RECLAMATION

Managing Water in the West

Feasibility Report
Appendix B – Alternatives Engineering Design and Cost

Friant-Kern Canal Middle Reach Capacity Correction Project

November 2019

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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- Attachment B.2 Alternatives Cost Estimates

Abbreviations and Acronyms

AACE	Association for the Advancement of Cost Engineering
ac	acre
BIM	Building Information Model
BODR	Alternatives Report Basis of Design Report
CEQA	California Environmental Quality Act
CCE	Construction Cost Estimate
cfs	cubic feet per second
CGPS	continuously operating GPS reference stations
CP	critical path
CPT	Cone Penetration Test
FHWA	Federal Highway Administration
FKC	Friant-Kern Canal
FR	Feasibility Report
FWA	Friant Water Authority
GDR	Geotechnical Data Report
GIR	Geotechnical Investigation Report
GIS	geographic information system
GPS	global positioning system
HGL	Hydraulic Grade Line
HSA	hollow-stem auger
IGCE	Independent Government Cost Estimate
LiDAR	Light Detection and Ranging
MC	Modified California sampling
MP	milepost
NAD	North American Datum
NAVD	North Atlantic Vertical Datum
NEPA	National Environmental Policy Act
NTP	notice to proceed
O&M	operations and maintenance
OM&R	operations, maintenance, and replacement
OPPC	opinion of probable project cost
PCE	Project Cost Estimate
PFR	Plan Formulation Report
PR&G	*Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies*
Project	FKC Middle Reach Subsidence and Capacity Correction Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RFP	Request for Proposals
ROW	Right-of-way

SPT	Standard Penetration Testing
ST	Shelby tube sampling
Study	FKC Middle Reach Subsidence and Capacity Correction Project Feasibility Study
TM	technical memorandum
USGS	US Geological Survey
WBS	work breakdown structure

Chapter 1 Introduction

This technical appendix to the Feasibility Report for the Friant-Kern Canal Middle Reach Subsidence and Capacity Correction Project (Project) documents the engineering setting and cost estimate analyses to support federal project feasibility evaluation. The Project is a feasibility study evaluating alternatives to increase water supply reliability and improve deliveries to Friant Division long-term contractors in the Southern San Joaquin Valley of California.

Scope and Purpose of this Appendix

The Middle Reach of the Friant-Kern Canal (FKC), located within Tulare County, extends approximately 33 miles and has experienced significant subsidence over the past decade. This reach also was originally designed with outdated standards that prevent the intended capacity to be actualized. Due to these two issues, the capacity in portions of the Middle Reach is estimated to be less than half the original design capacity. The Project is being developed to provide improvements to the FKC to address reduced conveyance capacity resulting from regional land subsidence, as well as from a design deficiency.

The FKC Middle Reach Subsidence and Capacity Correction Project Feasibility Study (Study) is being developed by the Friant Water Authority (FWA) for review and approval by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). Progress and results of the Study are being documented in a series of interim reports that will culminate in a Feasibility Report and associated National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) compliance documentation consistent with the *Principles, Requirements, and Guidelines for Federal Investment in Water Resources* (PR&G) (CEQ 2013), Reclamation directives and standards, and applicable environmental laws. This Feasibility Report (FR) is an interim planning report in the Project feasibility study process.

In the Plan Formulation stage, FWA, in collaboration with the Friant Division long-term contractors and Reclamation, developed, evaluated, and ranked seven Project alternatives. Of these, two projects were recommended for further development. The objective of this Appendix B –Alternatives Engineering Design and Cost (Engineering Appendix) is to provide detail regarding these two Project alternatives, including an assessment of the existing features affected, the new features added, the engineering design considerations, and cost estimation methodology and results.

Organization of This Appendix

This appendix is organized as follows:

Chapter 1, **Introduction**, provides the scope, purpose, and organization of this appendix.

Chapter 2, Engineering Setting, summarizes the existing conditions of the FKC and related facilities, along the geologic setting and geotechnical analyses.

Chapter 3, Overview of Initial Alternatives, provides a high-level summary of the seven initial alternatives and the measures proposed, by canal segment.

Chapter 4, Alternatives, introduces the two Alternatives in terms of major features, costs, and other defining characteristics.

Chapter 5, Cost Estimating Methodology, discusses the Reclamation cost estimate levels and the appraisal-level cost estimate approach.

Chapter 6 Appraisal-Level Cost Estimates, documents the appraisal-level cost estimates for each of the project alternatives, both with and without consideration of future subsidence.

Chapter 7, References, lists the sources used in preparing this technical appendix.

There are two attachments to this Engineering Appendix, as follows:

- **Attachment B.1** Feasibility Report Basis of Design Technical Memo
  - **Exhibit B.1a** Designs
- **Attachment B.2** Cost Estimates

Chapter 2 Engineering Setting

This chapter describes major existing facilities, surveying information, and available geotechnical data for the Project. The Alternatives Report Basis of Design Report provides the engineering parameters necessary for the appraisal-level engineering design and cost estimate work presented in this appendix.

Existing Facilities

Elements of the built environment in the study area are described in this section, including water resources facilities and related infrastructure. Constructed facilities include the FKC, in-canal structures, turnouts, bridges, and utilities along the FKC.

Friant-Kern Canal

The FKC flows 151.8 miles from Friant Dam to the Kern River at an average slope of approximately 6 inches per mile. The FKC was constructed by Reclamation in 1945, prior to the development of Reclamation's current Design Standards No. 3, Release No. DS-3-5, dated 1967, and revised in 1994. Approximately 85 percent of the FKC is concrete-lined, with 15 percent earth-lined. The canal initially had a maximum capacity of 5,000 cubic feet per second (cfs), gradually decreasing to 2,500 cfs to accommodate conveyance to downstream demand. In the late 1970s, Reclamation raised the FKC's concrete lining from the headworks to the Kings River Siphon, increasing the maximum capacity in this reach to 5,300 cfs. The FKC conveys Central Valley Project water to 25 Friant Division long-term contractors and delivers water to these contractors via gravity or pump turnouts primarily in Fresno, Tulare and Kern Counties.

It is important to understand the original design parameters in order to reestablish the original canal design intent and to establish new boundary conditions for rehabilitation of the subsided canal. The original design of the FKC consisted of 9 different canal (geometric) cross sections for its entire 152-mile length – 7 seven concrete-lined sections and 2 earth-lined sections. This Project is focused on evaluating the original design for the 33.6-mile reach of canal from the 5th Avenue Check (milepost (MP) 88.2) to the Kern River Check (MP 151.8). This segment was designed and constructed with concrete-lined canal Section Nos. 4 through 7 and earthen canal Section No. 2.

The 1992 *Information Report on the Friant-Kern Canal* (Friant Water Users Authority, 1992) included schematics for typical canal cross sections, for both the concrete-lined segments (Figure 2-1) and the compacted earth-lined segments (Figure 2-2).

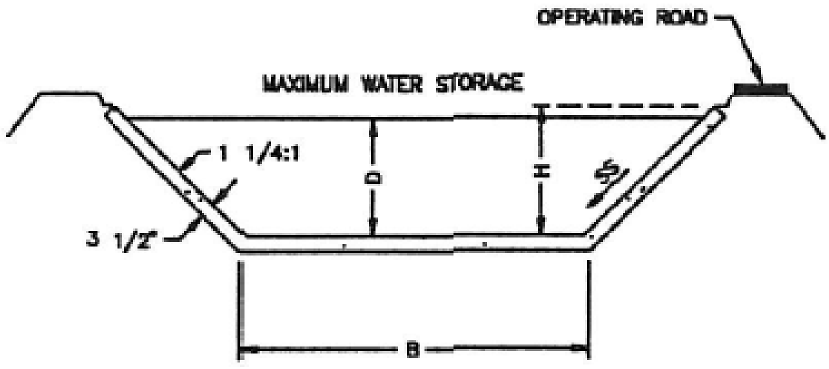


Figure 2-1. Typical Section, Concrete-lined Canal Segments

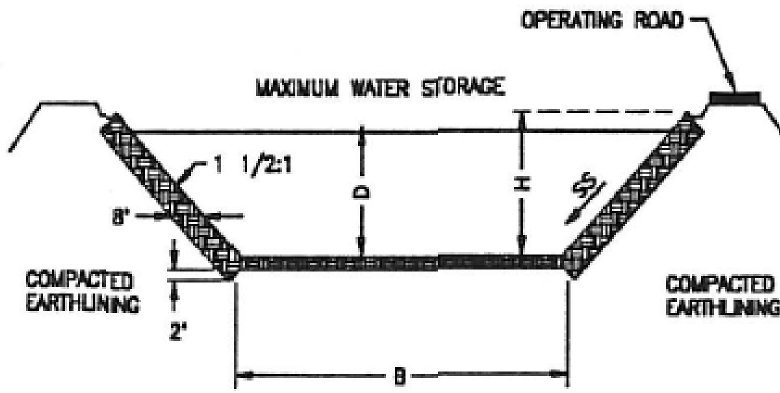


Figure 2-2. Typical Section, Compacted Earth-lined Canal Segments

Additionally, the original USBR "Profiles and Sections" design drawings for the Friant-Kern Canal (1948-1949) included schematics for typical canal cross sections, shown here for the concrete-lined Section 6 for thorough cut sections, one bank sections, and two bank sections (Figures 2-3 through 2-5, respectively).

