	$37.3	$2.4
December	31	170	203	33	$40.0	$38.5	$1.6
January	31	170	170	0	$40.0	$40.0	$0.0
February	28	170	170	0	$40.0	$40.0	$0.0
March	15	131	131	0	$42.3	$42.3	$0.0
Weighted Average	N/A	163	197	38.4	$40.4	$39.2	$1.24

EAD values were interpolated between values for given flood storage volumes from the HEC-FDA modeling reported in Table 5-8 to determine the EAD associated with the storage available under each Alternative at each point in the planning horizon. Following the same approach used for water supply benefits, EAD values for each year in the planning horizon were linearly interpolated between values computed for 2020, 2030, 2040 and 2070 and assumed constant after 2070. Table 5-10 presents the present value of flood control benefits provided by the No Action and project Alternatives over the planning horizon.

Table 5-11 presents the flood control benefits based on the change in total EAD between the No Action Alternative and the project alternatives. Because the differences in EAD are based solely the effect of storage capacity that would be available 90 percent of the time, the value of the benefit was calculated as 90 percent of the change in EAD.

Table 5-10. Planning Horizon Valuation Analysis of Flood Control Benefits

Year	No Action Alternative Average Annual Storage Available (TAF)	No Action Alternative EAD ($M)	Parallel Canal Alternative Average Annual Storage Available (TAF)	Parallel Canal Alternative EAD ($M)	Canal Enlargement Alternative Average Annual Storage Available (TAF)	Canal Enlargement Alternative EAD ($M)
1	181	$39.7	181	$39.7	181	$39.7
2	179	$39.8	179	$39.8	179	$39.8
3	177	$39.9	177	$39.9	177	$39.9
4	175	$39.9	194	$39.3	175	$39.9
5	173	$40.0	195	$39.3	195	$39.3
6	171	$40.1	195	$39.2	195	$39.2
7	169	$40.2	196	$39.2	196	$39.2
8	167	$40.3	196	$39.2	196	$39.2
9	165	$40.4	197	$39.2	197	$39.2
10	163	$40.4	197	$39.2	197	$39.2
20	162	$40.5	197	$39.2	197	$39.2
30	160	$40.6	197	$39.2	197	$39.2
40	159	$40.7	197	$39.2	197	$39.2
50	158	$40.7	197	$39.2	197	$39.2
60	158	$40.7	197	$39.2	197	$39.2
70	158	$40.7	197	$39.2	197	$39.2
80	158	$40.7	197	$39.2	197	$39.2
90	158	$40.7	197	$39.2	197	$39.2
100	158	$40.7	197	$39.2	197	$39.2
Present Value		$1,412		$1,369		$1,370

Table 5-11. Summary Flood Control Benefits

Item	Canal Enlargement Alternative	Parallel Canal Alternative
PV of EAD in the No Action Alternative[1,2]	$1,412	$1,412
PV of EAD in the Project Alternative[1,2]	$1,370	$1,369
Flood Control Benefit[1,2]	$41.9	$42.5
Flood Control Benefit Based on 90% Availability of Storage Capacity[1,2]	$37.7	$38.3

Notes:
[1] All costs are in millions of dollars
[2] Present Value based on 100-year planning horizon

Fish and Wildlife Enhancement Benefits – Restoration Flow Management in Millerton Lake

The increase in flood releases from Friant Dam caused by reduced capacity of the FKC presents challenges to the management of Restoration Flows stored in Millerton Lake. As shown in Figure 5-3, the volume of water that would be released as flood flows in the No Action Alternative would increase as subsidence reduces the capacity of the existing FKC. Additional flood flow releases would result from two conditions:

- Larger volumes of water released during flood operations due to limited diversion capacity resulting from conveyance constraints in the FKC.
- Increased occurrence of flood releases at times that otherwise would not have occurred in the absence of conveyance constraints in the FKC.

As flood management events come to an end, releases from Friant Dam are gradually reduced from flood releases to the target Restoration Flows. The ramp-down involves the use of Restoration Flow volume and is typically designed in consideration of other ecological factors, such as preserving sufficient Restoration Flow volume to enable year-round river continuity, gravel mobilization, bank stability, riparian habitat conditions, adult and juvenile fish migration, water temperature, water depth and flow rates, fish passage, and other Restoration Flow objectives. If Restoration Flows cannot be designed to fully accommodate flood control operations, portions of the San Joaquin River below Friant Dam would experience flows lower than Restoration Flow targets and are at risk of drying. Additional water would need to be acquired at Friant Dam and from downstream users to preserve the ability to release Restoration Flows and reduce the risk drying portions of the San Joaquin River.

Figure 5-4 shows a map of San Joaquin River reaches downstream from Friant Dam. During non-flood operations, Restoration Flows are provided through these reaches, including the reach downstream from Sack Dam (Reach 5 in Figure 5-4). During flood operations water users have the right to divert flows into the Chowchilla Bypass (Number 3 in Figure 5-4) and at Mendota pool (Number 4 in Figure 5-4), removing the ability to assure Restoration Flow targets can be met downstream from Sack Dam.

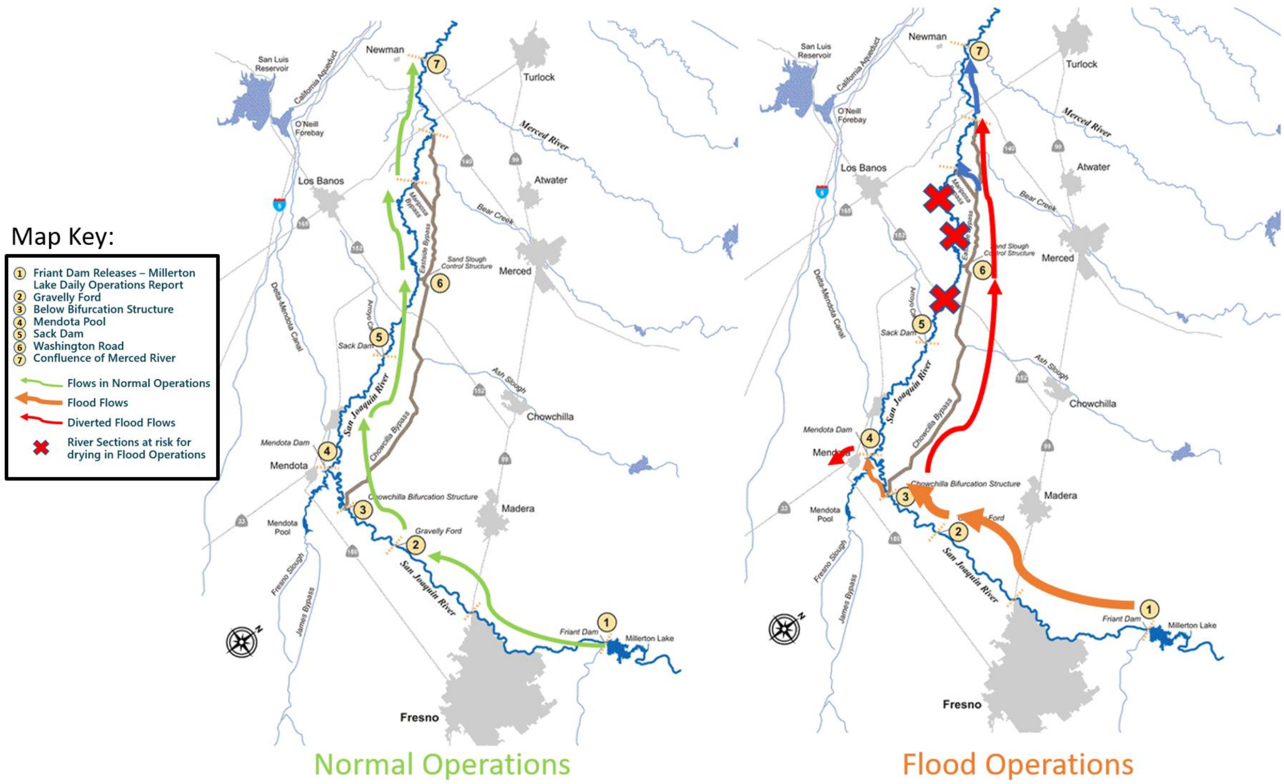

Figure 5-4. River Operations below Friant Dam under Normal and Flood Operations

The increased frequency of flood releases results in a greater use of Restoration Flows to move water below Sack Dam and for ramp-down operations, resulting in reduced availably of Restoration Flows for other purposes. It is not possible to quantify all effects to Restoration Flow management resulting from increased storage levels and flood releases from Millerton Lake. Therefore, the benefits valuation focuses only on avoided loss of Restoration Flow volume associated with ramp-down operations resulting from Project Alternatives, as compared to the No Action Alternative.

Table 5-12 summarizes the expected number of flood releases by water year type that would occur at the projected 2030 land subsidence condition. The simulation summarizes expected values over the 82-year simulation period for the No Action Alternative and the project alternatives. Both project alternatives would be fully constructed by 2030, and therefore would provide the same effect. As shown, the project Alternatives would reduce the number of flood occurrences in comparison to those that would occur in the No Action Alternative.

Table 5-12. Comparison of Flood Release Occurrences Under Projected 2030 Subsidence Conditions

San Joaquin River Basin Year Type	Number of Flood Release Occurrences in 82-year Simulation Period		
	No Action Alternative	Project Alternatives	Reduced Number of Occurrences with Project Alternatives
Wet	38	30	8
Above Normal	22	11	11
Below Normal	7	2	5
Dry	7	1	6
Critical	2	0	2
Total	76	44	32

Table 5-13 summarizes the differences in monthly release volumes when transitioning from a month with flood operations to a subsequent month without flood operations. In recognition that flood events could occur at any time during a month, it is assumed that ramping from flood flows to Restoration Flows would be achieved in a one-week period at the beginning of a non-flood release month following any month in which a flood releases would occur. The volume of water required to maintain Restoration Flows in the San Joaquin River downstream from Friant Dam while transitioning from flood operations to normal operations is estimated based on a one-week linear ramp-down. The volume of water needed to achieve linear ramp-down between flood flows and Restoration Flows under normal operations is estimated at one-eighth the difference between monthly releases for flood flows and monthly release for Restoration Flows, as shown in Table 5-13.

Table 5-13. Average Change in Monthly Release Volume From Flood Release to Restoration Flow Requirements Under Projected 2030 Subsidence Conditions

Year Type	Average Change in Total Monthly Release from Flood Occurrence to Restoration Flow (TAF)			Avoided Restoration Flow Releases for Flood Flow Ramp Down (TAF)
	No Action Alternative	Project Alternatives	Difference	
Wet	106	102	4	0.4
Above Normal	34	5	29	3.7
Below Normal	3	0	3	0.4
Dry	5	0	5	0.7
Critical	0.3	0	0.3	0.03
Weighted Average	39	31	8	1.0

The release of water supply identified in Table 5-13 to maintain restoration flows during the flood operations and ramp-down from additional flood occurrences to restoration flows would decrease the availability of Restoration Flows for other planned purposes to achieve the Restoration Goal. The fish and wildlife enhancement benefit of avoided additional flood ramping is calculated as cost to acquire the water supply lost to flood operations and ramp-down management. The monetary benefit of avoided use of restoration flow supplies for additional flood operations and ramping is calculated for each year type by multiplying the value of water presented in Table 5-3 by the restoration flow volumes lost to flood operations and ramp down. Calculations were made for projected subsidence conditions in 2020, 2030, 2040 and 2070. The results for the projected 2030 subsidence conditions is shown in Table 5-14.

Table 5-14. Average Annual Value of Avoided Restoration Flow Releases following Additional Flood Occurrences Under Projected 2030 Subsidence Conditions

Year Type	Avoided Use of Restoration Flows for Following Additional Flood Occurrences (TAF)	Value of Water Supply ($/TAF)	Benefit of Avoided Restoration Flow Ramp Down Following Additional Flood Events
Wet	0.4	$211	$82,781
Above Normal	3.7	$265	$970,278
Below Normal	0.4	$276	$118,310
Dry	0.7	$294	$200,734
Critical	0.03	$342	$11,839
Average Annual	1.0	n/a	$266,442

Table 5-15 presents the present value of fish and wildlife enhancement benefits analysis of Restoration Flow Management resulting from the No Action and project Alternatives over the planning horizon. Table 5-16 summarizes the fish and wildlife enhancement benefit for Restoration Flow Management, based on avoided water purchases needed to ramp down Friant Dam releases from additional flood occurrences to Restoration Flows. The monetary value of avoided acquisitions to preserve Restoration Flow targets as a result of diversion of flood flows is not included in the valuation; therefore, the benefits estimate is expected to be a lower bound estimate of benefits.

Table 5-15. Planning Horizon Valuation Analysis of Restoration Flow Management Benefits

Year	No Action Alternative Restoration Flow Management Lost Volume (TAF)	No Action Alternative Restoration Flow Management Lost Value ($)	Parallel Canal Alternative Restoration Flow Management Lost Volume (TAF)	Parallel Canal Alternative Restoration Flow Management Lost Value ($)	Canal Enlargement Alternative Restoration Flow Management Lost Volume (TAF)	Canal Enlargement Alternative Restoration Flow Management Lost Value ($)
1	0	-	0	-	0	-
2	0.05	$ 24,215	1.46	$ 24,215	1.46	$ 24,215
3	0.17	$ 54,494	2.29	$ 54,494	2.29	$ 54,494
4	0.29	$ 84,772			3.12	$ 84,772
5	0.41	$ 115,050				
6	0.53	$ 145,328				
7	0.65	$ 175,607				
8	0.77	$ 205,885				
9	0.89	$ 236,163				
10	1.01	$ 266,442				
20	2.02	$ 511,831				
30	2.01	$ 525,916				
40	2.01	$ 540,001				
50	2.01	$ 554,086				
60	2.01	$ 554,086				
70	2.01	$ 554,086				
80	2.01	$ 554,086				
90	2.01	$ 554,086				
100	2.01	$ 554,086				
Present Value		$14,160,126		$75,183		$153,329

Table 5-16. Summary of Restoration Flow Management Benefits

Item	Canal Enlargement Alternative	Parallel Canal Alternative
Restoration Flow Management Lost in the No Action Alternative[1,2]	$14.16	$14.16
Restoration Flow Management Lost in the Project Alternative[1,2]	$0.15	$0.08
Restoration Flow Management Benefit[1,2]	$14.01	$14.08

Notes:
[1] All costs are in millions of dollars
[2] Present Value based on 100-year planning horizon

Summary of Benefits

Table 5-17 presents a summary of total monetary benefits provided by the Alternatives. As discussed in Chapter 4, cost estimates for the Alternatives are reported as an opinion of probable construction cost (OPCC) and cost ranges were provided based on plus or minus 25 percent variation in field costs. The net present value of Alternatives costs include and life cycle costs (annual O&M and replacement costs) over the planning horizon and interest during construction (IDC) costs applied over the construction duration. For the calculation of net benefits, IDC was applied to total construction costs. This approach overstates IDC requirements, and therefore understates net benefits, because non-Federal funding will be required at the time of construction.