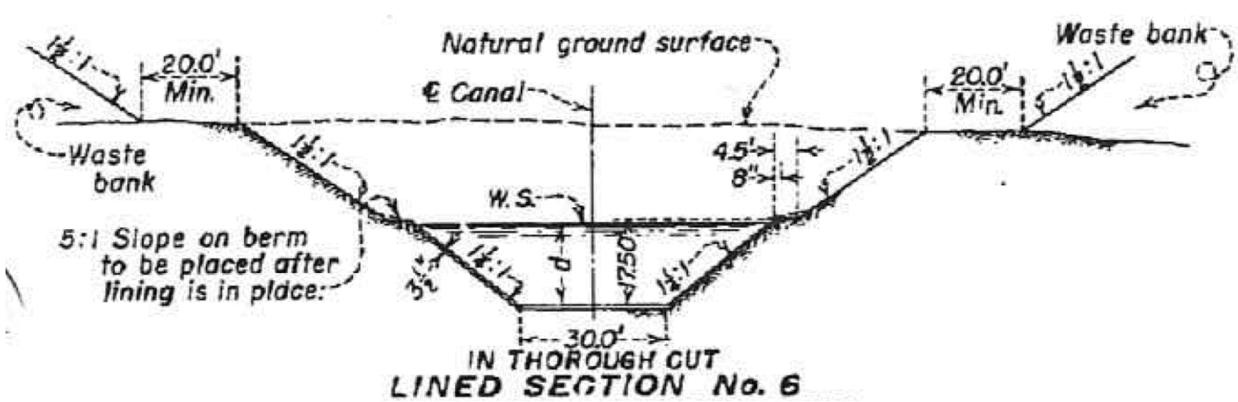


Figure 2-3. Typical Section, in Lined Thorough Cut Section

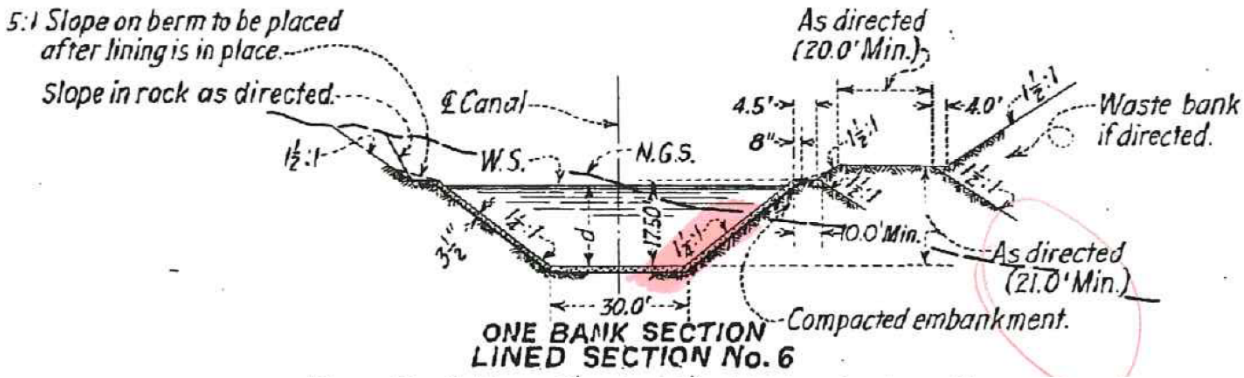


Figure 2-4. Typical Section, in Lined One Bank Section

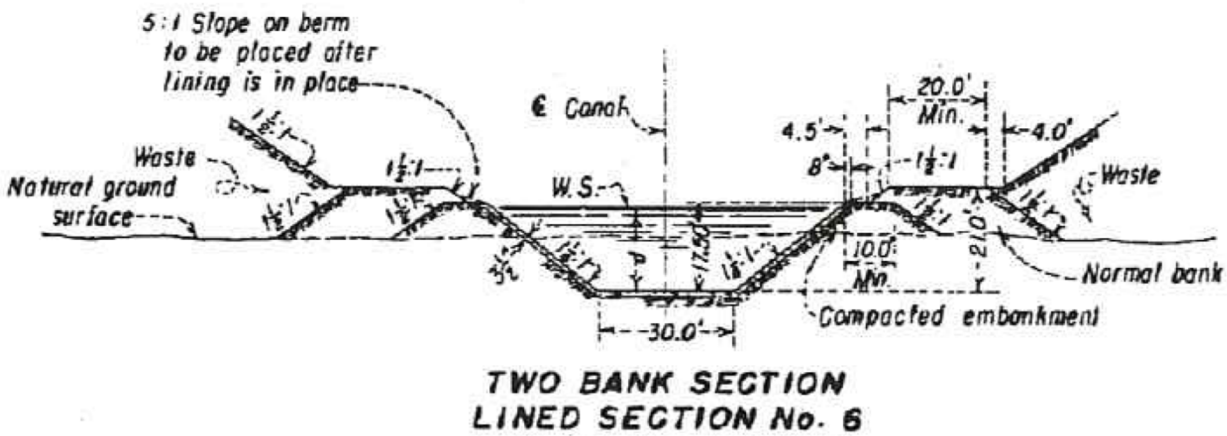


Figure 2-5. Typical Section, in Lined Two Bank Section

Table 2-1 and Table 2-2 provide geometric data for these canal sections for two design flow scenarios: (1) Normal Design Flow and (2) Max Design Flow. The Normal Design Flow represents the largest planned operational flows. The Max. Design Flow was provided to accommodate two primary functions: (1) transport short-terms flood flows released into the canal from the San Joaquin River for delivery to member districts as Class 2 water and/or released into various major cross drainage systems intercepted by the canal; and (2) accept cross drainage flows into the canal at specific locations rather than pass them over or under the canal.

Table 2-1. Original Design Canal Section Data for “Normal Design Flow”

Canal Data	Design Q (cfs)	Design V (ft/s)	Manning’s n	Bottom slope	B (ft)	d (ft)	Side slope (h:v)	D (ft)	Fb (ft)	MP	Lining
Section 2	2503	2.64	0.020	0.000055	40	14.50	2.00:1	15.2	2.3	119.5 – 121.5	Earth
Section 4	3500	4.32	0.014	0.000082	36	14.66	1.25:1	17.3	2.64	88.21 – 98.88	Concrete
Section 5	2998	4.04	0.014	0.000060	36	14.73	1.25:1	17.5	2.77	98.88 – 112.90	Concrete
Section 6	2502	3.61	0.014	0.000060	30	14.43	1.25:1	17.5	3.07	112.90 – 119.50	Concrete

Key:
cfs – cubic feet per second
D – depth of canal lining
Fb – freeboard
ft – feet
ft/s – feet per second
h:v – horizontal:vertical

Table 2-2. Original Design Canal Section Data for “Max Design Flow”

Canal Data	Design Q (cfs)	Design V (ft/s)	Manning’s n	Bottom slope	B (ft)	d (ft)	Side slope (h:v)	D (ft)	Fb (ft)	MP	Lining
Section 2	3,502	2.90	0.020	0.000055	40	17.22	2.00:1	15.2	2.3	119.5 – 121.5	Earth
Section 4	4,500	4.61	0.014	0.000082	36	17.04	1.25:1	17.3	0.26	88.21 – 98.88	Concrete
Section 5	3,999	4.04	0.014	0.000060	36	17.21	1.25:1	17.5	0.29	98.88 – 112.90	Concrete
Section 6	3,502	3.94	0.014	0.000060	30	17.24	1.25:1	17.5	0.26	112.90-119.50	Concrete

Key:
cfs – cubic feet per second
D – depth of canal lining
Fb – freeboard
ft – feet
ft/s – feet per second
h:v – horizontal:vertical

When the FKC was originally designed, Reclamation used the Manning’s equation with an “n” roughness value ranging from 0.014 to 0.0143 for the concrete-lined sections. In the 1960s, Reclamation conducted field tests as part of an extensive study of hydraulic losses in about a dozen large concrete-lined canals including the FKC. That study concluded that flow resistance in the five largest canals in the study (including the FKC) was larger than anticipated. Values of Manning’s n computed from the field tests ranged from 0.015 to 0.019 and were about 10 to 25 percent higher than design values.

A Manning’s n value of 0.016 has been adopted for design of the FKC rehabilitation projects. This selection is described further in the Alternatives Report Basis of Design Report (BODR) attachment. Applying this n value (instead of 0.014) to the original canal geometry results in approximately one foot of increased normal flow depth for the Normal Design Flow condition.

The 1992 report included the following canal dimensions and hydraulic properties:

- Length: 152 miles
- Typical maximum section (concrete-lined):
  - Lining Thickness: 3-1/2 inches
- Length of concrete-lined section: approx. 127 miles
- Typical maximum section (compacted earth lining):
  - Lining Thickness: 2 feet on bottom, 8 feet minimum horizontal thickness on sides
- Length of compacted earth-lined section: approx. 25 miles

In-Canal Structures

The Project reach includes numerous in-canal structures, including check structures, siphons, wasteways, checks, overchutes, and the Lake Woollomes equalizing reservoir. Checks are associated with Fifth Avenue, the Tule River, Deer Creek, and the White River. The 30 percent design will include further enumeration and discussion of the in-canal structures.

The 1992 report contained the following canal structures summary (note that these totals encompass the entire canal, not just the Project area):

- Major canal siphons: 34
- Wasteways: 8
- Checks: 14
- Overchutes: 11
- Equalizing reservoir: 1
- State highway bridges: 14
- Canal operating road bridges: 11
- Farm bridges: 82
- County highway bridges: 104
- Railroad bridge: 1

- Culvert: 68
- Turnouts: 109
- Inlet drains: 344
- Sump pumps: 21

Turnouts

The Project reach includes numerous turnouts, on both the east and west sides of the canal. Further discussion of the existing turnouts can be found in the *Turnout Inventory Technical Memorandum*, by Provost and Pritchard Consulting Group (September 2018) exhibit to the BODR attachment. Additionally, the 30percent design will include further enumeration and discussion of the in-canal structures.

Bridges

The Project reach includes 48 bridges in total, including five farm bridges and 43 state or county bridges. Most of the county bridges consist of two equal simply supported spans made up of five cast-in-place reinforced "T" beams. The "T" beam depths vary from 2'-8" to 2'-10" and includes the 6" concrete deck thickness. The beams are supported on a reinforced concrete pier wall and reinforced concrete seat type abutments with monolithic wingwalls. All supports are founded on reinforced concrete spread footings. The bridge lengths vary from 84'-4" to 102'-2" end to end, and span lengths vary from 41'-3" to 50'-0" centerline bearing to centerline bearing. Bridge skews vary from 0 to 35 degrees. The bridges have an outside width of 28'-4" and a curb to curb roadway width of 26'-0". The bridges carry two lanes of traffic, one in each direction. State Highway 65 is a notable exception at 40 feet in width. The farm bridges are typically 16 feet wide, single-lane, and made of timber. The farm bridges are typically designed to H-10 or H-20 loading, and the county bridges are typically designed to H-15 or H-20 loading.

Utilities

The Project reach includes over 100 utility crossings. Some utilities are attached to the upstream or downstream side of roadway bridges. Others cross over or under the canal, away from roadways. The utilities include power, natural gas, telephone, irrigation, and TV cable. The 30-percent design will include further enumeration and discussion of the utility crossings.

Physical Environment

Elements of the physical environment in the FKC vicinity are described in this section, including regional topography, geology, and soils. For further detailed discussion of these topics, please refer to the BODR, the Preliminary Geotechnical Interpretive Report (GIR), and the Geotechnical Data Report exhibits.

Topography

Land surface subsidence as a result of groundwater extraction has been well documented in California's Central Valley. Documentation of historical land subsidence in the 1950s and 1960s includes the portion of the Tule Sub-basin where the FKC is located. Land subsidence in this area was essentially arrested in the late 1970s and 1980s as the introduction of imported water into the area allowed for reduced groundwater pumping and groundwater levels recovered. The land subsidence was likely reactivated again in the 1990s with the return of groundwater overdraft conditions, and subsidence rates appear to have accelerated after 2007 due to increased pumping and drought conditions. The regional setting generally consists of rural agricultural farming communities. In general, the canal traverses open farmland and has few associated structures. An assortment of county bridges cross over the FKC.

Geology and Soils

Site Geologic Conditions

The project site is located in the southern portion of the Great Valley Geomorphic Province in Central California. This region is characterized as a 50-mile-wide and 400-mile-long sediment filled trough in which the sediments have been deposited, almost continuously, since the Jurassic period. The geology of the Great Valley generally consists of marine and continental deposits resting on a basement complex of metamorphic and igneous rocks.

Locally, the project site resides within the San Joaquin Valley. Geology within the San Joaquin Valley and the project area mainly consists of Jurassic to recent, marine, alluvial, and lake deposits that are several thousand feet thick. The regional surficial geology along the canal is mapped as Quaternary Alluvium and Older Alluvium (California Division of Mines and Geology, 1964 and 1965). For more information, a geologic map of the project area is presented as Figure 2 in the GIR exhibit. The site is located in a moderately active seismic area. The southern end of the project area is closer to known active faults than the northern project area. The estimated distance from the southern end of the project area (MP 110.3) to selected nearby mapped active faults is presented in Table 2-3.

Table 2-3. Active Faults in Site Vicinity

Fault	Distance (miles)[1]	Maximum Moment Magnitude[1]
Great Valley 14 (Kettleman Hills)	43.9	7.2
White Wolf	48.3	7.2
South San Andreas	51.7	8.2
Pleito	55.6	7.1
Great Valley 13 (Coalinga)	57.5	7.1

Note:

[1] Measured from National Seismic Hazard Maps (USGS, 2008).

As noted above, the closest known active fault is the Great Valley 14 Fault, located approximately 44 miles northwest of MP 110.3. For more information, a Regional Fault and Seismicity Map is presented as Figure 3 in the GIR exhibit.

Site Geotechnical Conditions

The Phase 1 geotechnical field investigation for the FKC Subsidence Correction Project was performed between September 11 and September 25, 2018, and consisted of the following:

- Nine hollow-stem auger (HSA) borings with Standard Penetration Testing (SPT), Modified California Sampling (MC), and Shelby tube (ST) sampling
- Seven Cone Penetration Tests (CPT).

Details of the subsurface conditions are presented in the Geotechnical Data Report – Phase 1 (GDR) exhibit. The information in the GDR was based on the Phase 1 geotechnical investigation performed by Stantec in September of 2018.

Based on the geometry of the embankment as described in the original as-built construction drawings from 1945 and the as-built construction drawings of the embankment raise in the 1970s, we developed a subsurface model comprising three units. The three soil units include uncompacted fill, compacted fill, and alluvium. The Phase 1 investigations only intersected the uncompacted fill and the alluvium. The compacted fill zone is located too close to the canal side of the embankment to be intersected by the Phase 1 explorations.

The GIR exhibit provides a summary of the material properties and interpreted design parameters for the encountered subsurface soil.

Groundwater

Groundwater was not observed in the borings or CPTs performed for the Phase 1 geotechnical investigation. Possible perched groundwater was observed in boring B-1 at a depth of approximately 25 feet as the sampler and sample were wet. However, the hole was dry upon completion of soil augering. The moisture content of a sample from boring B-8 at a depth of approximately 30 feet is close to saturation, which may also indicate perched groundwater at this location.

We understand the regional groundwater level is at least 100 feet below the ground surface. The seepage from the canal into the embankment likely travels vertically and horizontally in an unsaturated condition. Some of the seepage may also be lost through evapotranspiration.

Concrete is permeable and there is likely leakage into the embankment from the canal through both the intact concrete and the joints and cracks within the concrete lining. However, the leakage appears to be sufficiently small such that extensive saturated soil layers do not develop within the embankment.

Seepage

Seepage analyses were performed on a cross-section with the conditions/configuration observed at the Boring B-2/CPT-2 (MP 104.1) location in the Immediate Repair Area (MP 104.1 to 107.1). The purpose of the seepage analyses was to assist in developing mitigation options for ongoing toe seepage issues which have occurred at several locations within the Immediate Repair Area. However, we understand that implementation of mitigation for seepage control is no longer being considered. A secondary purpose for performing seepage analyses was to better understand flows during toe seepage events for a temporary raised canal level.

An HDPE liner will be constructed above the existing concrete liner to implement the temporary canal level raise. The information from the seepage analyses has been used in the slope stability analyses.