Table 5-17. Benefit and Cost Comparison of Alternatives

Item	Canal Enlargement Alternative	Parallel Canal Alternative
Water Supply Benefit[1,2]	$939	$947
Flood Control Benefit[1,2]	$37.7	$38.3
Fish and Wildlife Enhancement Benefit – Restoration Flow Management	$14.0	$14.1
Total Benefit	$990.7	$999.4
Present Value of Total Capital and Life Cycle Costs [1,3]	$461	$450
Net Benefit[4]	$529.7	$549.4

Notes:
[1] All costs are in millions of dollars
[2] Present Value based on 100-year planning horizon
[3] Total Capital and Life Cycle Cost = Total Construction Cost + IDC + OM&R
[4] Net Benefit equals Benefits minus Net Present Value of Total Capital and Life Cycle Cost

Evaluation of Alternatives using Federal Planning Criteria

The Federal planning process described in the PR&G includes four criteria for consideration in formulating and evaluating alternative plans: completeness, effectiveness, efficiency, and acceptability (CEQ 2013). For each criterion, evaluations were based on quantitative and qualitative information, and ratings were assigned based on a scale of low, moderate, or high. Evaluation results are provided in Table 5-18 and described in the following sections.

Table 5-18. Summary of Federal Planning Criteria Evaluation

Criterion	Parallel Canal Alternative	Canal Enlargement Alternative
Effectiveness	High	Moderate-High
Efficiency	High	Moderate-High
Completeness	High	Moderate-High
Acceptability	Moderate-High	Medium

Effectiveness

Effectiveness is the extent to which an alternative plan would alleviate problems and achieve the planning objectives for a project in a timely manner. Both Alternatives would restore the design capacity of the FKC Middle Reach and would restore the capability to convey water supplies based on historical operations. Therefore, both Alternatives would be effective in meeting the planning objectives.

The Parallel Canal Alternative could be constructed with minimal interference to the operation of the existing FKC with a construction schedule estimated at slightly more than three years. Because most construction of the Parallel Canal Alternative would be performed outside of the existing FKC cross section, water delivery restrictions during construction would be minimal. Construction of the Canal Enlargement Alternative would be within the of the existing FKC cross section and would require that water deliveries be suspended during some construction periods. The construction period of the Canal Enlargement Alternative is estimated at about four years, assuming FKC deliveries could be suspended up to three months each year. If wet hydrologic conditions occur during construction, water delivery requirements may shorten or eliminate the canal shut down period causing an extension of the construction period and delay in benefits realization.

Water delivery evaluations presented in this report are based on historical deliveries and do not include operational objectives in response to changing water supply conditions, particularly the implementation of SGMA. The performance of both Alternatives would improve similarly if future operational objectives to increase water deliveries above historical amounts, including deliveries that would exceed historical peak flows. Many Friant Division long-term contractors have considered development of local water projects such as groundwater banking, local canal enlargement or intertie projects, and other actions that would improve water management in response to reduced water supply availability. If the implementation of such projects results in delivery of water from Friant Dam under existing CVP contracts at flows that exceed historical FKC flow rates, both Alternatives would have the ability to convey greater water quantities in an equivalent manner.

In consideration of the above factors, the effectiveness of Parallel Canal Alternative is rated high and the effectiveness of the Canal Enlargement Alternative is rated moderate-high.

Efficiency

Efficiency is a measure of how an alternative plan alleviates the specified problems and realizes the specified opportunities at the least cost, or in a cost-effective manner. As noted in the discussion on Effectiveness, all analyses presented in this report are based on historical deliveries and do not include potential changes in future operations. Under this assumption both Alternatives, when fully constructed, would provide the same water delivery capability.

Water supply benefits were compared to costs estimated for the Alternatives described in Chapter 4 to determine net benefits. As shown in Table 5-18, both Alternatives produce net benefits that are greater than zero, and therefore both are efficient. The Parallel Canal Alternative provides the same capability at a lower cost than the Canal Enlargement Alternative. The Parallel Canal Alternative provides the same capability at a lower cost than the Canal Enlargement Alternative.

Long-term O&M costs in excess of current O&M expenditures were estimated at $1 million per year for both for the Parallel Canal and Canal Enlargement alternatives. While it is not possible at this level of project development to quantify specific requirements, it is likely that O&M costs for the Canal Enlargement Alternative would be greater than those of the Parallel Canal. The bottom portion of the existing canal prism would be preserved for all segments in the Canal Enlargement Alternative, whereas it would be preserved only in the segments of the Parallel Canal Alternative that involve modifications to the existing FKC. Additional O&M costs would be associated with maintenance of canal panels during dewatering, sediment removal, and corrective actions to reduce seepage through canal embankments.

In consideration of the above factors, the efficiency of the Parallel Canal Alternative is rated high and the efficiency of the Canal Enlargement Alternative is rated moderate-high.

Completeness

Completeness is a determination of whether an alternative plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others. Sub-criteria that are important in measuring completeness include (1) authorization, (2) planning objective(s), (3) reliability or durability, (4) physical implementability or constructability, and (5) effects on environmental resources. Each of these sub-criteria are described below.

Authorization
Authorization for Reclamation participation in this Project is provided by the Settlement Act (PL 111-11, Title X, Part III) and the WIIN Act (43 USC 390b, sec. 4007).

Part III of the Settlement Act authorizes the restoration of the FKC to such capacity as previously designed and constructed by the Bureau of Reclamation (PL 111-11, sec. 10201). Both Alternatives would restore the capacity of the FKC to the original maximum capacity with current Reclamation freeboard criteria. Both Alternatives are consistent with the Settlement Act.

Funding for preparation of the Study is provided, in part, under the authorization of the WIIN Act. The WIIN Act is applicable for Federal funding up to 50 percent of construction costs allocated to Federal purposes provided by the Project.

Planning Objectives
Both the Parallel Canal and Canal Enlargement alternatives meet the planning objectives of restoring the original designed canal capacity. The restored capacity of the FKC would increase water supply reliability to Friant Division long-term contractors south of the FKC choke point. Increased water deliveries would contribute to the conjunctive use function of the CVP Friant Division, provide revenue to the SJRSS Fund for continued implementation of the Restoration Goal, improve the operation management capability of Friant Dam in managing Restoration Flows for release to the San Joaquin River, a reduce flood risk to areas downstream from Friant Dam.

Reliability or Durability
Because both alternatives would be constructed to the same design capacity, they would perform similarly in response to future land subsidence in comparison the No Action Alternative. Both alternatives would enable raising embankments and canal lining to preserve the original design capacity in response to future land subsidence to year 2070. To account for anticipated 2070 subsidence levels the construction may need to be phased to account for possible long-term exposure of construction materials. Construction phasing will be addressed during the Final Design Process. Only those modifications to accommodate subsidence that could be implemented with minimal interference to canal operations during construction would be considered for deferral to a future time.

Over the project life, O&M requirements of the Canal Enlargement Alternative may be greater than that of the Parallel Canal Alternative because the lower portion of the enlarged FKC through the most subsided reach (Segments 2 and 3) would be the originally constructed FKC.

Physical Implementability or Constructability
Similar features have been included in both Alternatives to address requirements for turnouts, road crossings, checks, siphons, and utilities. Both alternatives are constructible using accepted construction methods, however constraints associated with construction of canal modifications

differ between the alternatives. Preliminary construction constraints and sequencing plans reveal several challenges associated with their construction, particularly within the prism of an operating canal.

- Borrow Material – The Parallel Canal Alternative could be constructed with either balanced material requirements for earthwork or a surplus that could be spoiled on project features. The Canal Enlargement Alternative would require significant borrow material, with borrow sources ideally located on each side of the FKC to limit hauling over the existing bridges, many of which have load restrictions. Depending on the location of borrow sources (which had not been identified at the time these alternatives were formulated and evaluated), constraints on the larger equipment ideally suited to hauling large loads may be imposed.

- Potential Reduction in Water Deliveries During Construction – The water surface elevation in the FKC will need to be lowered in order to remove existing concrete lining to construct a new bench (setback) below the existing top of lining. This is required to reduce additional loading on the existing 1.25:1 canal side slopes. During this portion of the construction, the conveyance capacity of the canal will be reduced significantly. Detailed analyses will need to be performed to define the actual bench elevation, with full consideration of geotechnical slope stability, and then estimate this impact to water supply deliveries. It is envisioned that scheduling of this construction will need to be coordinated with low delivery periods, which would extend the construction schedule so that water supply deliveries can be maintained as much as possible. Reduced water levels to accommodate in-prism construction would be more significant in the Canal Enlargement Alternative because the bench features would be constructed in all portions of the FKC Middle Reach, whereas bench features in the Parallel Canal Alternative would be located only in the upper-most and lower-most portions of the FKC Middle Reach.

- Safety Risk During Construction – The Canal Enlargement Alternative would have a greater safety risk to staff during construction than the Parallel Canal Alternative because more of the work would be completed within an active water delivery system.

- Tie-ins – Both Alternatives include structures, such as check structures, wasteways, and siphons, and parallel canal segments that will require upstream and downstream temporary or permanent tie-ins to the existing FKC. Tie-ins require appropriate advance planning, reliable concepts, and carry some risk that water deliveries could be interrupted during construction.

- Potential for Construction Delays to Accommodate Water Delivery Operations – The Parallel Canal Alternative would be constructed over a period of slightly more than three years and the Canal Enlargement Alternative would be constructed over a four-year period. Construction of the Canal Enlargement Alternative would require multiple canal shut-downs for periods up to three months to accommodate in-canal work. Construction of the Parallel Canal Alternative would require in-canal work in Segments 1 and 4 only and would require fewer tie-ins than the Canal Enlargement Alternative. Water delivery impacts during construction of the Parallel Canal Alternative would be minimal because most construction activities will be in the dry using new materials, and its construction would not rely on the existing embankments for stability. The Canal Enlargement Alternative would be more subject to delays during wet hydrologic conditions when construction may need to be suspended to enable water delivery because it requires more in-canal work and tie-ins than the Parallel Canal Alternative.

Environmental Resources

An analysis of potential environmental constraints was prepared and applied to the evaluation of Initial Alternatives. This evaluation contributed to the selection of the two alternatives evaluated in this chapter. Additional environmental resources comparison criteria were not applied in support of the analysis and comparison of the Alternatives. Information on environmental resources presented in Chapter 3 for Alternative 1 (applicable to the Canal Enlargement Alternative) and Alternative 5 (applicable to the Parallel Canal Alternative) was considered in this evaluation. The assessment of environmental resources relevant to the two alternatives evaluated in this chapter, as presented in Chapter 3, are similar and do not reveal significant differences.

Ratings for Completeness

In consideration of the factors described above, the completeness of the Parallel Canal Alternative is rated high and the completeness of the Canal Enlargement Alternative is rated moderate-high.

Acceptability

Acceptability is the viability and appropriateness of an alternative plan from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies. It does not include local or regional preferences for particular solutions or political expediency.

Environmental compliance and permitting processes are under way and will evaluate canal enlargement and parallel canal alternatives. An Environmental Assessment/Initial Study (EA/IS) was prepared by Reclamation and FWA. The EA/IS determined that an Environmental Impact Statement (EIS) will be required for compliance with the National Environmental Policy Act (NEPA) and an Environmental Impact Report (EIR) will be required for compliance with the California Environmental Quality Act (CEQA). As a result, a joint EIS/EIR will be prepared.

In preparing the EA, Reclamation identified environmental resources of concern that may require mitigation. Reclamation has also begun coordination for Endangered Species Act (ESA) and National Historic Preservation Act, Section 106 compliance. To date, these efforts have not identified environmental resources concerns, legal requirements, or policies that would require significant project modifications as a result of the NEPA or permitting processes.

New right of way would be required for both the Parallel Canal and Canal Enlargement alternatives. Estimated right of way requirements are based on the design of these Alternatives for construction relative to the surveyed 2018 land surface plus additional right of way that would be required to accommodate future embankment raising relative to the projected 2070 land surface. The Parallel Canal Alternative would require 510 acres of permanent right of way from 139 parcels adjacent to the eastern limit of existing right of way for the FKC. The Canal Enlargement Alternative would require 144 acres of permanent right of way from 142 parcels adjacent to the eastern and western limits of existing FKC right of way. The Parallel Canal Alternative would affect many of the same parcels affected by the Canal Enlargement Alternative east of the existing FKC, however the amount of acreage to be acquired from each would be greater because the additional space needed for construction of the new parallel canal segment.

As evaluated, both Alternatives would affect about the same number of parcels. Anticipated refinements of the Parallel Canal Alternative to reduce the length of the new canal alignment portion and to refine the canal cross section will reduce the required acreage and number of affected parcels. These refinements would not be applicable to the Canal Enlargement Alternative and therefore the potential to reduce the number of affected parcels for this alternative is less. Therefore, it is expected that the Canal Enlargement Alternative would require a greater number of parcels and would rank lower in acceptability.

Acceptability among Friant Division long-term contractors will consider several factors that have not yet been fully evaluated, including the availability of Federal and State funding, the allocation of costs among Friant Division contractors, and the need for conveyance capacity to accommodate potential future operational requirements.

In consideration of the above factors, acceptability for the Parallel Canal Alternative is rated moderate-high and acceptability for the Canal Enlargement Alternative is rated medium.

Identification of the Recommended Plan

The identification of the Recommended Plan is based on consideration of Federal Planning Criteria described above. As described below, the Parallel Canal Alternative is identified as the Recommended Plan. The selection of the Parallel Canal Alternative is supported by the findings of a Value Planning Study performed by Reclamation which ranked the alternative highest compared to alternatives considered during the value planning process. In selecting the Parallel Canal Alternative as the Recommended Plan, Reclamation also obtained input from FWA, the FKC operating entity.

National Economic Development Plan

The objective of the National Economic Development (NED) analysis is to estimate the economic benefits used in the determination of Federal feasibility and identify the alternative plan that maximizes net benefits. Parallel Canal Alternative is identified as the NED Plan because it provides the greatest net benefits, as shown in Table 5-7.

Value Planning Study

In October of 2019 Reclamation performed a value planning study of the Friant-Kern Canal Middle Reach Capacity Correction Project. The goal of the value planning study is to achieve the most appropriate and highest value solution for an identified problem. The value planning study included an examination of the component features of the Project, or activity to define the critical functions, governing criteria, and associated costs. Alternative ideas and solutions were suggested to perform the functions, consistent with the identified criteria, at a lower cost or with an increase in long-term value.

The Value Planning review of the Initial and Alternatives confirmed the Parallel Canal Alternative as the superior alternative considered in this Study. The value planning study considers the Parallel Canal Alternative as the Baseline Design in which alternative ideas are compared to, and additional design considerations are added to. The ideas were evaluated, analyzed, and prioritized, and a few of these were evaluated to a level suitable for comparison, decision-making, and adoption.

Reclamation produced the Draft Value Planning Report that summarizes the activities and ideas developed the value planning team. Table 5-19 shows the analysis matrix developed by the value planning team that ranked the developed ideas compared to the Baseline Design (Parallel Canal Alternative). From the proposed ideas the Parallel Canal Alternative was evaluated as the highest value project and confirms the Parallel Canal Alternative as the Recommended Plan.