Based on discussions with FWA, we understand relatively significant seepage has occurred at multiple locations at the land side toe of the embankment within the Immediate Repair Area. FWA has observed toe seepage at MP 99.5, 104.9, and 105.63. Seepage model calibration indicated that there may be relatively significant voids or piping channels (created by internal soil erosion) in the embankment soils at these locations that are resulting in large seepage volumes that would be unlikely for a homogenous embankment with the observed clayey material types. The implications of the presence of these potential voids and piping channels are discussed in the slope stability section of the GIR exhibit. Further discussion of the seepage analysis, including the resulting seepage volume and permeabilities used in the analyses, are presented in the GIR.

*S*lope Stability

Slope stability analyses were performed at the Immediate Repair Area to evaluate stability of the current embankment with higher canal water levels, and at other areas of the existing canal alignment to evaluate stability of an enlarged canal geometry that is currently being considered as a mitigation option. Two cross-sections (MP 104.1 and 106.1) have been evaluated in the Immediate Repair Area for the existing geometry and seven cross-sections (MP 97.5, 104.1, 106.1, 107.1, 108.9, 110.3, and 115.6) have been evaluated for the enlarged canal geometry.

Slope stability factor of safety and seismic loading criteria were provided by Reclamation; see GIR Tables 6 and 7 for more detail.

Static and seismic slope stability analyses were conducted to evaluate the stability of the existing embankment in the Immediate Repair Area, and the proposed embankments for the enlarged canal.

The analyses were completed to assess the factor of safety against instability using a limit equilibrium slope stability method (Spencer method of slices) incorporated into the software program Slope/W (Geo-Slope, 2018). The findings of the analysis are presented briefly here, and more detail can be found in the GIR exhibit.

All of the static loading conditions for the enlarged canal were found to meet or exceed the Reclamation criteria. The Downstream Seismic loading at MP 97.5, 104.1, and 107.1 do not meet criteria from Reclamation. However, at MP 97.5 and 104.1, the factors of safety do meet criteria when the slip surfaces are forced to extend laterally to at least the canal side of the embankment crest.

Seismic Deformation Analysis

Seismic deformation was evaluated for the MP 107.1 cross section using the simplified seismic deformation model developed by Bray and Travasarou (2007), which is a commonly used method in California.

The Bray and Travasarou procedure estimates seismically induced deformations based on the earthquake demand including magnitude and spectral acceleration, site geometry and dynamic properties including slope height and shear wave velocity, and dynamic slope capacity characterized by the yield acceleration. The earthquake characteristics were obtained from the 2014 US Geological Survey deaggregation using a 2,475-year return period with a Seismic Site Class D soil.

The calculated median and plus one standard deviation seismic deformation using the parameters above is 4 inches and 8 inches, respectively. At the time of this report, Reclamation has not provided criteria for seismic deformation. However, the calculated values are considered to be indicators that seismic deformations will be relatively small, and that the embankment is likely to perform adequately if subjected to the design seismic event. Similarly, the other cross sections at MP 97.5 and 104.1 will have lower estimated seismic deformations than those calculated above. Accordingly, these cross-sections are also likely to perform adequately if subjected to the design seismic event.

Slope Stability Conclusions

The slope stability analyses performed for the proposed enlarged canal indicate that the modified canal embankments will meet factor of safety criteria provided by Reclamation. Some of the assumptions and qualifications associated with this conclusion and with the evaluations performed are provided below.

- The evaluations in this report are based on geotechnical information obtained from The Phase 1 geotechnical investigation performed on the operations and maintenance (O&M) road. The Phase 1 geotechnical investigation will be supplemented by a Phase 2 investigation that will focus on explorations at the toe of the existing embankments and at other locations where canal modifications are proposed. Accordingly, the results and recommendations provided in this report should be considered preliminary and subject to revision based on the findings from the Phase 2 investigation.

- The scope of the current investigation and evaluations is based on a 30 percent design level deliverable. Additional investigations and evaluations beyond the Phase 1 and Phase 2 efforts will need to be performed to support the project final design.

- The evaluations assume that all of the uncompacted fill in the existing embankment will be removed and replaced as compacted fill. Additional earthwork recommendations will be provided in subsequent reports. These will include recommendations relating to excavation, benching, compaction and moisture, material types, testing and observation, and other related earthwork recommendations.

- The shear strength of the compacted fill used in the slope stability analyses was based on limited laboratory testing. Relatively large volumes of imported fill will be needed to construct the enlarged canal. Shear strength testing of the imported fill will need to be performed to ensure minimum shear strengths equal to or greater than those used in the analyses are obtained. As discussed previously, the seepage analyses performed in the area where toe seepage was observed by FWA indicates there may be voids and piping channels in the embankment at these locations. While there has not been any reported slope instability at these toe seepage areas, piping channels and voids in the embankment can potentially cause slope instability. Some options to mitigate the potential instability include construction of a seepage barrier such as a slurry wall, or by removing the uncompacted material and increasing the width of the embankment such as what is proposed for the enlarged canal.

- The slope stability analyses performed indicate that the proposed enlarged canal will be grossly stable in both static and seismic conditions.
- The static factors of safety calculated for the existing canal in the Immediate Repair Area generally meet Reclamation criteria. The dry canal condition may potentially be considered a temporary condition. The calculated factor of safety for this dry canal is lower than Reclamation criteria (1.2 calculated versus 1.3 Reclamation criteria). These analyses indicate that the existing canal in the Immediate Repair Area is considered grossly stable for static conditions.

Subsidence

Stantec retained Thomas Harder & Company to conduct a hydrogeological analysis of potential future subsidence specifically focused along the FKC using a calibrated numerical groundwater flow model of the Tule Subbasin and surrounding area. The results of the analysis are presented in the Plan Formulation Report Attachment B.2, Selection of Future Subsidence Condition, and its Exhibit A, Subsidence Modeling Technical Memorandum (TM).

In order to provide adequate flow capacity into the future, the performance of alternative designs must be evaluated relative to potential future conditions after additional subsidence has occurred. Subsidence projection studies were developed using the Tule Subbasin Groundwater Model under four potential groundwater pumping and hydrologic scenarios. Results for each scenario are provided by decade (2030 – 2070), providing a total of 20 potential subsidence profiles in the project area.

Possible future subsidence along the canal alignment was represented using four potential ground profiles of estimated subsidence, combined with four possible scenarios of the timing and magnitude of future groundwater pumping and various hydrologic conditions. Attachment B.2 notes that “Neither future groundwater pumping nor future hydrology can be predicted with certainty. Therefore, it is impossible to quantify exactly how and when subsidence will occur;” thus, “It is more informative to frame and analyze subsidence possibilities without tying these possibilities to exact conditions that cause them or to dates when they will occur.” Group 3, a severe mid-term profile that represents a blend of moderate scenario results from 2030 through 2070 (“Scenario 2 in the years 2040 to 2070 and Scenario 3B in the year 2030”), is the recommended subsidence projections, and it results in an 8-foot maximum subsidence point in the most affected area of the canal profile. Note that 8 feet is the maximum subsidence under the Group 3 profile, but it is not the maximum subsidence across all projections. Further discussion of the subsidence modeling performed and the range of subsidence projections can be found in the Thomas Harder & Company Subsidence Modeling TM, and exhibit to the Selection of Future

Subsidence Conditions TM, which is an attachment to the Plan Formulation Report Engineering Appendix.

Survey and Mapping

General

The aerial surveying and mapping for the Project was performed by Towill, Inc. Additional supplemental surveying for Friant Division contractor turnouts was performed by Provost and Pritchard Consulting Group. Aerial and topographic mapping was conducted along the length of the project in August 2018. This data is currently being processed to create topographic base mapping to cover the extents of the project area. The completed survey data files are anticipated to be completed by the end of September 2018.

Additional flight lines were conducted approximately 3,000 to the east to pick up airborne Light Detection and Ranging (LiDAR) data of the FKC and an approximate area for a bypass canal alternative. The LiDAR was collected by an aircraft suitable to map the terrain within the mapping corridor. The LiDAR data was prepared at a nominal density of nine points per square meter. No imagery, planimetrics, or “bare-earth” classification of LiDAR data was processed initially; however, it may be post-processed at a later date, if needed.

Primary Control Points

A survey control network was established at approximately one-mile intervals. Survey datums are referenced to the North American Datum (NAD)83 (CSRS Epoch 2011.00) horizontal datum and Geoid 2012B North Atlantic Vertical Datum (NAVD)88 vertical datum, based on continuously operating GPS reference stations (CGPS) reference stations that are remotely situated and are not affected by local ground subsidence. Global positioning system (GPS) surveying technology was used to accomplish the control survey. The basis for the coordinate projection is California Zone 4 with distances measured in feet.

Mapping

Upon completion of the ground control survey and acquisition of aerial photography, analytical aerotriangulation was performed to extend control throughout the project photography to achieve a network of points. A digital topographic map will be compiled at a scale of 1" = 100' for the mapping area. Planimetric features – such as buildings, roads, fences, bridges, and the like will be digitized at elevations that provide the best horizontal accuracy. The final topographic mapping will have a contour interval of 1 foot.

Chapter 3 Initial Alternatives

Capacity Restoration

The objective of the Project is to restore the capacity of the FKC, consistent with Settlement Act authority. The Settlement Act is the San Joaquin River Restoration Settlement (Title X, Subtitle A) provisions of Public Law [P.L.] 111-11, the Omnibus Public Land Management Act of 2009. This involves restoring the original design capacity of the FKC consistent with current Reclamation design standards. Therefore, the design of all canal enlargement, pump stations, new bypass and new parallel canal measures have a canal operating capacity equal to the Design Maximum Flow Rate (Table 3-1). Canal lining depths will equate to the normal depths at the Design Maximum Flow Rates plus the established lined freeboard criteria. The design flow rates were used to develop the hydraulic grade line profiles for the initial alternatives.

Note that, for a new canal system, “normal” depth design concepts apply since flow is uniform. However, under existing conditions where the canal is operating in a gradually varied flow environment, “normal depth” does not exist, and water surface levels are based upon analytic water surface levels (backwater curves analysis). Freeboard criteria were applied and top of lining elevations were established based upon the addition of this criteria to the backwater curve results. Section designs are based upon those elevations. The design flow rates that are presented in Table 3-1 are significant to establish the backwater curve results.

Table 3-1. Design Flow Rates

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

Key:
cfs = cubic feet per second
HWY = highway
MP = milepost

Hydraulic Grade Line

A water surface control elevation of 399.13 feet was established on the upstream side of the Woollomes check structure. This elevation is the key balance point for the system. This elevation can be held without significant modifications to the existing Lake Woollomes Check or the Lake Woollomes Regulating Reservoir.

As a result of analysis, this level was chosen for the following reasons:

- This Hydraulic Grade Line (HGL) elevation of 399.13 feet is 1.14 feet lower than the original design water surface elevation at Woollomes. There has been 2.54 feet of subsidence at that location, so the control elevation of 399.13 is 1.4 feet higher than the original level relative to canal invert. Thus, the normal depth at the Lake Woollomes check will also be 1.4 feet higher than the normal depth shown for the original design.

- The additional 1.4 feet of relative HGL provides valuable head to supply flow downstream to Kern River in the future.

- This HGL also significantly reduces cost in the canal upstream from Woollomes by maintaining water levels throughout the Middle Reach that reduced canal cost (e.g. new canal size, enlarged canal size, and/or pump head).

- This HGL permits full use of regulatory storage in Woollomes Reservoir, which is a major benefit to canal operations.

Freeboard

Lining Freeboard

The minimum operating freeboard provided for the concrete lining, from maximum water depth at the design flow to the top of the concrete lining is shown for each reach of the canal sections in Table 3-2.

Table 3-2. Design Freeboard Requirements

CANAL REACH			FREEBOARD AT RECLAMATION FLOOD FLOW AND MAX FLOW					
Canal Section No.	**Canal Reach (Milepost to Milepost)**	**Description**	**Design Flow (cfs)**	**Flood Flow Lining Freeboard (ft)**	**Required Canal Lining Height at Flood Flow[1] (ft)**	**Max Flow Lining Freeboard (ft)**	**Required Canal Lining Height at Max Flow[1] (ft)**
4	88 to 95.67	5th Ave. to Tule	4,500	1.18	19.30	2.35	20.47
5	95.67 to 112.90	Tule to White River	4,000	1.15	19.63	2.29	20.77
6	112.90 to 128.69	White River to Poso	3,500	1.11	19.62	2.23	20.74

Note:
[1] Freeboard calculated per Reclamation canal design standards.
Key:
cfs – cubic feet per second
ft – feet

The flood flow lining freeboard and resulting canal lining height at flood flow shown in Table 3-2 represents the minimum standard that Reclamation would require the canal prism to be designed to. This is the freeboard requirement that Reclamation has designed previous phases of FKC rehabilitation projects to. Reclamation allows for the reduction in max flow lined freeboard by one-half for short term flood flows that enter the canal from cross drainage and can be evacuated from canal by wasteways. However, the FKC max design flow freeboard includes captured flood flows (i.e., Class 2 water) that are transferred over a long period of time, with no intention of evacuating the excess flows from the canal. Based on this, the design assumption is that minimum lined freeboard for the FKC alternatives will be as shown in the “Max Flow” conditions in Table- 3-2.

Earth Freeboard

In all cases the minimum earthen freeboard, from the top of the concrete lining to the top of the earthen embankment will be 2.5 feet per Reclamation standards.

Initial Alternatives

Seven initial alternatives were developed to meet Project objectives: (1) Canal Enlargement, (2) Pump Station at MP 109, (3) Pump Station at Woollomes, (4A) Bypass Canal from Tule to White River, (4B) Bypass Canal from Tule to Woollomes, (5A) Parallel Canal from Tule to White River, and (5B) Parallel Canal from Tule to Woollomes. Although there are different approaches to meeting the Project objectives, all alternatives return the canal to its original design capacity.

Initial Alternative 1: Canal Enlargement

Initial Alternative 1 would increase the capacity of the FKC by either raising the embankments and 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 in 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 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.

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

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

Selection of Alternatives for Further-Level Evaluation

Alternatives 1 and 5 were further evaluated following the failure of Proposition 3 in November 2018, a key potential funding source for the Project. The additional evaluation considered various design capacity and freeboard requirements for Initial Alternatives 1 and 5 with the objective of identifying challenges that may be associated with Project phasing.

Estimates of material quantities and costs were prepared for Initial Alternatives 1 and 5 under the following capacity and freeboard four options:

- **Option 1 – Maximum Historical Flow with Flood Freeboard**. This option was defined based on a review of historical peak flows in each segment of the FKC. The existing flood freeboard was applied based on the assumption that historical peak flows were associated with the conveyance of flood flows.

- **Option 2 – Design Normal Flow with Standard Freeboard**. This option was defined based on the original normal design flow using the current standard freeboard requirements.

- **Option 3 – Design Maximum Flow with Flood Freeboard**. This option was defined based on the original maximum design flow using the current flood freeboard requirements.

- **Option 4 – Design Maximum Flow with Standard Freeboard**. This option was defined based on the original maximum design flow using the current standard freeboard requirements. This assumption was applied in the assessment of all Initial Alternatives.

A summary of results the additional analysis of Initial Alternatives is presented in Table 3-3.

Table 3-3. Alternatives Summary for Four Options

Alternative Features by Segment		Alternative 1 - Canal Enlargement				Alternative 5 - Parallel Canal			
Segment	Feature	Option 1 Historical Max Flow Flood Freeboard	Option 2 Design Normal Flow Design Standard Freeboard	Option 3 Design Max Flow Flood Flow Freeboard	Option 4 Deisgn Max Flow Design Standard Freeboard	Option 1 Historical Max Flow Flood Freeboard	Option 2 Design Normal Flow Design Standard Freeboard	Option 3 Design Max Flow Flood Flow Freeboard	Option 4 Deisgn Max Flow Design Standard FB
Segment 1 5th Ave. to Tule River	Design Flow (cfs)	4,008	3,500	4,500	4,500	4,008	3,500	4,500	4,500
	Design Freeboard (ft)	1.12	2.23	1.12	2.35	1.12	2.23	1.12	2.35
	Canal Cross Section			Widen and Raise FKC	Widen and Raise FKC			Widen and Raise FKC	Widen and Raise FKC
	Length of New or Modified Canal (miles)			7.40	7.40			7.40	7.40
Segment 2 Tule River to Deer Creek	Design Flow (cfs)	3,497	3,000	4,000	4,000	3,497	3,000	4,000	4,000
	Design Freeboard (ft)	1.08	2.15	1.08	2.29	1.08	2.15	1.08	2.29
	Canal Cross Section	Raise FKC	Raise FKC	Widen and Raise FKC	Widen and Raise FKC	Parallel Canal	Parallel Canal	Parallel Canal	Parallel Canal
	Length of New or Modified Canal (miles)	6.90	6.90	6.90	6.90	6.92	6.92	6.92	6.92
Segment 3 Deer Creek to White River	Design Flow (cfs)	2,888	3,000	4,000	4,000	2,888	3,000	4,000	4,000
	Design Freeboard (ft)	1.08	2.15	1.08	2.29	1.08	2.15	1.08	2.29
	Canal Cross Section	Raise FKC	Raise FKC	den and Raise FKC	den and Raise FKC	Parallel Canal	Parallel Canal	Parallel Canal	Parallel Canal
	Length of New or Modified Canal (miles)	10.20	10.20	10.20	10.20	10.16	10.16	10.16	10.16
Segment 4 White River to Lake Woollomes	Design Flow (cfs)	2,490	2,500	3,500	3,500	2,490	2,500	3,500	3,500
	Design Freeboard (ft)	1.03	2.06	1.03	2.23	1.03	2.06	1.03	2.23
	Canal Cross Section		Raise FKC	Widen and Raise	Widen and Raise		Parallel Canal	Parallel Canal	Parallel Canal
	Length of New or		6.50	6.50	6.50		6.52	6.52	6.55

From this point forward these two alternatives will be referred to as Alternative 1 – Canal Enlargement and Alternative 5 – Parallel Canal. The following sections provide descriptions of these alternatives.