Table 5-19. Analysis Matrix from Value Planning Study

Analysis Matrix

Criteria	A		B		C		D		E		F		Raw Score	Weighted Score	Ranking	Disposition
Weight	0.07		0.04		0.19		0.04		0.33		0.33					
Idea	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted				
Baseline Design	4	0.27	5	0.22	5	0.93	5	0.22	4	1.31	5	1.64	28	4.6	**1**	
RCC Embakment	2	0.14	2	0.09	4	0.75	5	0.22	4	1.31	2	0.66	19	3.2	**4**	
MSE Wall	3	0.20	5	0.22	4	0.75	4	0.18	4	1.31	4	1.31	24	4	**3**	
Unlined Parallel Canal	4	0.27	5	0.22	5	0.93	3	0.13	3	0.99	5	1.64	25	4.2	**2**	
Recharge w/ Existing	5	0.34	5	0.22	5	0.93	5	0.22	2	0.66	5	1.64	27	4.01		

Score: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, Poor = 1

Score 4-5 (green)
Score 3-4 (yellow)
Score 2-3 (red)

Operating Entity Input and Collaboration

Reclamation sought input from the FWA, the operating entity for the FKC, in the identification of the Recommended Plan. FWA reviewed analyses presented in this Report and considered other information related to potential phased construction and long-term O&M of the Alternatives. The FWA reviewed evaluations of various capacities for the Parallel Canal and Canal Enlargement alternatives to identify potential challenges that may be associated with incremental project phasing that could result from funding limitations. The FWA also considered long-term O&M requirements and the potential for water delivery restrictions during construction associated with the Alternatives. As a result of these evaluations and considerations, the FWA concurred with Reclamation's identification of the Parallel Canal Alternative as the Recommended Plan.

Summary of Refinements to the Parallel Canal Alternative

Subsequent to the identification of the Parallel Canal Alternative as the Recommended Plan, several refinements were made to reduce material requirements and improve constructability and project resilience. Design refinements included reduction of the required length of canal realignment portion, refinement of the location of the center-line of the realigned segment, selection of canal cross-sections that provide greater resiliency under future subsidence conditions, identification of potential borrow sites, and other considerations. Refinements to the Parallel Canal Alternative described below are reflected in the description of the Recommended Plan presented in Chapter 6.

Refinement of Length of Canal Realignment

The Parallel Canal Alternative included a realigned canal segment from south of Ave. 152 near MP 96 to Garces Highway near MP 119. Through additional modeling and refinement, it was determined that the length of canal realignment segment could be shortened and achieve the maximum design capacity and HGL. The canal realignment in the Recommended Plan extends from MP 96 to Avenue 8 near MP 116. This refinement resulted in reducing the canal realignment by approximately 3 miles, reducing the among of required embankment material and reducing project costs.

Refinement of Canal Realignment Offset from Existing FKC

The realigned canal portion of Parallel Canal Alternative, which was developed based on minimizing ROW requirements, required the placement of material within the existing FKC. Upon consideration of material requirements, the centerline of the realigned canal was moved further east such that the west embankment of the realigned canal tied into the existing the eastern canal embankment. This refinement reduced the required embankment material by about 1 million cubic yards and enables a construction sequencing that provides for potential use of material in the existing canal embankments to construct parts of the realigned canal embankments.

Refinement of Raised and Widened Canal Segment Cross-Sections

The Parallel Canal Alternative included canal enlargement in Segment 1 and a portion of Segment 4 through raising and widening the FKC. In these segments, the raised and widened section would include a 24-foot bench on either side of the canal. Through additional hydraulic modeling, it was determined that required capacity could be achieved by extending the existing prism by raising the embankment and extending the lining, thereby eliminating the need to widen the canal. Depending on location, the required lining raise varies from 15 inches to 24 inches. The elimination of the bench reduced the amount of embankment material and liner on the bench portion, and lowered cost. Table 5-20 shows the approximate lining raise required in Segment 1, a portion of Segment 2, and Segment 4B to achieve the maximum design flow.

Table 5-20. Lining Raise Requirements for the Recommend Plan

Segment	Maximum Design Flow (cfs)	Required Lined Freeboard	Canal Milepost (MP)	Canal Milepost (MP)	Approx. Canal Length	Lining Raise "H"
1	4,500 cfs	1.15' (13.80")	88.2 (5th Ave Check Outlet)	95.1 (Ave 180 Bridge)	6.9-miles	15"
			95.1 (Ave 180 Bridge)	95.7 (Tule Check Inlet)	0.6-miles	24"
2	4,000 cfs	1.11' (13.32")	95.7 (Tule Check Outlet)	96.3 (Ave 152 Bridge)	0.6-miles	24"
2/3/4A	*4,000 cfs 3,500 cfs*	*1.11' 1.08'*	*96.3 (Ave 152 Bridge)*	*115.9 (Ave 8 Bridge)*	*19.6-miles Parallel Canal*	
4B	3,500 cfs	1.08' (12.96")	115.9 (Ave 8 Bridge)	119.5 (Woollomes Rd Bridge)	3.6-miles	13"
4C	3,500 cfs	1.08' (12.96")	*119.5 (Woollomes Rd Bridge)*	*121.5 (Woollomes Check Inlet)*	*2.0-miles Existing Earth Canal (No Mods Necessary)*	

Key:
ave = avenue
cfs = cubic feet per second
mp = milepost
rd = road

Refinement of Realigned Canal Segment Cross-Sections

The cross-section geometry of the Parallel Canal Alternative was based a 40-foot bottom width of the canal in all realigned segments. Further evaluation revealed that material balance could be improved and resiliency under future subsidence could be increased if the bottom width were narrowed. An analysis was performed to identify effect on canal capacity under future subsidence for a variety of bottom-width canal designs at the same design capacity Table 5-21 shows the reduction in capacity resulting from capacity on a variety of canal sections designed to convey 4,000 cfs. Under a future subsidence of 4 feet, the capacity of a 16-foot bottom width would be reduced by about 12 percent whereas the same subsidence would cause a 25 percent reduction of the capacity for a 40-foot bottom with canal. On the basis of this analysis, the design for the Recommended Plan was revised to include varying widths from 16 to 24 feet. This change was made to minimize the canal capacity loss that would be experienced in the future from subsidence. This reduction in bottom width has the added advantage of reducing the amount of concrete lining required as part of the construction.

Table 5-21. Effect of Subsidence on Canal Capacity of Various 4,000 cfs Canal Designs

Future Subsidence	Canal Capacity Reduction Resulting from Subsidence			
	16-ft Bottom Width	24-ft Bottom Width	32-ft Bottom Width	40-ft Bottom Width
2-feet	5% (200 cfs)	7% (280 cfs)	10% (400 cfs)	12% (480 cfs)
4-feet	12% (480 cfs)	16% (640 cfs)	20% (800 cfs)	25% (1,000 cfs)
8.5-feet	32% (1,280 cfs)	41% (1,640 cfs)	49% (1,960 cfs)	56% (2,240 cfs)

Key:
cfs = cubic feet per second

Refinement to Identification of Borrow Sources

During the refinement of the Recommended Plan, as described above, additional potential borrow sites were identified through coordination with Friant Division long-term contractors. In response to SGMA requirements, some Friant Division long-term contractors are advancing plans to develop permanent groundwater recharge basins. To date, Friant Division long-term contractors have expressed interest in developing three sites in the general vicinity of the Project Area and have indicated their interest in making material from these sites available as borrow. In addition, at least one site, which is immediately adjacent to the FKC, is a candidate construction staging location. Preliminary designs, environmental compliance and permitting has been completed for some sites, whereas others have been evaluated at a conceptual or appraisal level. Geotechnical information is available at all sites and further evaluations will be included in the design development of the Recommended Plan.

Based the current design of the Recommended Plan and consideration of potential borrow from nearby and adjacent identified sites, the identified available borrow to construct exceeds the requirements for the Recommended Plan. Table 5-22 shows the borrow source and the amount of material identified as available from that source. As noted in Table 5-22 over 9 million cubic yards of potential borrow material has been identified, which significantly exceeds the estimated material requirements of approximately 6.4 million cubic yards.

Table 5-22. Borrow Sources and Estimated Volume Available

Borrow Source	General Location	Estimated Volume Available (CY)
Excavation of Realigned Canal	Milepost 96 to Milepost 116	2.1M
Existing FKC Bank Material[1]	Along 20 miles of existing canal (MP 96 to MP 116)	3.0M
Site B - Terra Bella Irrigation District Site	East of canal at Milepost 102.2	1.5M
Site A – Private Landowner Site	East of canal at Milepost 97.4	0.5M
Site C - Delano-Earlimart Irrigation District Site	One mile west of canal near Milepost 114.0	2.0M
Total Potential Available Borrow		9.1M

Notes:
[1] Material is not available until segments of old canal are out of operation.

Chapter 6 Recommended Plan

This chapter demonstrates the feasibility of the Recommended Plan and evaluates the areas of potential risk and uncertainty. Initial Alternatives presented in Chapter 3 and Alternatives presented in Chapters 4 and 5 were designed to achieve the maximum design capacity based on 2018 surveyed land surface. The Recommended Plan was designed to achieve the maximum design capacity based on projected land surface elevations in 2070 so that the constructed project can maintain maximum design capacity as future land subsidence occurs.

In addition to refinements to the Parallel Canal Alternative described in Chapter 5, the Recommended Plan includes the following specific features to accommodate future subsidence:

- Sufficient embankment height to allow the FKC to continue to be operated at the required hydraulic grade line to provide design capacity as future subsidence occurs;
- Road crossing siphons designed to function under increased water pressure associated with greater submergence resulting from future subsidence with no loss of conveyance capacity or risk of overtopping; and
- Structural modifications to turnouts, siphon walls, and check structures designed to operate at the design hydraulic grade line without the need for further modifications as future subsidence occurs.

Description of Recommended Plan Features

A single-line diagram showing features included in the Recommended Plan is provided in Figure 6-1A and Figure 6-1B. The Recommended Plan includes modification to enlarge the FKC where practical, and construction of a new canal realignment in locations where the land subsidence has occurred or is expected to occur to an extent that modifying the existing FKC to achieve the design capacity and HGL is considered less practical. Features of the Recommended Plan are described in the following sections and additional detail is provided in Appendix D.

Canal Alignment and Cross Sections

The Recommended Plan would include modifications to the current FKC alignment from 5th Ave. Check (MP 88) to Ave. 152 (MP 96.3). Through this reach, the cross section of the existing FKC would be enlarged with a canal embankment and lining raise to increase canal capacity to meet the Design Maximum flow rate and HGL in this segment, as shown in Figure 6-2. From 5th MP 88 to MP 96.3 existing bridge soffits are anticipated to be above the new maximum water surface elevation in the canal. Many of the existing turnouts in this segment of the canal will require raising the top deck by 0.5 to 2 feet. The extent of the raise at each turnout is dependent upon the lining raise at that location.

At MP 96.3, the new canal alignment would head east, away from the existing canal centerline, and run on a generally parallel alignment to the existing FKC until it reaches Ave. 8 (MP 115.94). In this reach, the new canal alignment would have a regular trapezoidal shape based on the configuration shown in Figure 6-3. At MP 115.94, the canal realignment would reconnect with the existing alignment of the FKC, which would be enlarged between MP 115.94 to Woollomes Ave. (MP 120) as described above and shown in Figure 6-2. From MP 120 to Reservoir Check Structure (MP 121.5) will remain as is with no modifications necessary to convey the Design Maximum flow.

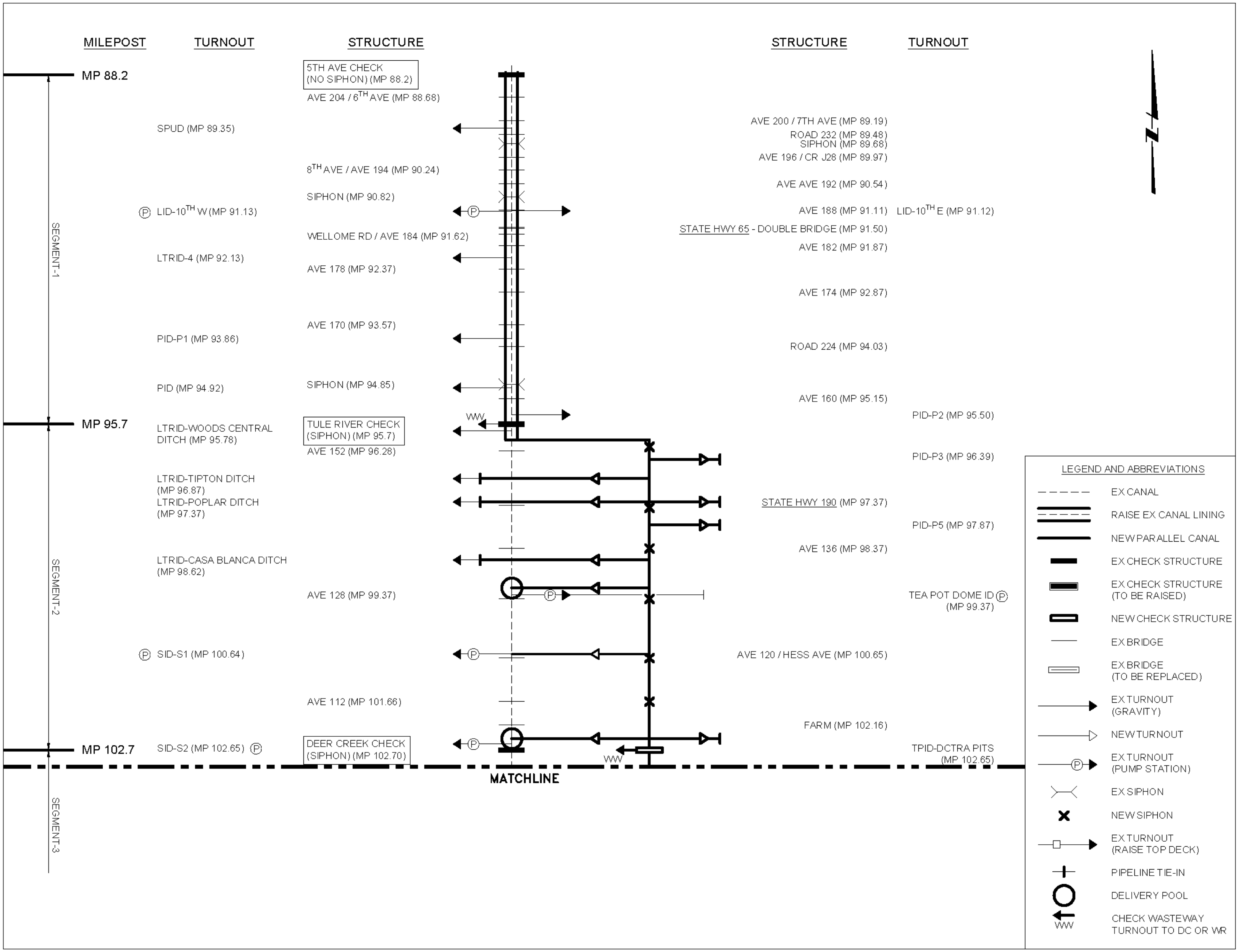

Figure 6-1A. Recommended Plan Single-Line Diagram of Segments 1 and 2

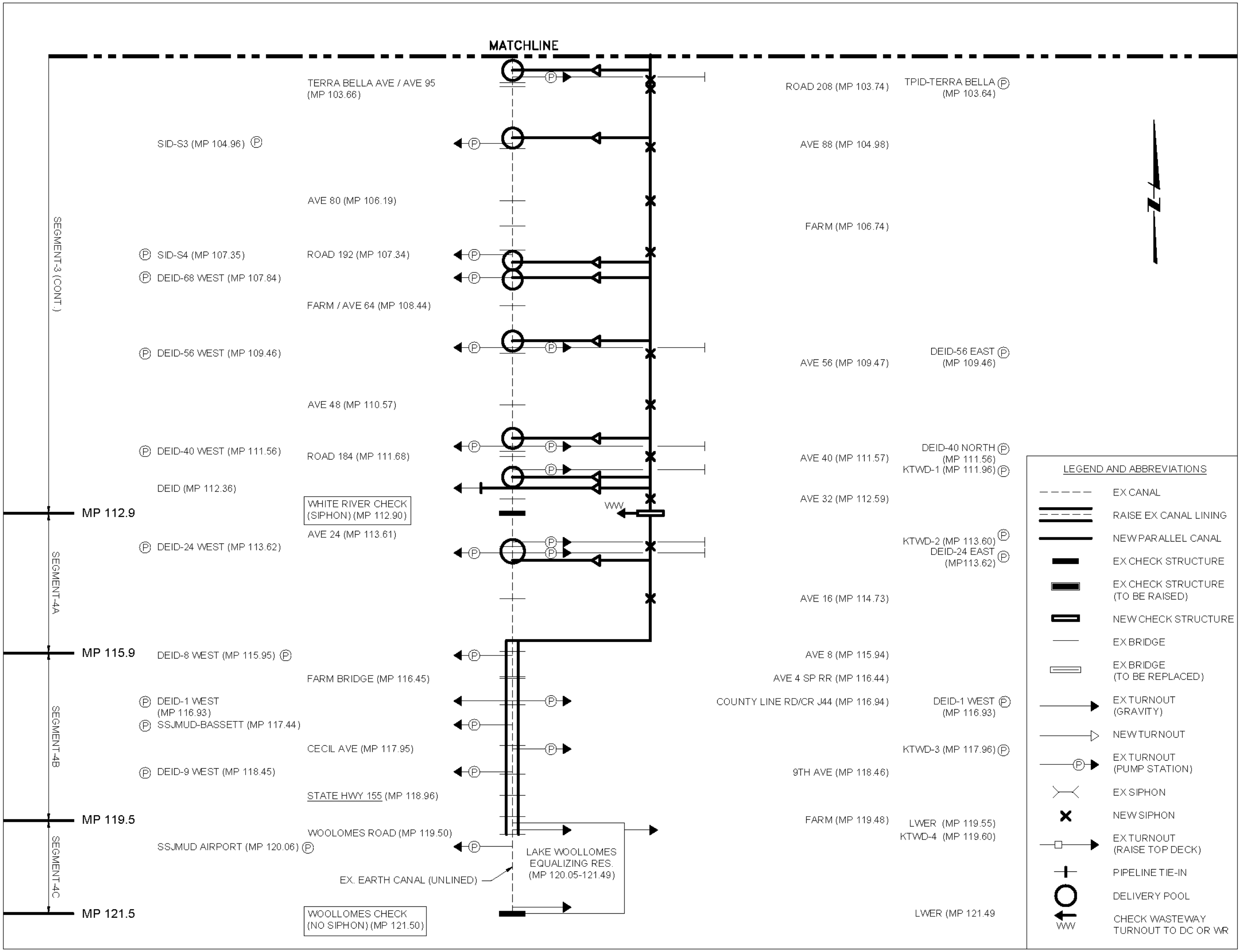

Figure 6-1B. Recommended Plan Single-Line Diagram of Segments 3 and 4

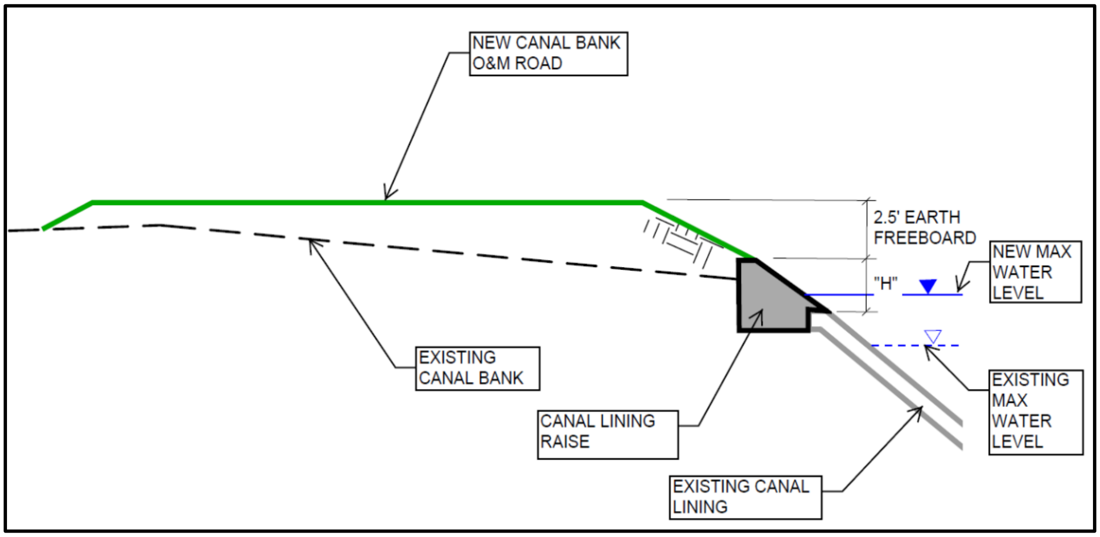

Figure 6-2. Canal Lining Raise in Segment 1 and Segment 4b of the Recommended Plan

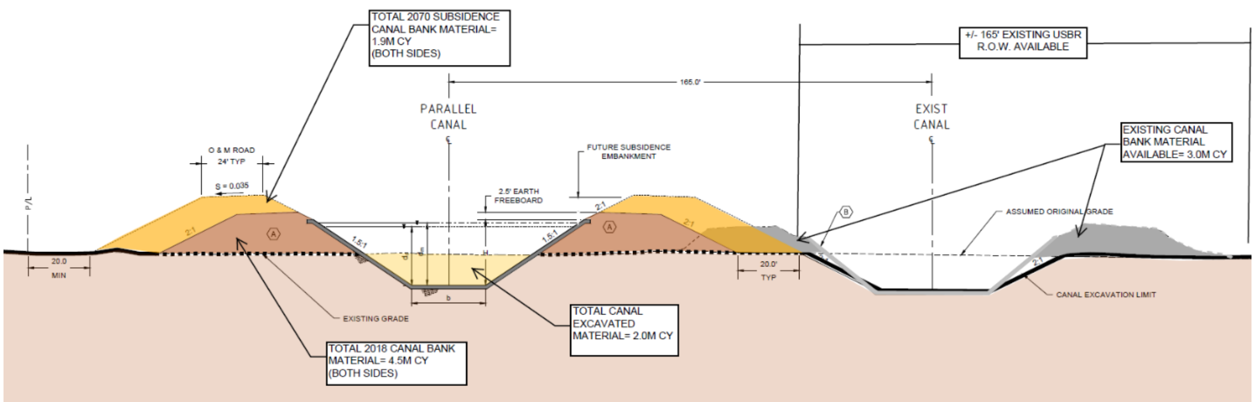

Figure 6-3. Trapezoidal Cross Section of Realigned Canal Segments in the Recommended Plan

Construction Sequencing

The canal realignment portion of the Recommended Plan would be constructed as follows:

- Construct the new canal from Tule River Check to Ave 128, with canal excavation material and borrow material from private site in area.
- The new canal from Tule to Ave 128 is put into operation with permanent tie in on north and temporary tie in on south end. Decommission and abandon the existing FKC from Tule River Check to Ave 128.

- Construct the new canal from Ave 128 to Ave 96. Construct the new Deer Creek Check Structure and Siphon. Construction of the new canal from canal excavation material and borrow material from private site in area.

- The new canal from Ave 128 to Ave 96 is put into operation with temporary tie in on south end. Decommission and abandon existing FKC from Ave 128 to Ave 96.

- Construct the new canal from Ave 96 to Ave 56 with canal excavation material and borrow material from private site in area.

- The new canal from Ave 96 to Ave 56 is put into operation with temp tie in on south end. Decommission and abandon existing FKC from Ave 96 to Ave 56.

- Construct the new canal from Ave 56 to Ave 8 and the new White River Check Structure and Siphon. Constructed of the new canal from canal excavation material and old FKC spoil material on Reclamation ROW in area.

- The new canal from Ave 56 to Ave 8 put into operation with permanent tie in on south end. Decommission and abandon existing FKC from Ave 56 to Ave 8.

- Entire new canal in operation and old FKC decommissioned and abandoned from Tule to Ave 8.

- With new canal in operation build entire 2070 future subsidence banks from abandoned FKC bank material.

Turnouts

The Recommended Plan includes features to address water delivery at existing turnouts, based in part, on input provided by Friant Division long-term contractors. The Recommended Plan incorporates design concepts at turnouts to pressurized and gravity distribution systems to provide compatibility between the canal and the contractors' distribution systems, maintain water delivery capability during constructions, control overflow, and enhance the ability to manage water surface elevation at turnouts.

Pressurized Turnout Modifications

In the Middle Reach, many of the 21 pressurized distribution systems have subsided at different rates than the land under the canal, causing varying differential head conditions from those used in the original system designs. All alternatives have been developed to achieve the proposed HGL, which is higher than the current water surface in the FKC. Increasing the HGL would increase head on the suction side of the pumping plants, which would increase the delivery head on district distribution systems. The removal and replacement of current pump stations at a location compatible with the current design was considered and dropped because of significant costs.

The water elevation in the new realigned canal would often be above the elevation of the top decks of existing pump stations. If a pump station were to unexpectedly shutdown, the incoming flow from the adjacent canal could overflow the pump station and flood the facility and surrounding land, resulting in equipment and property damage. To avoid the potential risk associated with unexpected shutdowns, the Recommended Plan includes small delivery pools at each pump station turnout in the canal realignment section.

As shown in Figure 6-4, the delivery pool would be created by preserving small portions of the existing FKC to serve as a forebay for the existing turnout pump station. Water would flow from the new realigned canal through a new pipe to the delivery pool. The new canal realignment would be modified at the location of each pump station turnout and be customized to meet the specific needs of each pressurized delivery system. A list of the modifications proposed to the pump station turnouts is provided in Table 6-1.

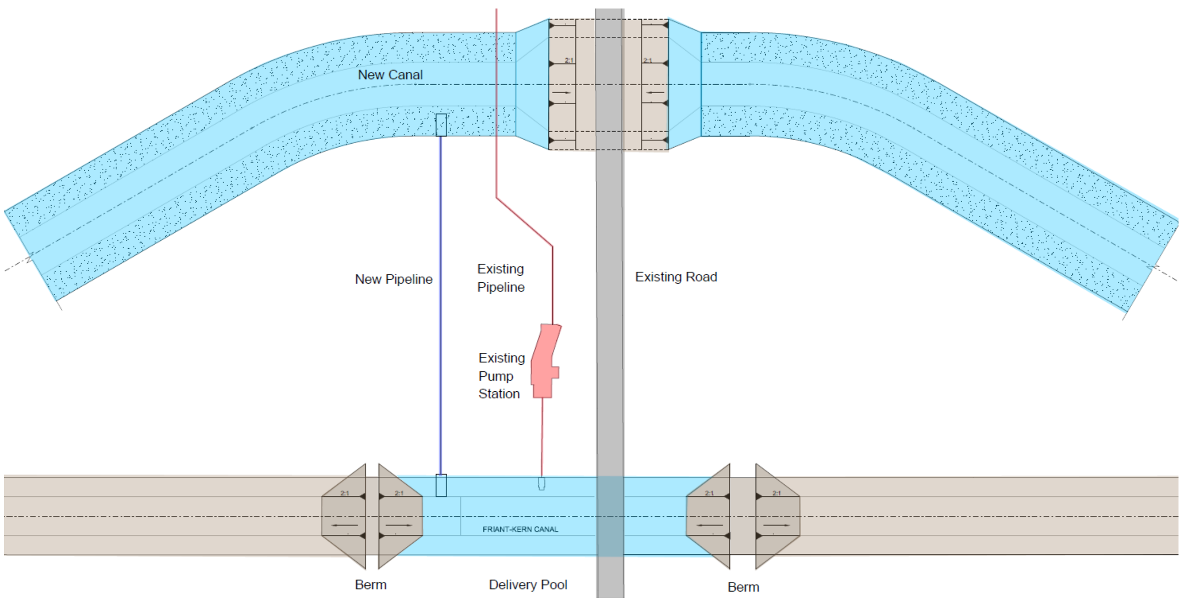

Figure 6-4. Example Pressurized System Turnout Design in the Recommended Plan

Gravity Turnout Modifications

The Middle Reach includes 17 turnouts to gravity distribution systems, each of which was individually analyzed to determine an appropriate design approach. The analysis revealed that all existing turnouts to gravity distribution systems can either be preserved and reused or connected to new turnouts and pipelines on the new canal realignment. A summary of actions for gravity turnouts under the Recommended Plan is provided in Table 6-1.

Table 6-1. Modifications at Pump Station Turnouts in the Recommended Plan

Segment	Name	Milepost	Canal Side	Type	Modification
1	SPUD-STRATHMORE	89.35	West	G	Raise Top Deck
1	LID-10th E	91.12	East	G	Raise Top Deck
1	LID-10th W	91.12	West	P	Raise Top Deck
1	LTRID-4	92.13	West	G	Raise Top Deck
1	PID-P1	93.85	West	G	Raise Top Deck
1	PID-Porter Slough	94.92	West	G	Raise Top Deck
1	PID-P2	95.50	East	G	Raise Top Deck
2	LTRID-Woods Central Ditch	95.78	East	G	Raise Top Deck
2	PID-P3	96.39	East	G	New Gravity Turnout on Canal Realignment
2	LTRID-Tipton Ditch	96.87	West	G	New Gravity Turnout on Canal Realignment
2	LTRID-Poplar Ditch N&S	97.37	West & East	G	New Gravity Turnout on Canal Realignment
2	PID-P5	97.86	East	G	New Gravity Turnout on Canal Realignment
2	LTRID-Casa Blanca Ditch	98.62	West	G	New Gravity Turnout on Canal Realignment
2	TPDWD-Teapot Dome	99.37	East	P	New Delivery Pool Turnout
2	SID-S1	100.64	West	G	New Gravity Turnout on Canal Realignment
2	TBID-DCTRA Pits	102.65	East	G	New Gravity Turnout on Canal Realignment
2	SID-S2	102.65	West	P	New Delivery Pool Turnout
3	TBID-Terra Bella	103.64	East	P	New Delivery Pool Turnout
3	SID-S3	104.96	West	P	New Delivery Pool Turnout
3	SID-S4	107.35	West	P	New Delivery Pool Turnout
3	DEID-68 West	107.84	West	P	New Delivery Pool Turnout
3	DEID-56 West and East	109.46	West & East	P	New Delivery Pool Turnout (Shared)
3	DEID-40 West and North	111.56	West & East	P	New Delivery Pool Turnout (Shared)
3	KTWD-1	111.96	East	P	New Delivery Pool Turnout
3	DEID	112.36	West	G	New Gravity Turnout on Canal Realignment
4	KTWD-2	113.60	East	P	New Delivery Pool Turnout (Shared)
4	DEID-24 West and East	113.62	West & East	P	New Delivery Pool Turnout (Shared)
4	DEID-8th West	115.95	West	P	Raise Top Deck
4	DEID-#1 West	116.93	East	P	Raise Top Deck
4	SSJMUD-Bassett	117.44	West	P	Raise Top Deck
4	KTWD-3	117.96	East	P	Raise Top Deck
4	DEID-9th West	118.45	West	P	Raise Top Deck
4	LWER	119.55	East	G	Unmodified
4	SSJMUD-Airport	120.06	West	P	Unmodified
4	LWER	121.49	East	G	Unmodified

Key: G = Gravity P = Pressurized

Checks and Siphons

The Recommended Plan project area includes five existing check structures located at 5th Avenue (MP 88.2), Tule River (MP 95.7), Deer Creek (MP 102.7), White River (MP 112.9), and Lake Woollomes (MP 121.5). Check Structures are essential to the operation of the FKC. These structures house radial gates that maintain the water level in the upstream canal segments to provide enough head to maintain submergence of turnouts. Table 6-2 provides a description of the existing check structures, and appurtenance facility, as well as the proposed modifications for each. The Recommended Plan would include new check structures at Deer Creek and White River. Additionally, there are 5 existing siphons, 3 in Segment 1 that will not require modification, and siphons at Deer Creek and White River that will require replacement.