Canal Hydraulic Grade Line and Water Supply Deliveries to Turnouts

A common hydraulic grade line (HGL) was established for the FKC that meets the required boundary conditions. This modification to the current HGL required investigations into the capability of the 39 turnouts to provide needed water supply deliveries; with minimum and maximum water surface elevations important information needed to ensure operational compatibility with the planned alternatives. The turnouts vary in size and configuration, supplying water to both gravity and pressurized systems, with the pump stations for the pressurized type systems mostly located immediately adjacent to the FKC. It is worth noting that the distribution systems served by the FKC turnouts have likely subsided different amounts than the FKC, that could lead to distribution systems being subjected to different (i.e. higher) head conditions to that which was originally planned. Figures 3-2 and 3-3 provide HGLs for a range of operating conditions (i.e. approximate existing HGL, minimum flow and maximum flow) along with detailed information on the turnouts.

The new water surface elevation in the canal could overtop the existing pump wetwell deck resulting in uncontrolled flooding of adjacent land. Additionally, the increased head on the old distribution systems may result in over pressurization and pipe joint failures. The proximity of the existing pumping stations to the FKC is also a challenge, given that potential relocations of this type of infrastructure could lead to significant construction costs. To address some of these concerns, a solution was developed to create delivery pools for existing turnouts in the FKC with embankments constructed in the existing canal and on either side of the existing turnouts. A delivery pool turnout would be constructed on the new canal to convey water to the delivery pool. This concept would be used for both alternatives, although the length of this new canal for Canal Enlargement would be enough only to meet minimum radius of curvature criteria. Refer to Figure 3-1 for an example of this concept.

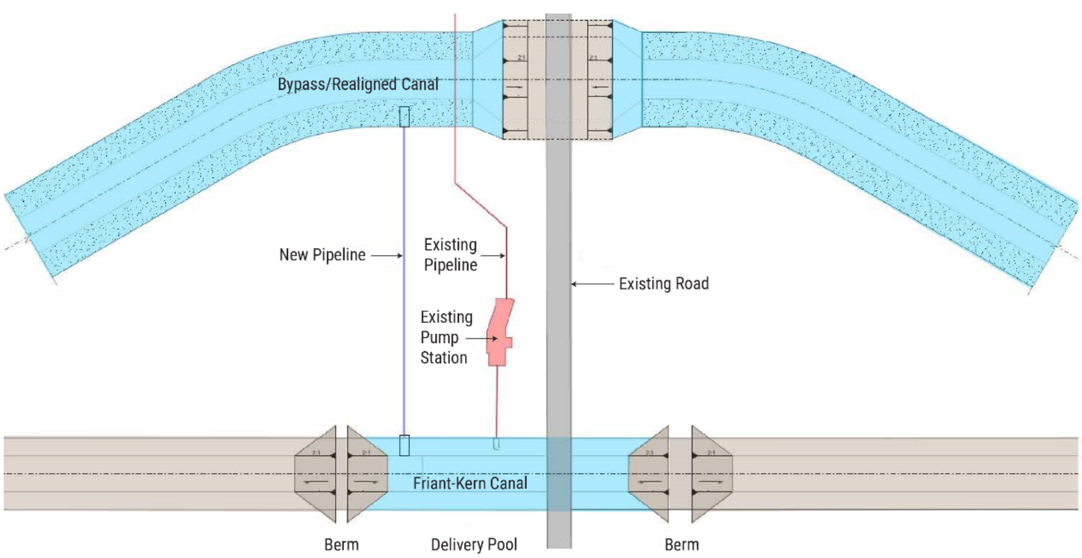
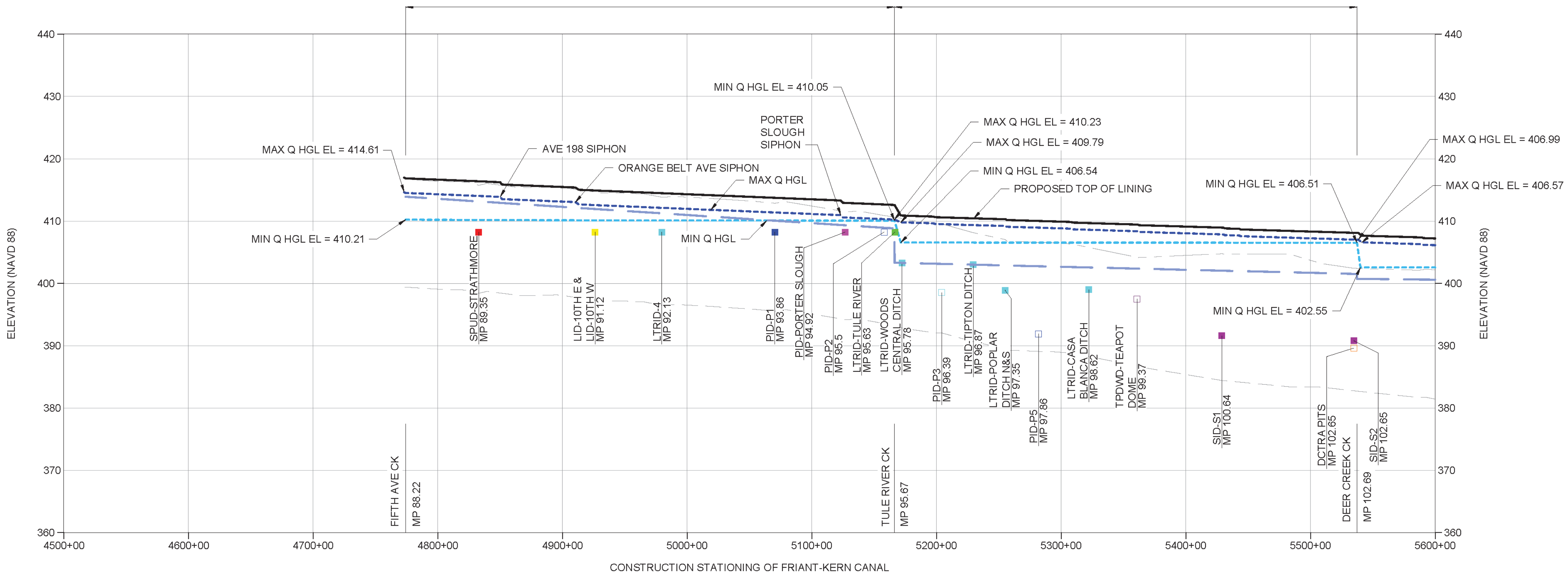