Table 6-2. Modifications at Existing Check Structures Recommended Plan

Description	MP	Modification
Fifth Avenue Check	88.22	No Modification
Tule River Wasteway	95.64	No Modification
Tule River Check and Siphon	95.66	No Modification
Deer Creek Wasteway	102.69	Abandon Existing – Replace on New Realigned Canal
Deer Creek Check and Siphon	102.69	Abandon Existing – Replace on New Realigned Canal
White River Wasteway	112.9	Abandon Existing – Replace on New Realigned Canal
White River Check and Siphon	112.9	Abandon Existing – Replace on New Realigned Canal
Lake Woollomes Check	121.5	No Modification

Road Crossings

The FKC Middle Reach has approximately 45 existing bridge crossings, some of which will require replacement to accommodate the project. The majority of existing bridges are cast-in-place concrete type with a system of reinforced concrete “T” beams, or girders supporting a concrete roadway deck, and supported by a concrete pier wall in the center of the FKC and concrete abutments with monolithic wingwalls on either side of the canal. Two measures are proposed to accommodate all roadway crossings in the Middle Reach; leave in place or replace bridge with concrete box siphon.

The leave in place measure would include minimal to no modifications to the existing bridges. This is typically the case with existing bridges in the enlarged sections of the existing canal in Segments 1 and 4.

The concrete box siphon measure would be applied in the new realigned canal roadway crossings in Segments 2, 3, and part of 4. Along these segments County and State bridges would be removed and the crossings would be replaced with concrete box siphons. The concrete box siphons would generally consist of a buried cast-in-place concrete triple box siphon with each of the three boxes estimated to be 19 feet tall by 19 feet wide.

Canal lining transitions approximately 50 feet long would be provided at the siphon entrance and exit to transition from the trapezoidal open canal geometry to the square box geometry. The length of the siphons would vary by location but would range from 100 to 200 feet The concrete box siphons are designed to accommodate potential subsidence by considering future soil loading and extension of the concrete headwalls at the entrance and outlets.

Table 6-3 provides a summary of the existing bridges and proposed modifications of roadway crossings in the Recommended Plan. Figure 6-5 shows the concrete box siphon concept. At each new siphon, the adjacent existing bridge over the current FKC would be demolished and the abandoned portion of the FKC would be filled to road grade and the paved road surface reconstructed on earth fill.

Table 6-3. Road Crossing Modifications in the Recommended Plan

Segment	Name	MP	Modification
1	6th Avenue Bridge	88.67	No Modifications
1	7th Avenue Bridge	89.17	No Modifications
1	Road 232 Bridge	89.45	No Modifications
1	Frazier Highway/ Ave 196 Bridge	89.95	No Modifications
1	8th Avenue Bridge	89.95	No Modifications
1	Avenue 192 Bridge	90.23	No Modifications
1	Avenue 188 Bridge	91.10	No Modifications
1	State Highway 65 Northbound Bridge (Double Bridge)	91.51	No Modifications
1	Welcome Avenue Bridge (Avenue 184)	91.60	No Modifications
1	Avenue 182 Bridge	91.85	No Modifications
1	Avenue 178 Bridge	92.35	No Modifications
1	W Linda Vista Avenue	92.85	No Modifications
1	W North Grand Avenue Bridge	93.55	No Modifications
1	Avenue 224/N Westwood Street Bridge	94.01	No Modifications
1	Avenue 180/W Henderson Avenue Bridge	95.12	No Modifications
2	Avenue 152/Olive Avenue Bridge	96.26	Concrete Box Siphon
2	Avenue 144 Bridge (Highway 190)	97.35	Concrete Box Siphon
2	Avenue 136 Bridge	98.35	Concrete Box Siphon
2	Avenue 128 Bridge	99.37	Concrete Box Siphon
2	Hesse Avenue Bridge	100.64	Concrete Box Siphon
2	Avenue 112 Bridge	101.64	Concrete Box Siphon
2	Timber Farm Bridge	102.14	None
3	Road Terra Bella Avenue (J24)	103.65	Concrete Box Siphon
3	Road 208 Bridge	103.72	Concrete Box Siphon
3	Avenue 88 Bridge	104.95	Concrete Box Siphon
3	Avenue 80 Bridge	106.72	Concrete Box Siphon
3	Farm Bridge	106.75	None
3	Road 192 Bridge	107.32	Concrete Box Siphon
3	Avenue 64 Bridge	108.42	None
3	Avenue 56 Bridge	109.45	Concrete Box Siphon
3	Avenue 48 Bridge	110.55	Concrete Box Siphon
3	Avenue 40 Bridge	111.55	Concrete Box Siphon (Shared)
3	Road 184 Bridge	111.66	Concrete Box Siphon (Shared)
3	Avenue 32 Bridge	112.57	Concrete Box Siphon
4	Avenue 24 Bridge	113.59	Concrete Box Siphon
4	Avenue 16 Bridge	114.71	Concrete Box Siphon
4	Avenue 8 Bridge	115.91	No Modifications
4	Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	No Modifications
4	County Road Avenue 0 Bridge	116.91	No Modifications
4	Cecil Avenue Bridge	117.92	No Modifications
4	9th Avenue Bridge	118.44	No Modifications
4	Garces Highway Bridge	118.94	No Modifications
4	Timber Farm Bridge	119.46	No Modifications
4	Woollomes Avenue Bridge	120.02	No Modifications

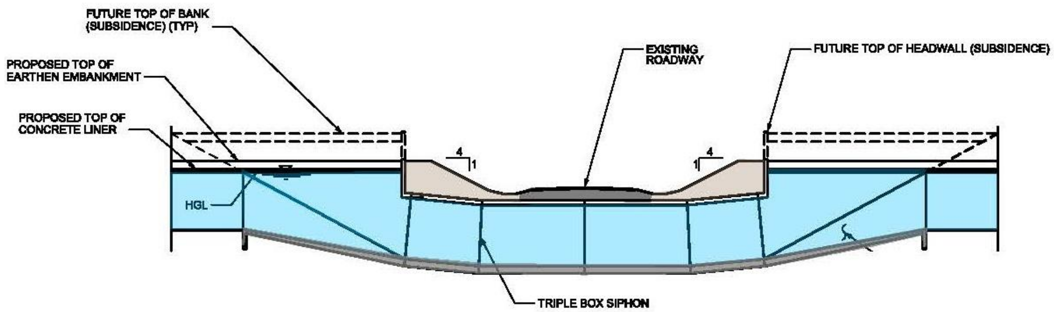

Figure 6-5. Typical Siphon Road Crossing

Utilities

Numerous utilities located in, along, and across the FKC would be affected by implementation of the Recommended Plan. The utilities include pipeline overcrossings, overhead power lines, adjacent wells, irrigation crossings under the existing canal, and utilities connected to bridges. Depending on the location and extent of canal modifications, the utilities will either be relocated or entirely replaced, as determined in the final design. Table 6-4 summarizes utility modifications in the Recommended Plan. These quantities should be considered approximate until field locating confirms actual locations.

Table 6-4. Preliminary Estimate of Modifications to Utilities for the Recommended Plan

Utility Modification	Quantity
Parallel Overhead Powerline Relocations	~1 mile
Overhead Electrical Crossing Modifications	20 crossings
Adjacent Groundwater Well Abandonments	10 wells
Drainage Culvert Conflicts	4 Conflicts
Pipeline Overcrossing Replacements	5 replacements
Pipeline Undercrossing Replacements	5 replacements
Utility Crossings at Bridges	20 crossings

Estimated Quantities and Cost

A list of items that will be included in the summary of quantities and costs is included in Table 6-5. A cost estimate is provided in Table 6-6.

Table 6-5. Recommended Plan Alternative Summary of Estimated Quantities

		Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Ave. 8	Seg 4: Ave. 8 to Woollomes	
Design Flow (Design Maximum) (cfs)	-	4,500	4,000	4,000	3,500	3,500	-
From MP to MP	-	88.2-96.67	95.67-102.7	102.7-112.9	112.9-115.94	115.94-121.5	-
Total Canal Miles	-	7.47	7.0	10.2	3.04	5.56	-
Description	***Unit***	***Quantity***	***Quantity***	***Quantity***	***Quantity***	***Quantity***	***Total***
NEW CANAL							
Excavation	CY	184,136	2,391,280	3,767,682	489,991	137,500	**6,970,589**
Concrete Lining	SY	15,305	448,373	735,803	204,394	142,300	**1,546,175**
Concrete for Structures	SY	-	20,035	30,731	6,051	-	**56,817**
Reinforcing Steel	lbs	-	3,822,812	5,945,669	117,035	-	**9,885,516**
Ladders	EA	105	99	144	46	-	**394**
Aggregate base O&M road surfacing	SY	104,221	98,653	105,011	47,000	77,067	**431,952**
CHECK STRUCTURES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
New Check/Siphon Structure	-	-	1	1	-	-	**2**
Existing Check Structures Demolition and Disposal	-	-	1	1	-	-	**2**

Table 6-5. Recommended Plan Alternative Summary of Estimated Quantities (contd.)

		Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Ave. 8	Seg 4: Ave 8 to Woollomes	
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Bridge Replacement (County or State) on Existing Canal	EA	-	-	-	-	-	-
Bridge Replacement (Farm) on Existing Canal	EA	-	-	-	-	-	-
Existing Bridge Demolition	EA	-	6	8	2	-	18
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	-	6	9	2	-	17
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Raise/Modify Existing Turnout Top Deck and Actuators	EA	7	1	-	-	5	13
Turnouts on New Canal	EA	-	9	8	1	-	18
Delivery Pools	EA	-	2	7	1	-	10
UTILITIES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Parallel Overhead Powerline Relocations	Feet	-	800	4,400	-	-	5,200
Overhead Electrical Lines	EA	-	7	11	1	-	20
Adjacent Groundwater Well Abandonments	EA	-	4	6	-	-	10
Culvert Extensions (Each End)	EA	-	2	2	0	-	4
Pipeline Overcrossing Replacements (8" to 12")	EA	-	1	2	2	-	5
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	-	5	11	4	-	20
LAND ACQUISITION	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Impacted Parcels	EA	-	17	25	20	-	62
Permanent Land Acquisition (ROW)	Acre	-	138	230	62	-	430

Key:
- = Not Applicable or zero
cfs = cubic feet per second
CY = cubic yard
EA = each
Lbs = pounds
LF = linear feet
LS = lump sum
MI = mile
MP = milepost
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 6-6. Recommended Plan Alternative Cost Estimate

Item	Reference	Cost	Notes/ Inclusions
Segment 1 - 5th Ave to Tule	from estimate	$8,807,070	
Segment 2 - Tule to Deer Creek (New Bypass Canal)	from estimate	$86,647,325	
Segment 3 - Deer Creek to White River (New Bypass Canal)	from estimate	$103,823,656	
Segment 4a - White River to Garces Hwy (New Bypass Canal)	from estimate	$21,517,177	
Segment 4b - Garces Hwy to Woollomes (Widen Existing Canal)	from estimate	$7,853,837	
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$6,997,503	
Subtotal		$262,646,569	
Contract Cost Allowance - Design Contingency	17%	$44,649,917	
Contract Cost		**$310,000,000**	Rounded
Construction Contingencies	20%	$62,000,000	
FIELD COST		**$370,000,000**	Rounded
Land Purchase - Construction Phase and ROW		$20,375,000	Based on market research
Environmental Mitigation		$29,000,000	From separate estimate
Engineering, Permitting, and Construction Management	20%	$74,000,000	Calculated as % of Field Cost
Legal and Administrative	2%	$7,400,000	Calculated as % of Field Cost
Non-Contract Costs		**$130,000,000**	Rounded
TOTAL CONSTRUCTION COST		**$500,000,000**	Rounded
Interest During Construction	2.75% Discount Rate	$20,941,837	3-year construction period
TOTAL CAPITAL COST		**$520,000,000**	Rounded
Annualized Capital Costs		$19,500,000	2.75% (FY19) over 50 years; Rounded
Additional Annualized O&M Costs		$1,000,000	Excludes current O&M costs; 2.75% (FY19) over 50 years; Rounded
TOTAL ANNUALIZED COST		**$21,000,000**	Rounded

Initial Feasibility Determination for the Recommended Plan

An initial determination of feasibility is based on a review of four tests of feasibility: technical, environmental, economic and financial.

Technical Feasibility

Technical feasibility consists of engineering, operations, and constructability analyses verifying a plan is physically and technically possible to construct, operate, and maintain. This report provides an initial determination of technical feasibility of the Recommended Plan, which includes features to address constructability and long-term operations. In accordance with the process described in FAC 10-01, a Design, Estimating and Construction (DEC) review was performed on the Recommended Plan.

The purpose of the DEC review process is to provide independent oversight to ensure products related to design, cost estimating, and construction are technically sound and provide a credible basis for decision making by the Bureau of Reclamation and other decision makers. Major functional categories of the DEC review's technical analysis include, but are not limited to, hydrology and hydraulics; civil, mechanical, geotechnical, and electrical engineering; constructability; surveying; and cost estimating. Ultimately, the DEC review process assesses whether the product meets the requirements of Technical Feasibility, identifies deficiencies, and presents recommendations.

Resolutions for all DEC findings have been documented by a Joint Resolution Memo completed December 2019. The project has been found to be technically feasible, constructible and can be operated and maintained. Completion of the Joint Resolution Memo satisfies the Technical Feasibility component in accordance with CMP 09-02.

Environmental Feasibility

Environmental feasibility consists of analyses verifying that constructing or operating the project would not result in unacceptable environmental consequences or require costs that would adversely affect economic feasibility. Generally, environmental feasibility is based on the completion of NEPA compliance and environmental permitting processes. These processes are underway and are expected to be completed during 2020.

The NEPA process began with preparation of an Environmental Assessment (EA) which analyzed actions that would not require further analysis and those actions that have the potential to impact the human environment and require evaluation under NEPA. An environmental constraints analysis was performed and applied to the evaluation of Initial Alternatives and selection of Alternatives that were evaluated in the EA.

The EA/IS identified the following resource areas that may have potentially significant impacts resulting from construction of the alternatives: agriculture/land use, air quality/Green House

Gases, biological, cultural and tribal, hydrology, and water quality. Through the EA/IS process Reclamation has determined that an Environmental Impact Statement (EIS) will be prepared because the Project could result in significant impacts, is a major undertaking, and private land acquisition will be required.

A Notice of Intent (NOI) for the Project was prepared and published to the Federal Register on December 2, 2019. The NOI included the EA. Following the issuance of the NOI, a Public Scoping meeting was held December 18, 2019 in Porterville, CA. The draft Public Scoping Report indicates there are 11 comments, mostly focusing on funding and coordination. Land coordination meetings have indicated public support among landowners that could be affected by this project.

Three cultural resources reports have been completed to support National Historic Preservation Act (NHPA) Section 106 compliance for geotechnical investigations of the Project. To date, the findings of two of these reports have been concurred on and the third is currently under review by the California Office of Historic Preservation. Additionally, a Section 106 technical memorandum was prepared in support of immediate repair activities from MP 103 to MP 107 and those findings have also been concurred on by the California Office of Historic Preservation.

Work is progressing on preparation of NHPA Section 106 reporting for the complete Project. Reclamation has established an Area of Potential Effect (APE) that accounts for potential direct and indirect effects of the Recommended Plan. Pedestrian surveys have been completed for all property within the Reclamation ROW and on publicly-accessible lands and private lands for which land-owner permission was provided within the APE. In addition, a records search within a 1-mile search area of the entire project area from Mile Post 88 to 121 has been completed. The effects analysis is underway, the Section 106 report is in preparation, and a historic property treatment plan is in the early stages of development. Initial indications from the completed surveys have not discovered any cultural sites of significance. The FKC is under the jurisdiction of a Programmatic Agreement (PA) that defines the Section 106 process providing streamlined reviews. The PA is currently being modified to include the footprint of the Recommended Plan.

For biological resources, two Endangered Species Act (ESA) Section 7 consultations have been completed for geotechnical investigations of the Project and the Biological Assessment for the complete project has been submitted to US Fish and Wildlife Service. Biological surveys completed in support of the consultations have been completed for the Federal species of concern; specifically, the San Joaquin Kit Fox and the Buena Vista Lake Shrew. The survey results were negative for the San Joaquin Kit Fox and found localized areas of habitat for the Buena Vista Lake Shrew. Avoidance measures will be used where possible on these localized areas.

On the basis of information compiled through cultural and biological resources investigations completed to date, it appears that appropriate mitigation measures are available and will be applied to reduce impacts that cannot be avoided through project design. Land acquisition will not occur, and construction activities will not commence until the necessary NEPA, ESA, and Section 106 compliance requirements are complete.

Environmental Mitigation Cost Estimates

The alternatives cost estimates presented in Chapter 5 included an allowance for environmental mitigation, which includes cultural resources mitigation, at 5 percent of the field cost. More detailed environmental mitigation cost estimates have been developed and incorporated into the cost estimate for the Recommended Plan.

The design and environmental analyses conducted to date for the project indicate that cost elements associated with environmental mitigation can be grouped into three main categories: 1) biological mitigation, 2) cultural mitigation, and 3) air quality mitigation. It is recognized that potential impacts of other project elements not yet defined, such as borrow pits, construction staging areas, and installation of construction access roads, could result in additional mitigation requirements. Details for each of these three main categories are summarized below.

- Biological Mitigation; general preconstruction surveys, San Joaquin Kit Fox pre-construction surveys, worker environmental awareness training (WEAT), environmental compliance monitoring during construction, fish salvage during canal tie-ins, and compensatory mitigation for San Joaquin Kit Fox.

- Cultural Mitigation; data recordation and mitigation for above-ground bridges and the FKC, WEAT, Construction monitoring for archeological and paleontological resources, and tribal monitoring in the vicinity of Deer Creek and White River.

- Air Quality Mitigation; preparation of a fugitive dust plan, and Voluntary Emission Reduction Agreement (VERA) with the San Joaquin Valley Air Pollution Control District.

Table 6-7 provides a budget estimate for each of the cost elements listed above, grouped into the three main categories. The following assumptions were used in developing these cost estimates:

- Construction monitoring for cultural resources, tribal resources, San Joaquin Kit Fox, and other biological resources for 3 years.

- San Joaquin Kit Fox compensatory mitigation approach similar to the California High Speed Rail Project. Mitigation ratios of 2.0 to 1 for natural habitat; .and 0.1 to 1 for developed habitat.

- San Joaquin Kit Fox compensatory mitigation cost $15,000 per acre

- VERA approach similar to Reclamation’s 2017 Reach 2B Mendota Pool Bypass Project

Table 6-7. Estimated Environmental Mitigation Cost

Item	Cost Estimate
Biological Mitigation	
General Pre-construction surveys	$133,000
San Joaquin Kit Fox pre-construction surveys	$1,464,000
WEAT	$20,000
During-construction compliance monitoring	$3,337,000
Fish Salvage	$279,000
Compensatory San Joaquin Kit Fox mitigation	$13,895,000
Subtotal, Biological Mitigation	**$19,128,000**
Cultural Mitigation	
Data recordation and mitigation for above-ground bridges and the FKC,	$150,000
WEAT	$20,000
Construction monitoring for archeological and paleontological resources	$2,246,000
Tribal monitoring in the vicinity of Deer Creek and White River	$1,123,000
Subtotal, Cultural Mitigation	**$3,539,000**
Air Quality Mitigation	
Fugitive dust plan	$100,000
VERA	$6,000,000
Subtotal, Air Quality Mitigation	**$6,100,000**
Total Estimated Mitigation Cost	**$28,767,000**

Economic Feasibility

The monetary benefits of the alternatives are based were determined using a 100-year planning horizon that anticipates the regional subsidence will continue to cause capacity reductions in the FKC if the Preferred Alternative is not implemented. The benefits of the alternatives presented in Chapter 5 were calculated for water supply, flood control, and fish and wildlife enhancement based on revenue to the SJRRS Fund and Restoration Flow management in Millerton Lake. Benefits of the Recommended Plan are the same as those presented in Chapter 5 for the Parallel Canal Alternative, and therefore the details are not presented herein. A summary of benefits provided by the Recommended Plan are presented in Table 6-8. As shown in Table 6-8, the calculated B-C ratio for the Recommended Plan is 1.91.

Table 6-8. Benefit-Cost Analysis of the Recommended Plan

Item	Recommended Plan
Water Supply Benefit[1,2]	$947
Flood Control Benefit[1,2]	$38.3
Fish and Wildlife Enhancement Benefit – Restoration Flow Management	$14.1
Total Benefit	$999.4
Present Value of Most Probable Total Capital and Life Cycle Costs [1,3]	$538
Cost Range of Present Value of Total Capital Cost[1,4]	($444 - $632)
Net Benefit[5]	$461.4
Range of Net Benefit[1,5]	(367.4 - 555.4)
Benefit Cost Ratio based on Most Probable Total Capital Cost	1.86
Range of Benefit Cost Ratios based on Cost Range of Total Capital Cost	(1.58 – 2.25)

Notes:
[1] All costs are in millions of dollars
[2] Present Value based on 100-year planning horizon
[3] Total Capital and Life Cycle Cost = Total Construction Cost + IDC + OM&R
[4] +/- 25% applied to field cost
[5] Net Benefit equals Benefits minus Present Value of Total Capital and Life Cycle Cost

Financial Feasibility

Financial feasibility consists of consideration of the project beneficiary's capability to pay for its share of the costs to construct, operate, and maintain the proposed project in accordance with the applicable cost-share or repayment obligations. Funding for the Project is expected to be derived from Federal and non-Federal sources. Federal sources include SJRRS Act funds and funding provided under Section 4007 of the WIIN Act. The WIIN Act limits Federal funding through the Department of the Interior to no more than 50 percent of construction costs if the Secretary determines that a proportionate share of project benefits are federal benefits.

The initial construction cost assignment for the Recommended Plan assigns $413.90 million of construction costs to a Non-Federal partner as shown in Table 6-17 later in this chapter. As shown in Table 6-18, if $208.1 million is provided toward construction through WIIN Act authorities, $164 million will need to be reimbursed and $250 million would need to be provided by a non-Federal source.

<u>Financial Analysis of Reimbursable Federal Expenditure:</u>

The reimbursable share of the WIIN Act Funding is expected to be repaid over a 40-year period, with interest paid where appropriate in accordance with Reclamation Law. Reclamation is working through the negotiation of a cost-share agreement with the FWA to identify the necessary non-Federal share of funding required if WIIN Act funding is provided. Through those negotiations, Reclamation and FWA will also identify the appropriate repayment vehicle for the reimbursable share of WIIN funding.

Table 6-9 provides a range of the estimated cost per acre-foot for the water supplies provided through the Preferred Alternative based on two delivery scenarios over the course of the 40-year repayment period. The first cost scenario spreads repayment evenly across all water deliveries[1] provided by FWA and the second spreads the repayment obligation only over water deliveries[2] provided to contractors with diversion points below the Preferred Alternative. Based on $164 million of reimbursable WIIN Act funding, the average annualized cost of new construction repayment obligation is between $6.85 and $10.60 per acre-foot.

Table 6-9. WIIN Act Repayment Obligation

	WIIN Repayment $/AF
Scenario 1 (630k AF)	$ 6.85
Scenario 2 (405k AF)	$ 10.60

Table 6-10 shows the existing average cost per acre-foot of water deliveries by the FWA, based on rates and charges from 2008 to 2018. The cost per acre-foot for deliveries to Class 1, Class 2, and M&I customers over the period 2008 to 2018 was $59 per acre-foot. Total annual costs are relatively stable and the calculated cost per acre-foot is largely determined by hydrologic conditions. The average cost per-acre foot for 75th percentile and 25th percentile hydrologic conditions is provided in Table 6-10 to provide a range of costs under normal hydrologic conditions.

The Additional construction repayment obligations between $6.85 and $10.60 per acre-foot would increase the average cost of FWA deliveries by between 12% and 18%. Further the additional cost added by the repayment obligations for the proposed WIIN Act funding is within the historic range of $44 to $103 created by the middle fifty percent of hydrologic conditions, which represent an annual fluctuation of cost per acre-foot between -25% and 74% of the 10-year average. The increase is smaller than the normal range fluctuation in cost per acre-foot paid by contractors receiving water supplies on the FKC.

Table 6-10. FWA Average Cost per AF 2008-2018 (2018 Dollars)

	75th % Hydrology (Wetter Years)	10-Year Average	25th % Hydrology (Drier Years)
Existing Costs $/AF	$ 43.89	$ 59.00	$ 102.84

[1] Over the period 2008 to 2018, the FKC delivered approximately 630,000 acre-feet per year on average to Class 1, Class 2, and M&I contractors.

[2] The long-term annual deliveries below the section corrected by the Preferred Alternative is 405,000 acre-feet.

Farm Net Income for FWA Counties

The three counties served by the FKC produce high value crops, with Tulare, Kern, and Fresno counties being ranked the top three counties for total crop value in 2015 by the California Department of Food and Agriculture. In 2015 the three counties produced crops with a total value of more than $20 billion. Table 6-11 provides estimates for the net income per acre for Fresno, Kern, and Tulare counties, based on the 2017 USDA National Agricultural Statistics Service (NASS) Census of Agriculture. The average net income in the three counties served by the FKC is estimated to be $398 per acre. Based on a water duty of three acre-feet per acre, the additional reimbursable cost resulting from implementing the Preferred Alternative would increase expenses by $20.55 to $31.88 per acre of land. The increase in reimbursable expense is between 5% and 8% of the average net income for the counties served by the FKC.

Table 6-11. Net Farm Income for Irrigated Agriculture in Fresno, Kern, and Tulare Counties

County	Net Income per Irrigated Acre
Fresno	$ 502
Kern	$ 335
Tulare	$ 358
Average	**$ 398**

Market Value of Alternative Supplies

Spot market transactions for water supplies in the Central Valley over the 10-year period from 2005 to 2015 averaged $270 per acre-foot. Table 6-12 shows the range for the middle 80 percent of prices observed over the 10-year period at 2018 price levels. Generally, the prices observed were higher in dry years, with prices well over $500 per acre-foot in critically dry years. The 10th percentile market price of $88.58 is 50% higher than the 10-year average cost of water supplies delivered through the FKC. The average market price overserved of $269 is more than 300% higher than the current cost of water supplies delivered through to FWA contractors.

Table 6-12. Spot Market Price Per AF year 2005-2015 (2018 Dollars)

	Price per Acre-Foot
10th%	$ 88
Average	$ 269
90th%	$ 705

The value of surface water in the eastern San Joaquin Valley has increased over the past several years as a result of changes from annual to permanent crops, drought, and increased depth to groundwater. As described in Chapter 1, the State of California enacted SGMA in 2014. The entire Friant Division of the CVP overlies groundwater basins that are designated as “high priority basins”, therefore it is expected that full SGMA compliance in the eastern San Joaquin Valley will be achieved by 2040. As discussed in Chapter 5, the California Water Commission estimated the value of water supplies in the Eastern San Joaquin Basin to average $271 per acre-foot by 2030 and $540 per acre-foot by 2045, when taking into consideration impacts to water supply availability resulting from SGMA implementation. Based on analysis of market transactions and expected value for water in the Eastern San Joaquin Valley under SGMA implementation, it is reasonable to expect that the incremental increase of repayment obligations resulting from implementation of the Preferred Alternative would be competitive with alternative water supplies available to water users on the FWA.

Non-Federal Cost-Share:

The FWA is evaluating and pursuing multiple potential funding sources to provide the non-Federal cost share, including potential funding from the State of California, financing through the FWA or member agencies, and other sources. It should be noted that the California State Legislature is considering options for providing non-reimbursable State funding toward the completion of the FKC correction, in whole or in part.

If all of the required $250 million of up front non-Federal funding comes from a bond financed by public water agencies impacted by the conveyance constraints proposed for remedy under the Recommended Plan, the costs could be spread over approximately 405,000 acre-feet of deliveries per year. The incremental construction cost attributed to these deliveries is calculated to be approximately $41 to $44 per acre-foot per year[3]. This additional cost per acre-foot is also within the upper bound of the range for cost per acre-foot delivered to FWA contractors created by the 25th percentile hydrologic conditions. The range of additional cost represents 10% to 11% of the net income per-acre estimated in Table 6-11. Existing spot market transactions show a willingness to pay for water in the Central Valley well above the expected total cost following implementation of the Preferred Alternative. In addition, future value of water supplies estimated by the California Water Commissioner indicate that alternative water supplies in the Eastern San Joaquin Valley will be significantly higher than the cost of water supplies provided through the FKC following implementation of the Preferred Alternative.

Reclamation and FWA are working to negotiate a cost-share agreement for the necessary non-Federal cost share as identified by the WIIN Act as well as the repayment terms for any reimbursable requirements for federal appropriations. Reclamation and FWA are working to

[3] Assumes a 3.5% rate for bond based on 30-year A-Rated bond issued by a governmental entity in California for the $250 million non-Federal cost share based on information from January 2019 data from the California Debt and Investment Advisory Commission. This cost includes $6.85 to $10.60 per acre-foot for repayment of the $164 million reimbursable Federal funding provided through the WIIN Act. Restricting repayment to only those water deliveries downstream of the Preferred Alternative, shares the cost over 405,000 acre-feet of deliveries per year on average.

finalize the cost share agreement by October 2020 prior to commencement of construction of the project.

Risk and Uncertainty

Several assumptions in the analysis of the Recommended Plan can affect estimated project benefits and the resulting B-C ratio. In the economic analysis of the Recommended Plan, most assumptions regarding uncertainty were made that would result in conservative (i.e. lower benefit) estimates. This section describes how uncertainty regarding assumptions could affect estimated project benefits and the B-C ratios of the Recommended Plan. The evaluations presented below provide a reasonable range of expected outcomes under uncertainty and shows how the B-C ratios based on the most probable cost estimates would be affected. This section also shows how B-C ratios would be affected if high range and low range cost estimates are considered.