Figure 3-1. Delivery Pool Turnout Concept



FKC - EXISTING TURNOUTS

	Color Code	T/O ID	Location			No of Gates and Sizes	Receiving Contractor	Peak Delivery (3)		Physical Elevations		
			Mile Post	Const STA	Direction			Q (cfs)	HGL	TOB	TOL	Floor
✳		SPUD-STRATHMORE	89.35	4832+85	West	1-20"	Strathmore New SPUD	3	408.2	419.98	415.73	
✳		LID-10th E	91.12	4926+17	East	4'x4'	Lindmore ID	22	408.2	418.32	414.41	
✳		LID-10th W	91.12	4926+17	West	2 - 4.5'x4.5'	Lindmore ID	72	408.2	418.21	414.55	
✳		LTRID-4	92.13	4979+67	West	2 - 7'x7'	Lower Tule River ID	557	408.2	418.20	413.82	
✳		PID-P1	93.86	5070+41	West	2 - 4.5'x4.5'	Porterville ID, Castle Ditch	25	408.2	416.38	412.84	
✳		PID-Porter Slough	94.92	5126+75	West	2 - 5'x5'	Porter Slough	52	408.2	415.58	411.50	
✳		PID-P2	95.5	5157+99	East	1 - 4.5'x4.5'	Porterville ID	32	408.2	415.25	410.87	
✳		LTRID-Tule River	95.63	5166+77	West	Weir	Tule River Wasteway Parshall	764	408.2	414.20	410.60	
✳		LTRID-Tule River	95.64	5166+77	West	4 - 11'x10.75'	Tule River Wasteway		408.2	414.20	410.60	
		LTRID-Woods Central Ditch	95.78	5172+34	West	3-4'x4'	Lower Tule River ID, Wood Central Ditch	270	403.3	414.63	410.31	397.00
		PID-P3	96.39	5204+22	East	1-36"	Lower Tule River ID, Porterville ID	24	398.5	413.25	409.53	393.29
		LTRID-Tipton Ditch	96.87	5229+51	West	2-4.5'x4.5'	Lower Tule River ID, Tipton Ditch	203	403.0	411.82	408.12	396.08
		LTRID-Poplar Ditch N&S	97.35	5255+02	West	2 - 4.5'x4.5'	Lower Tule River ID, Porterville ID, Popular Ditch	40	398.9	410.81	407.02	392.09
		PID-P5	97.86	5281+91	East	1-36"	Porterville ID	8	391.9	410.25	406.57	386.61
		LTRID-Casa Blanca Ditch	98.62	5322+16	West	3 - 4.5'x4.5'	Lower Tule River ID, Casa Blanca Ditch	237	399.0	409.70	405.76	392.53
		TPDWD-Teapot Dome	99.37	5360+89	East	1 - 3'x3'	Tea Pot Dome ID	38	397.5	408.28	404.18	392.06
		SID-S1	100.64	5428+88	West	2 - 4'x4'	Saucelito ID	82	391.6	407.25	404.74	385.12
		DCTRA Pits	102.65	5534+69	East	1 - 3'x3'	Terra Bella ID	52	389.6	405.10	402.41	383.94
		SID-S2	102.65	5534+69	West	2 - 4.5'x4.5'	Saucelito ID	102	390.8	405.19	402.70	383.99

✳ THESE TURNOUTS WERE NOT SURVEYED. HGL IS ASSUMED.

LEGEND AND ABBREVIATIONS

HGL	HYDRAULIC GRADE LINE
FLOOR	TURNOUT FLOOR ELEVATION
TOB	TOP OF EMBANKMENT
TOL	TOP OF LINING
	TOP OF LINING PER 2018 TOWILL SURVEY
	APPROX INVERT
	PROPOSED TOP OF LINING
	MAX Q HGL
	MIN Q HGL
WSEL	APPROXIMATE EXISTING HGL @ EXISTING Q SHOWN
✳	OPERATIONAL REQ WSEL @ CHECK STRUCTURE
□	ESTIMATED REQ HGL @ TURNOUT TO EAST
■	ESTIMATED REG HGL @ TURNOUT TO WEST

NOTES:

1. TURNOUT ELEVATION SHOWN REPRESENT AN ELEVATION 2' ABOVE THE TOP OF GATE ELEVATION SURVEYED IN 2018.
2. HYDRAULIC GRADE LINES AND FLOWS SHOWN CORRESPOND TO BYPASS CANAL - ALTERNATIVE 5 OPTION 3.
3. PEAK DELIVERY FLOW RATE BASED ON HISTORICAL MAXIMUM DAILY DELIVERY RECORDED BETWEEN JANUARY 2003 AND AUGUST 2017.

Figure 3-2. Hydraulic Profile from 5th Avenue to Deer Creek

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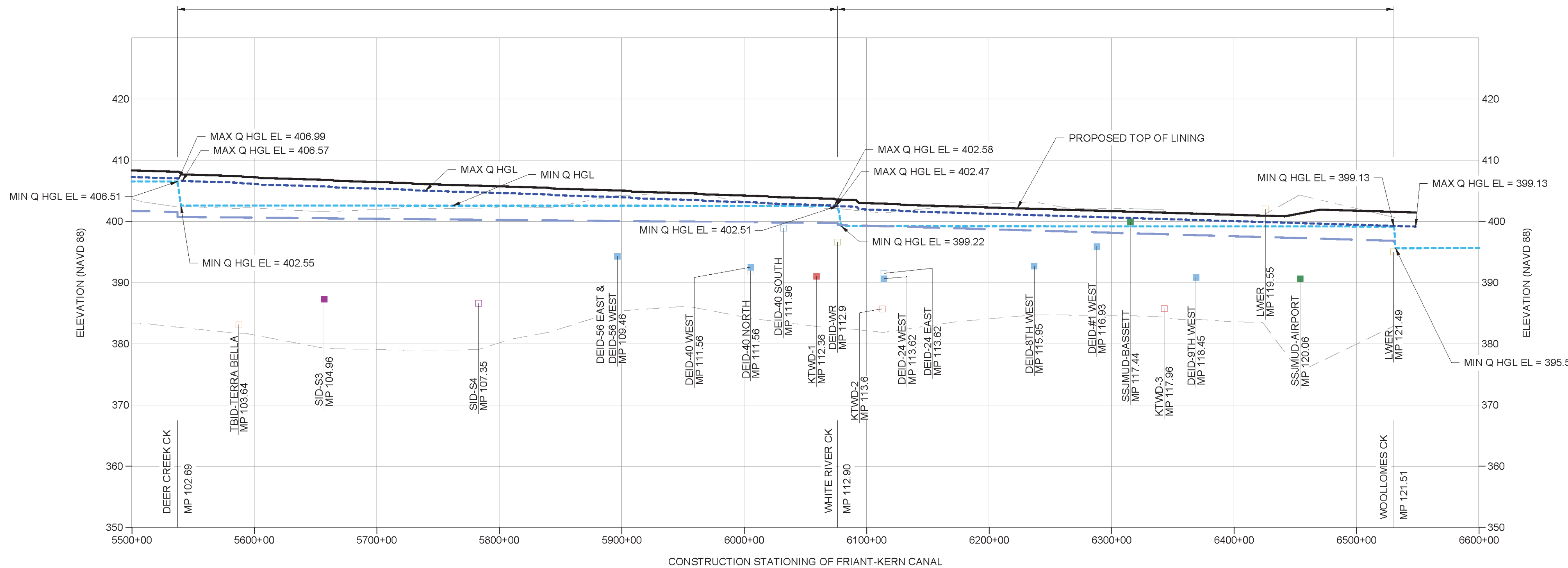

FKC - EXISTING TURNOUTS

Color Code	T/O ID	Location			No of Gates and Sizes	Receiving Contractor	Peak Delivery (3)		Physical Elevations		
		Mile Post	Const STA	Direction			Q (cfs)	HGL	TOB	TOL	Floor
	TBID-Terra Bella	103.64	5587+33	East	Pumping plant	Terra Bella	111	400.5	403.71	402.10	383.09
	SID-S3	104.96	5656+99	West	2 - 4'x4'	Saucelito ID	77	387.3	404.28	401.73	380.98
	SID-S4	107.35	5782+98	East	2 - 3.5'x3.5'	Saucelito ID	13	386.6	404.59	402.18	380.40
	DEID-56 East	109.46	5894+58	East	1 - 4.5'x4.5'	Delano-Earlimart ID	29	394.3	406.78	403.95	386.45
	DEID-56 West	109.46	5894+60	West	2 - 4.5'x4.5'	Delano-Earlimart ID	110	394.3	406.64	404.02	386.47
	DEID-40 North	111.56	6005+41	East	1 - 4'x4'	Delano-Earlimart ID	22	391.9	405.49	403.00	385.40
	DEID-40 West	111.56	6005+43	West	2 - 4.5'x4.5'	Delano-Earlimart ID	86	392.5	405.16	403.09	385.58
	DEID-40 South	111.96	6031+98	East	1 - 4'x4'	Delano-Earlimart ID	22	398.9	405.33	402.71	392.64
	KTWD-1	112.36	6058+95	West	2 - 4.5'x4.5'	Kern Tulare	42	391.0	404.27	402.15	384.06
	DEID-WR	112.9	6076+77	East	Weir	White River Wasteway Parshall	29	#VALUE!	404.23	402.06	396.88
	KTWD-2	113.6	6112+61	East	1 - Unknown	Kern Tulare WD	52	#VALUE!	403.90	401.70	385.68
	DEID-24 East	113.62	6114+09	East	1 - 4.5'x4.5'	Delano-Earlimart ID	39	391.5	405.46	401.65	383.93
	DEID-24 West	113.62	6114+10	West	2 - 4.5'x4.5'	Delano-Earlimart ID	113	390.6	405.48	401.69	383.10
	DEID-8th West	115.95	6236+79	West	2 - 4'x4'	Delano-Earlimart ID	110	392.7	407.44	401.89	385.82
	DEID-#1 West	116.93	6288+03	West	3 - 4.5'x4.5'	Delano-Earlimart ID	23	395.9	405.53	401.96	388.76
	SSJMUD-Bassett	117.44	6315+39	West	2 - 4.5'x4.5'	SSJMUD	39	399.1	410.78	402.07	402.84
	KTWD-3	117.96	6342+98	East	1 - Unknown	Kern Tulare WD	59	398.6	407.14	401.63	385.74
	DEID-9th West	118.45	6369+07	West	1 - 3'x3'	Delano-Earlimart ID	30	390.8	406.78	401.32	385.09
	LWER	119.55	6425+52	East	4 - 2.5'	Lake Woollomes Equalizing Reservoir		402.0	405.39	Unlined Section	398.03
	SSJMUD-Airport	120.06	6453+98	West	2 - 4.5'x4.5'	SSJMUD Airport and Hiett	82	390.6	405.32	Unlined Section	383.91
	LWER	121.49	6530+32	East	2 - 3'x3'	Lake Woollomes Equalizing Reservoir		395.0	404.91	Unlined Section	389.63