Potential Increase in Future Water Value

The economic analysis of the Recommended Plan is based on the estimated current value of agricultural water in the eastern San Joaquin Valley (representative of the Friant Division of the CVP). These values were developed by the CWC in 2015 through application of the State-Wide Agricultural Production (SWAP) model using output from CALSIM II simulations of CVP and SWP operations that reflect water rights, contracts, and regulatory requirements, and the continued unrestricted availability of groundwater. The CWC classified the values of water estimated under projected 2030 land-use conditions as current values. The economic analyses of the Recommend Plan applied the 2030 (current) water values on a constant basis throughout the 100-year planning horizon. This analysis assumes water values would not increase in response to reduced water supply availability due to SJRRS and SGMA implementation, changes in commodity values, changes in irrigation technology, or other factors.

The value of surface water in the eastern San Joaquin Valley has increased over the past several years in response to several factors including an increased percentage of land planted to permanent crops, irrigation technology improvements, additional land in agricultural production, reduced reliability of surface water supply in the San Joaquin Valley, increased reliance on groundwater and greater depth to groundwater. As described in Chapter 1, the State of California enacted SGMA in 2014, which requires the development and implementation of sustainable groundwater management practices. SGMA mandates that GSPs be developed by 2020 and groundwater sustainability be achieved by 2040 for “high priority basins”. The entire Friant Division of the CVP overlies groundwater basins that are designated as “high priority basins”, therefore it is expected that full SGMA compliance in the eastern San Joaquin Valley will be achieved by 2040. It also is expected that water values in the eastern San Joaquin Valley will change over time in response to changes in water supply availability, particularly in response to SGMA implementation, because less groundwater will be available.

In 2015, the CWC also prepared estimates of future agricultural water value in California based on the same land uses, water rights, contracts and regulatory requirements as those included in the 2030 analysis, plus assumed groundwater availability limitations due to SGMA implementation. The resulting values are significantly greater than those based on 2030 conditions that do not reflect SGMA implementation. While it is not certain that actual water values will result as projected, these estimates provide an indication of the potential future value of agricultural water supply in the eastern San Joaquin Valley once SGMA compliance is achieved. A comparison of 2030 (non-SGMA) and 2040 (with SGMA) values is provided in Table 6-13. For the economic analysis of the Recommend Plan, the 2030 values provided by the CWC in 2015 were escalated to a 2018 price level using once the U.S. Bureau of Economic Analysis GDP Deflator. The same escalation was applied to the 2040 values for use in this uncertainty analysis.

Table 6-13. Estimated Water Values in the Eastern San Joaquin Valley

Year	**Estimated Consumptive Use Water Value ($/AF)**	
	2015 Price Level	2018 Price Level
2030	$256	$271
2040	$511	$540

Source: CWC WSIP Technical Reference Document

If the value of agricultural water in the eastern San Joaquin Valley increases from the current value of $271/af to $540/af by the year 2040 in the planning horizon analysis and then remained constant at that value for the remaining of the planning horizon with all other variables unchanged, the benefits of the Recommended Plan would increase by $857M and the B-C ratio based on the most probable cost estimate would increase to 3.45.

Reduced Ability to Reschedule Affected Water Deliveries in Millerton Lake

The economic analysis of the Recommended Plan assumes that water deliveries prevented because of reduced capacity in the FKC could be rescheduled in Millerton Lake to subsequent months when the Friant Division contractor has sufficient water demand and capacity in the FKC is available. Opportunities to reschedule affected water deliveries in available conservation space in Millerton Lake would occur to the extent they are foreseeable, could be rescheduled in coordination with other supplies available to affected contractors, and are consistent with water rights, contracts, and Reclamation policy. Affected Class 1 water supplies would have the highest priority for use of available conservation storage capacity for rescheduling and for rescheduled diversion to the FKC, followed by Class 2, then RWA/215 supplies. This operation would not change existing flood control requirements.

The analysis assumes that water users could increase the use of non-CVP water supplies when canal capacity limits deliveries and would have perfect foresight of hydrologic conditions to predict when such changes would be required. The application of these assumptions likely results in an overestimate the amount of affected water supply that could be rescheduled, and therefore underestimate of the water supply impact of the No Action Alternative. While it is not possible to precisely estimate the extent to which water users and Reclamation could optimize the use of Millerton Lake and the FKC to reschedule allocated water supplies, it is expected that no more than 70 percent of the affected water supply could be available for rescheduling in Millerton Lake and delivery in any given month.

If the amount of affected water supply available for rescheduling in Millerton Lake is limited to 70 percent and all other variables remain unchanged, the benefits of the Recommended Plan would increase by $134M and the B-C ratio based on the most probable cost estimate would increase to 2.11.

Extended Construction Duration Due to Funding Availability

The economic analysis of the Recommended Plan assumes a construction duration of three years, and the availability of funding to enable uninterrupted construction of all plan features. In the economic analysis, this assumption is reflected in the planning horizon analysis in the benefits provided by the project in the first three years and costs associated with construction and IDC. If the availability of funds is delayed, the construction duration would increase.

If funding availability to implement the Recommended Plan caused the construction duration to increase from three years to six years and all other variables remain unchanged, the net benefits of the Recommended Plan would decrease by $39M and the B-C ratio based on the most probable cost estimate would decrease to 1.79.

Reduced Deliveries in the Subsided Portion of the FKC

As described in Chapter 2, the reduced capacity of the FKC caused by subsidence limits flows can be conveyed for downstream deliveries, resulting in reduced water supplies to downstream Friant Division long-term contractors. The benefits of the Recommended Plan are based on avoiding reduced downstream deliveries that would occur in the No Action Alternative. In addition, subsidence in the FKC Middle Reach has decreased, and will further decrease, available head (water level) at water turnouts in the subsided reach and in some upstream portions of the FKC. The water diversion capacity of up to 6 gravity turnouts downstream from Tule River Check Structure and the upstream from Deer Creek Check Structure is reduced and will further decline in the No Action Alternative as subsidence continues. It is likely that modifications would be required to some or all of these gravity turnouts to maintain continued delivery of allocated CVP contract supplies.

While specific improvements to gravity turnouts in the subsided section of the FKC have not been evaluated or valued, it is expected that temporary permanent, pumps would be installed to assure access to contract water supplies. The timing of pump installation and use in the No Action Alternative would depend on site specific conditions for each contractor and CVP water supply availability. The Recommended Plan will return the HGL to restore the ability of these turnouts to deliver water at their designed capacity. If the reduced deliveries immediately upstream of the subsided section of the canal were valued, the quantified benefits of the Recommended Plan would be greater than those presented in this Report.

Summary of Risk and Uncertainty Findings

A summary of risk and uncertainty factors on project costs and benefits is provided in Table 6-14. Although the identified risk and uncertainty factors have the potential to increase or decrease project costs and benefits, none have been identified that could be expected to reduce the benefit cost ratio to less than one.

Table 6-14. Risk and Uncertainty on Economic Feasibility of the Recommended Plan

Risk and Uncertainty Factor	Change in Net Benefits from Recommended Plan ($M)	Cost Benefit-Ratios Based on Most Probable Cost Estimate	Cost Benefit Ratios Based on Low Range Cost Estimate	Cost Benefit Ratios Based on High Range Cost Estimate
Recommended Plan	No change	1.91	2.25	1.58
Potential Increase in Future Water Value	857	3.45	4.18	2.94
Reduced Ability to Reschedule Affected Water Deliveries in Millerton Lake	134	2.11	2.55	1.79
Extended Construction Duration Due to Funding Availability	-39	1.79	2.16	1.52
Reduced Water Deliveries in the Subsided Portion of the FKC	Increase	Increase	Increase	Increase

Cost Allocation and Assignment of the Recommended Plan

The purpose of cost allocation is to assign costs to beneficiaries. Reclamation law and policy require an initial and final allocation of costs to project purposes. The final allocation of costs is conducted to determine actual assignment of costs to beneficiaries when construction is substantially complete.

As reimbursement requirements differ by law among the purposes served by a project, a systematic and impartial cost allocation process is required to determine and allocate costs that are clearly identifiable with a single purpose served, and to equitably allocate the remaining joint costs serving two or more purposes. Cost allocation is a financial exercise rather than an economic evaluation. Consequently, project costs may be presented differently in a cost allocation than in an economic analysis.

Cost Allocation

A separate costs-remaining benefits (SCRB) cost allocation analysis was prepared for the Recommended Plan to determine how construction costs would be allocated and demonstrate that a proportionate share of the project benefits are Federal benefits eligible for funding under the WIIN Act.

The Recommended Plan produces benefits for three authorized Federal purposes: water supply, flood control, and fish and wildlife enhancement. For each purpose, the SCRB cost allocation identifies the justifiable expenditure as the lesser of benefits provided or costs for a single purpose alternative to achieve at least the same benefit. Separable costs, if any, are deducted to determine the remaining justifiable expenditure. No separable costs have been identified for any of the Federal purposes provided by the Recommended Plan. Proportions calculated on the remaining justifiable expenditure are used to allocate project costs to each purpose. The cost allocation for the Recommended Plan is shown in Table 6-15.

Table 6-15. Cost Allocation of Recommended Plan Construction Costs

Num	Item	Water Supply (A)	Flood Control (B)	F&WE Restoration Flow Management (C)	Total (E)
1	NPV of Project Benefits Provided[1]	$947.0	$38.3	$14.1	$999.4
2	Single Purpose Alternative Cost[1]	$500.0	> $38.3	> $14.1	n/a
3	Justifiable Expenditure (lesser of 1 or 2) [1]	$500.0	$38.3	$14.1	$552.4
4	Separable Costs[1]	$0.0	$0.0	$0.0	$0.0
5	Remaining Justifiable Expenditure (3-4) [1]	$500.0	$38.3	$14.1	$552.4
6	Percent Allocation of Costs (A5 to C5)/(E5)	91%	7%	3%	100%
	Cost Allocation (A6 to C6) * Cost[1]	$452.6	$34.7	$12.7	$500.0

Water supply benefits are based on the value of avoided lost water supplies, up to 145 TAF/yr, resulting from the Recommended Plan. The implementation of SGMA precludes consideration of additional groundwater pumping as a source of water supply. Potential single-purpose alternatives that could provide the same water supply to affected Friant Division long-term contractors include developing new surface water storage capacity in the Tulare Lake Basin; importing additional water supply from the Sacramento and San Joaquin Rivers Delta; acquiring existing water supplies in the region; and implementation of the Recommended Plan.

Opportunities to enlarge existing dams or construct new reservoirs in the Tulare Lake Basin are few, and any project that may produce sufficient new water supply equal to the avoided losses would be much more costly than the Recommended Plan. For example, as estimated in the USJRBSI Draft Feasibility Report (Reclamation, 2015), Temperance Flat Reservoir (on the San Joaquin River immediately upstream from Friant Dam) would provide less new water supply than the avoided losses provided by the Recommended Plan at an estimated construction cost of over $3 billion in 2014 dollars and would require at least 15 years to permit, design and construct.

Importing additional supply from Northern California would be prohibitive from a hydrologic perspective and would require the construction of North-of Delta storage capacity or through-Delta conveyance infrastructure. Projects of this type are under consideration by Reclamation and, when combined with conveyance improvements in the San Joaquin Valley to enable delivery of sufficient Delta supplies to Friant Division long-term contractors, would cost more and require more time to implement than the Recommended Plan. The acquisition of existing water supplies in the region would be at least as costly as the estimated value of water used to calculate water supply benefits. Because the cost and potential implementation time of available single purpose alternatives would exceed the those of the Recommended Plan, the justifiable expenditure for water supply is the cost of the Recommended Plan.

Flood control benefits are based on changes in EAD resulting from the availability of additional storage capacity in Millerton Lake provided by the Recommended Plan, as calculated using the USACE FDA model. Single purpose alternatives that could produce similar benefits include enlarging Millerton Lake to provide sufficient additional storage capacity, improving levees along the San Joaquin River between Friant Dam and the Delta to safely convey higher flood flows, acquiring water supplies from Friant Division long-term contractors, and restoring the designed conveyance capacity of the FKC through construction of the Recommended Plan. The net present value over a 100-year planning horizon of any of these actions would exceed the value of the benefits provided; therefore, the justifiable expenditure for flood control is equal to the benefits provided.

Fish and wildlife enhancement Restoration Flow management benefits are based on the value of additional water supply needed to ramp down reservoir releases from additional flood occurrences to Restoration Flows. The single purpose alternative to achieve this benefit would be enlarging Millerton Lake storage capacity to capture additional inflow or acquiring water supply from willing Friant Division long-term contractors. Increasing storage capacity of Millerton Lake would be more costly than the benefits provided, and the acquisition of water from willing sellers would be at least as costly as benefits provided. Therefore, the justifiable expenditure for fish and wildlife enhancement Restoration Flow management is equal to the benefit provided.

Cost Assignment

Repayment for Federal water resources projects is based on the principle that beneficiaries pay for benefits received. Existing legislation describing Federal financial participation for purposes that could be used to allocation costs for the Recommended Plan is summarized in Table 6-16. Reimbursable costs are those that, through some form of up-front cost sharing, repayment, or financial agreement, are paid by non-Federal entities or repaid to the government. Non-reimbursable costs are those borne by the Federal government.

Table 6-17 shows the assignment of total construction costs to Federal non-reimbursable and non-Federal reimbursable project purposes, consistent with existing Federal legislation.

Table 6-16. Existing Authorities for Federal Financial Participation for Monetized NED Benefit Categories and Purposes of the Recommend Plan

Purpose/NED Benefit Category	Pertinent Federal Legislation	Description
Water Supply	P.L. 111-11 Part III, Sections 10201 and 10203	Nonreimbursable. The Secretary is authorized and directed to restore the designed and constructed capacity of the FKC and Madera Canal in an amount not to exceed $35,000,000. In addition, there are authorized to be appropriated $50,000,000 (October 2008 price levels) to carry out the purposes of this part which shall be non-reimbursable.
Water Supply	Reclamation Act of 1902, as amended	Reimbursable. This act allows for up-front Federal financing of water supply purposes, with 100% repayment of construction costs, without interest, and OM&R by beneficiaries.
Flood Control	Reclamation Project Act of 1939	Nonreimbursable.
Fish and Wildlife Enhancement	Federal Water Project Recreation Act of 1965 (PL 89-72), as amended	PL 89-72 allows Federal non-reimbursable share of 75% and non-Federal share of at least 25% for fish and wildlife enhancements. In addition, 50% of annual OM&R and replacement costs would be a non-Federal responsibility.

Key:
FY = fiscal year
NED = National Economic Development
OM&R = Operations Maintenance and Replacement
P.L. = Public Law

Table 6-17 Construction Cost Assignment for the Recommended Plan

		Construction Cost Assignment Summary ($ millions)				
		Non-Federal		Federal		
Federal Purpose	**Authority**	**Assigned Percentage**	**Assigned Cost**	**Assigned Percentage**	**Assigned Cost**	**Total**
Water Supply	PL 111-11 Part III, Sections 10201 and 10203 FY 2013 and future appropriations	0%	$0.0	100%	$41.9	$41.9
Water Supply	Reclamation Act of 1902, as amended	100%	$410.7	0%	$0.0	$410.7
Total Water Supply			$410.7		$41.9	$452.6
Flood Control	Reclamation Project Act of 1939	0%	$0.0	100%	$34.7	$34.7
F&WE Restoration Flow Management	PL 89-72, as amended	25%	$3.2	75%	$9.6	$12.7
Total			$413.9		$86.1	$500.0

Key:
F&WE = Fish and Wildlife Enhancement
FY = fiscal year
SJRRS = San Joaquin River Restoration Settlement

Eligible funding amounts from existing Federal legislation under the authority of the Secretary of the Interior are shown in Table 6-18.

Table 6-18. Project Funding Sources

Authorization	Federal Interior		Other	Total
	Nonreimbursable	Reimbursable[1]		
PL 111-11 SJRRS Act Sections 10201 and 10203	$41,900,000		-	$41,900,000
PL 114-322 WIIN Act Section 4007	$44,226,800	$163,873,200	-	$208,100,000
Other Funding Sources			$250,00,0000	$250,000,000
Total	$86,126,800	$163,873,200	$250,000,000	$500,000,000

Notes:
[1] Represents that maximum eligible funding under WIIN Act authority that could be expended and reimbursed through repayment contracts. It has not yet been determined if repayment contracts would be sought by non-Federal entities.
Key:
P.L. = Public Law
SJRRS = San Joaquin River Restoration Settlement
WIIN Act = Water Infrastructure Improvement for the Nation Act

Implementation Requirements

Implementation of the Recommended Plan would include major activities for design, environmental compliance and permitting, land acquisition, financing, and construction and O&M. A Construction Management Plan will be developed that identifies Reclamation, FWA and Contractor roles and responsibilities during construction. A schedule for implementation is shown in Figure 6-6, and brief descriptions of major activities is provided in the following sections.

Design Activities

FWA, under cooperative agreement with Reclamation, has begun to advance design of the Recommended Plan. This will include several the following key steps:

- Preparation of a 30 percent design report
- Geotechnical investigations to support final design
- Preparation of 60 percent, 90 percent, and 100 percent designs
- Establishing agreements with key project partners and stakeholders (e.g. Tulare County, SCE, So Cal Gas, Kern County) related to planning design, and construction activities.
- Preparing detailed plans, specifications, and bid packages.

Environmental Compliance and Permitting

Reclamation is initiating environmental compliance and permitting activities, in coordination with the FWA, to conduct and complete required NEPA and CEQA environmental compliance and all necessary permitting before implementation of the Project. Several key activities include the following:

- Required environmental compliance under NEPA and CEQA will involve preparation of a joint EIS/EIR document and issuance of a Record of Decision (ROD) and Notice of Determination (NOD), on the following schedule:
  - Notice of Intent/Notice of Preparation (NOI/NOP) – December 2019
  - The Draft EIS/EIR release for public review – May 2020
  - The Final EIS/EIR released to public – September 2020
  - The Record of Decision (ROD) – October 2020
- Permitting requirements of Federal, state, and local laws, policies and environmental regulations.
- Implementation of mitigation measures may proceed before, or consistent with construction of project physical features.

Land Acquisition

Following completion of NEPA and CEQA compliance, and in compliance with the Uniform Relocation Act, FWA will initiate activities, as appropriate, in coordination with Reclamation to complete the acquisition of required lands, easements, and ROW.

Financing

Funding for the project would be obtained through Federal appropriations and non-Federal sources prior to the initiation of construction. If all project funds are not available at the time of construction initiation, the Project would be segmented into construction packages that could be accomplished with available funding to address the most urgent capacity correction portions of the Project.

Project Construction and Transfer to O&M Status

After the completion of environmental compliance and permitting, design, land acquisition, and financing, project implementation efforts would transition to the preparation and execution construction contracts. One or more contracts would be awarded for implementation of mitigation measures, construction activities, and commissioning of new facilities. Contract award would be based on availability of funds and procurement of rights of way. As shown in Figure 6-6, construction is estimated to occur over a 3-year period.

Transfer to O&M status will be done in accordance with applicable Reclamation Directives and Standards as well as Regional guidance.

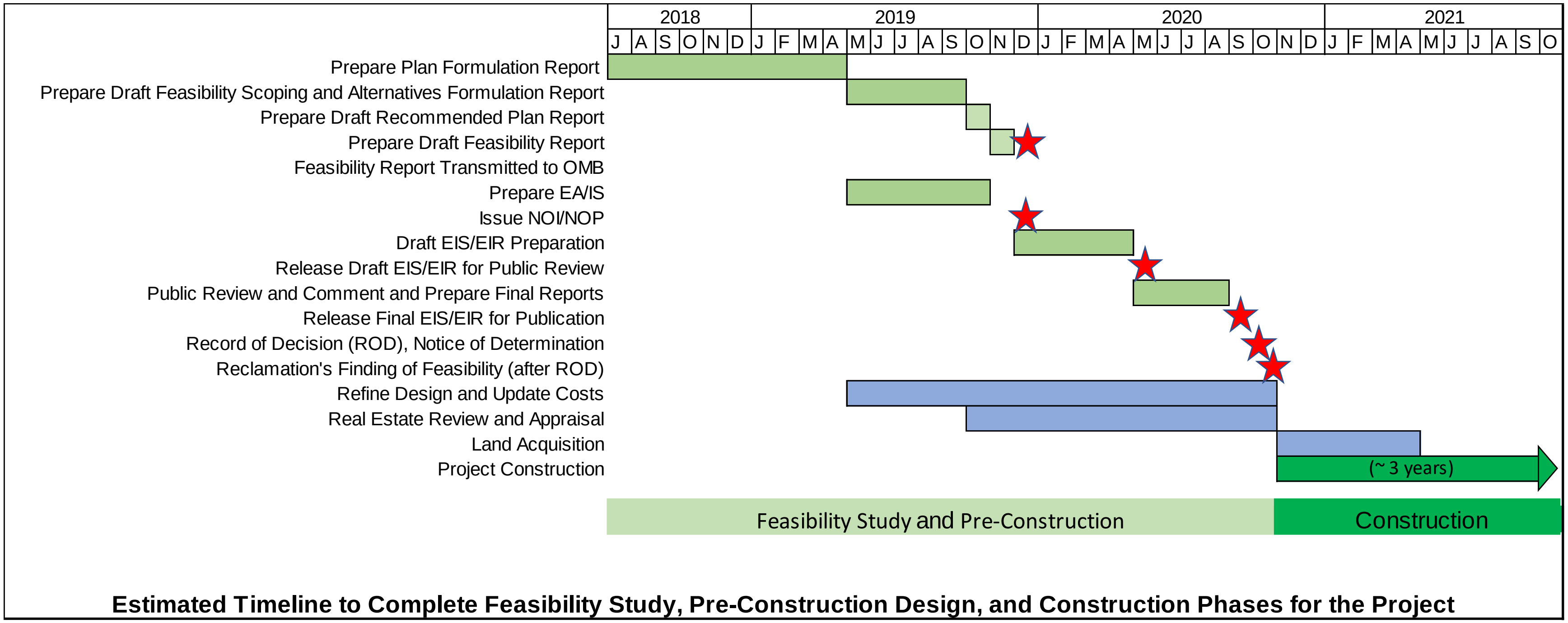

Figure 6-6. Project Timeline

Chapter 7 Summary and Recommendations

This Study includes development, evaluation, and comparison of alternatives consistent with the Federal PR&G (CEQ 2013). In coordination with this report, a Final EIS/R will be prepared consistent with NEPA and CEQA. This chapter provides a summary of information presented in this report and provides recommendations for action by the Secretary or through Congressional action in support of implementing the Recommended Plan.

Need for Project

The reduced capacity of FKC Middle Reach has resulted in water delivery impacts on Friant Division long-term contractors, reduced ability of the FKC to convey flood waters during wet periods, and reduced ability to implement provisions of the Water Management Goal as described in Paragraph 16 of the San Joaquin River Restoration Settlement (Settlement). The reduced delivery of water via the Friant-Kern Canal under long-term Friant Division contracts, the Recovered Water Account (RWA), and Unreleased Restoration Flows (URFs) also reduces funding necessary to implement the Restoration Goal provisions of the Settlement as described in Paragraph 11.

The purpose of the Project is to restore the conveyance capacity of the FKC Middle Reach to such capacity as previously designed and constructed by Reclamation, as provided for in the San Joaquin River Restoration Settlement Act (Public Law 111-11, Title X, Part III(a)(1)), and to include design features that will preserve the design capacity of the FKC as future subsidence occurs. The purpose of this Study is to describe the formulation, evaluation, and comparison of alternatives that address Project planning objectives and identify a Recommended Plan consistent with Federal authorizations and requirements. Information developed through the Study will be used in preparation of required environmental compliance documentation.

Recommended Plan

As required by the PR&G, the plan that produces the greatest net public benefit is identified as the Recommended Plan and is typically selected for recommendation to the Secretary of the Interior for consideration and approval (CEQ 2013). The identification of the Recommended Plan based upon the evaluation and comparisons described in Chapter 5. The Recommended Plan is described in detail in Chapter 6 and summarized below.

Recommended Plan Major Components

Major components of the Recommended Plan include:

- **Canal Enlargement** — The existing canal would be enlarged by raising the lining one to four feet from MP 88.2 to MP 95.7 and MP 115.94 to MP 121.5.

- **Canal Realignment** — A new realigned canal would be the exclusive water conveyance and delivery mechanism and most of the existing FKC would be demolished, filled in, and taken out of service. The realignment would stretch from MP 96.3 to MP 115.94.

- **Turnouts** — The approach to the turnouts varies by location and configuration. Turnouts in the canal enlargement portion would modified. In the canal realignment portion gravity turnouts would be replaced and new delivery pool turnouts would be constructed for pressurized turnouts along the canal realignment potion.

- **Checks and Siphons** — New or replacement check structures, wasteways and siphons would be required at the Deer Creek and White River crossings.

- **Road Crossings** — Road crossings would either be left in place or replaced with a concrete box siphon, depending on the location.

- **Utilities** — Depending on the location and extent of canal modifications, the utilities like overhead power lines, adjacent wells, and elevated pipeline canal crossings would either be relocated or entirely replaced.

The Recommended Plan includes the following specific features to accommodate future subsidence:

- Sufficient embankment height to allow the FKC to continue to be operated at the required hydraulic grade line to provide design capacity as future subsidence occurs;

- Road crossing siphons designed to function under increased water pressure associated with greater submergence resulting from future subsidence with no loss of conveyance capacity or risk of overtopping; and

- Structural modifications to turnouts, siphon walls, and check structures designed to operate at the design hydraulic grade line without the need for further modifications as future subsidence occurs.

Costs and Benefits

A summary of the B-C analysis of the Recommended Plan is presented in Table 7-1.

Table 7-1. Benefit-Cost Analysis of Recommended Plan

Item	Recommended Plan
Water Supply Benefit[1,2]	$947
Flood Control Benefit[1,2]	$38.3
Fish and Wildlife Enhancement Benefit – Restoration Flow Management	$14.1
Total Benefit	$999.4
Present Value of Most Probable Total Capital and Life Cycle Costs [1,3]	$538
Cost Range of Present Value of Total Capital Cost[1,4]	($444 - $632)
Net Benefit[5]	$461.4
Range of Net Benefit[1,5]	(367.4 - 555.4 -
Benefit Cost Ratio	1.86
Range of Benefit Cost Ratios	(1.58 – 2.25)

Notes:
[1] All costs are in millions of dollars
[2] Present Value based on 100-year planning horizon
[3] Total Capital and Life Cycle Cost = Total Construction Cost + IDC + OM&R
[4] +/- 25% applied to field cost
[5] Net Benefit equals Benefits minus Present Value of Total Capital and Life Cycle Cost

Feasibility of the Recommended Plan

The Recommended Plan was designed based on projected land surface in 2070 to account for future subsidence. The Recommended Plan is technically feasible and constructible and could be implemented with a balance or surplus of material. Designs and cost estimates for the Recommended Plan were developed to a feasibility level.

The Recommended Plan would restore the ability of the FKC to convey flood waters during wet periods and implement provisions of the Water Management Goal as described in Paragraph 16 of the San Joaquin River Restoration Settlement. The restored capacity of the FKC would avoid water shortages and improve the ability to manage the volume and timing of Restoration Flows and flood flows at Friant Dam.

The Recommended Plan would support greater conjunctive management of Friant Division resulting in greater groundwater storage and improved management of Friant Division water supplies in Millerton Lake.

The Recommended Plan is economically feasible on the basis that monetized benefits for avoided water supply shortages exceed project costs. The B-C ratio was calculated using a 100-year planning horizon benefits analysis and feasibility-level construction costs, IDC, and, life cycle costs. Recommended Plan produces a B-C ratio of 1.86.

Environmental compliance and permitting processes are under way. Cultural and biological resources analysis are ongoing and will be incorporated into the EIS. The Record of Decision for the EIS is anticipated for October 2020. Costs for biological mitigation, cultural mitigation, and air quality mitigation are incorporated to the cost estimate for the Recommended Plan.

Funding for the Project is may be derived from the SJRRS Act, PL 111-11 Extraordinary Maintenance provisions, the WIIN Act, and other sources obtained through the FWA or member agencies.

Risks and Uncertainty

The effect of uncertainty on net benefits and the B-C ratio resulting from several factors, such as future water value, rescheduling of affected water deliveries in Millerton Lake, and lengthened construction duration was evaluated. The resulting B-C ratios based on the most probable cost estimate would range from 1.79 to 3.45. When combined with high and low range cost estimates, the resulting B-C ratios would range from 1.52 to 4.18. In all cases, the risk and uncertainty analyses revealed that the B-C ratio would exceed unity.

The performance of the Recommended Plan was evaluated using historical operations and does not consider potential future water deliver requirements that could exceed historical peak flows in the FKC. The net benefits and B-C ratio of the Recommend Plan would increase if future operational objectives include deliveries that exceed historical peak flows.

Federal Interest

This Report demonstrates Federal interest in the Recommended Plan. The Recommended Plan was identified as the NED Plan and produces a B-C ratio of 1.86 that could range from 1.52 to 4.18. Federal participation for planning, design and permitting is authorized in Part III of the Settlement Act, and the Project is eligible for Federal funding pursuant to PL 111-11 Extraordinary Maintenance provisions and the WIIN Act.

Environmental Compliance and Permitting Requirements for Project Implementation

The Final EIS will satisfy NEPA requirements by providing a meaningful analysis of all issues relevant to the physical, biological, cultural and human environments. Implementation of the

Recommended Plan will also be subject to additional Federal, State, and local laws, policies, and environmental regulations. All Federal, State, and local agencies with permitting or approval authority over any aspect of project implementation will be expected to use the information that will be included in the Final EIS to meet most, if not all, of their information needs, to make decisions, and/or issue permits with respect to the authorized project. Land acquisition will not occur and construction activities will not commence until the necessary NEPA, ESA, and Section 106 compliance requirements are complete.

Recommendations

As the Recommended Plan is being reviewed for Congressional recommendation and appropriations, the following items should be considered:

- Approve the Recommended Plan, as described in this Report.
- Allow Reclamation to increase the construction cost to allow for escalation from stated price levels (2019) to the notice to proceed for each contract or work package, based upon Reclamation’s Construction Cost Trends publication, or similar source.
- Appropriate funds such that pre-construction activities are completed within 2 years and construction is completed within 3 years following construction initiation to avoid cost overruns and ensure timely completion.
- Allow the Federal Government to accept title to any non-Federal property within the Project boundaries.

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