LEGEND AND ABBREVIATIONS

HGL HYDRAULIC GRADE LINE
FLOOR TURNOUT FLOOR ELEVATION
TOB TOP OF EMBANKMENT
TOL TOP OF LINING
TOP OF LINING PER 2018 TOWILL SURVEY
APPROX INVERT
PROPOSED TOP OF LINING
MAX Q HGL
MIN Q HGL
APPROXIMATE EXISTING HGL @ EXISTING Q SHOWN
WSEL OPERATIONAL REQ WSEL @ CHECK STRUCTURE
ESTIMATED REQ HGL @ TURNOUT TO EAST
ESTIMATED REG HGL @ TURNOUT TO WEST

NOTES:

1. TURNOUT ELEVATION SHOWN REPRESENT AN ELEVATION 2' ABOVE THE TOP OF GATE ELEVATION SURVEYED IN 2018.
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3. PEAK DELIVERY FLOW RATE BASED ON HISTORICAL MAXIMUM DAILY DELIVERY RECORDED BETWEEN JANUARY 2003 AND AUGUST 2017.

Figure 3-3. Hydraulic Profile from Deer Creek to Lake Woollomes

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Specific advantages to the turnout delivery pools include the following:

- Operational flexibility – each pool can be designed to meet the needs/concerns of each District
- Flood control – Pools significantly reduces risk of pump station overflow that would not only damage pump stations but flood and damage adjacent land owner property.
- Cost effectiveness – Avoids cost impacts of replacing 9 pump stations on the east side of the canal and modifying 9 pump stations on the west side of the canal, for Alternative 5. Avoids the cost of replacing 7 pump stations on the east and modifying 6 pump stations on the west for Alternative 1.
- Constructability – Since existing turnouts are remaining at pools, sequencing cut overs from new canal to existing turnouts will be more seamless as opposed to having to hard pipe to existing wet wells and take existing turnouts offline one by one.

It is worth noting that the location of the pressurized turnouts often coincided with roadway crossings and the development of the delivery pool concept was also coordinated with the concrete box siphon solution at the numerous roadway crossings.

Construction Constraints

Although a detailed construction constraints and sequencing plan has not been developed for Alternative 1, there are several challenges that will need to be overcome, several associated with the fact that construction will need to occur within the prism of an operating canal:

- Reduction in Water Supply Deliveries – The water surface elevation 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 the earth 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. 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. This will result in extending the construction schedule so that water supply deliveries can be maintained as much as practicable.
- Impacts of Required Borrow – This alternative will require significant borrow, with borrow sources ideally located on each side of the canal to limit hauling over the existing bridges, many of which have load restrictions on them. Depending on the location of borrow sources (which have not yet been identified), constraints on the larger equipment ideally suited to hauling large loads may be imposed.

- Additional Safety Risk During Construction – As compared to Alternative 5 – Parallel Canal, this alternative has a greater risk to construction staff given that the work is within an active water delivery system.

- Tie-ins – With a new check structure, wasteway and siphon planned at Deer Creek, upstream and downstream tie-ins to the existing canal. While this is certainly achievable, tie-ins require appropriate advance planning, reliable concepts, and carry some risk that water supply deliveries would be interrupted during construction.

Chapter 4 Alternatives

This chapter provides a description of the two alternatives. Note that portions of this content can also be found in the Feasibility Report main body Chapter 4 and the Feasibility Report Basis of Design Report attachment to this Appendix.

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 4-1.

Table 4-1. 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 design evaluated as Initial Alternative 5 and incorporates refinements to the alignment, water delivery turnouts, canal cross-section design, road crossings, check structures, utilities, and costs. The design of the Parallel Canal Alternative is based on providing maximum design flow with flood freeboard at the surveyed 2018 land surface. A single-line schematic showing features included in the Parallel Canal Alternative is provided in Figure 4-1A and Figure 4-1B. 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.

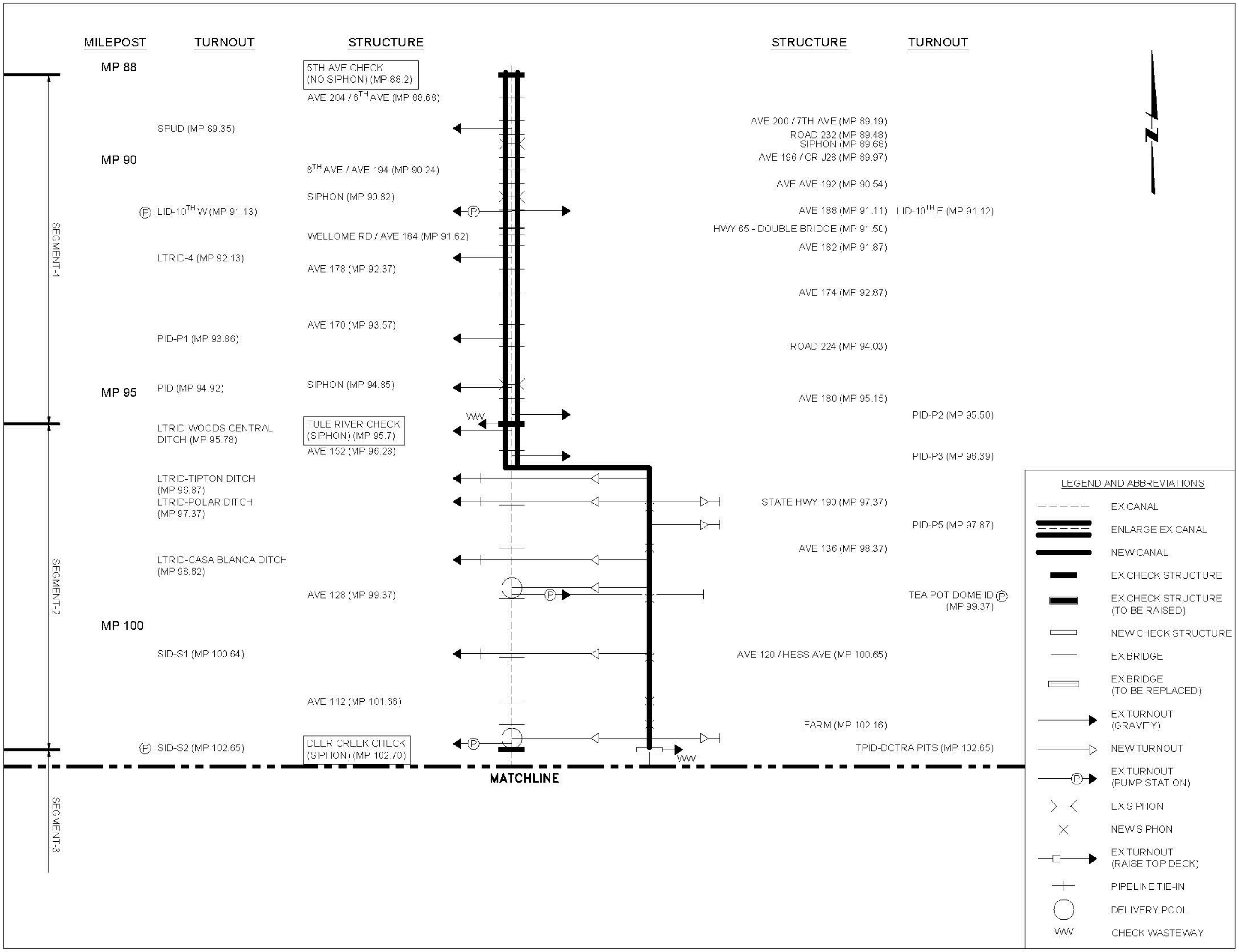

Figure 4-1A. Parallel Canal Alternative Single-Line Diagram of Segments 1 and 2

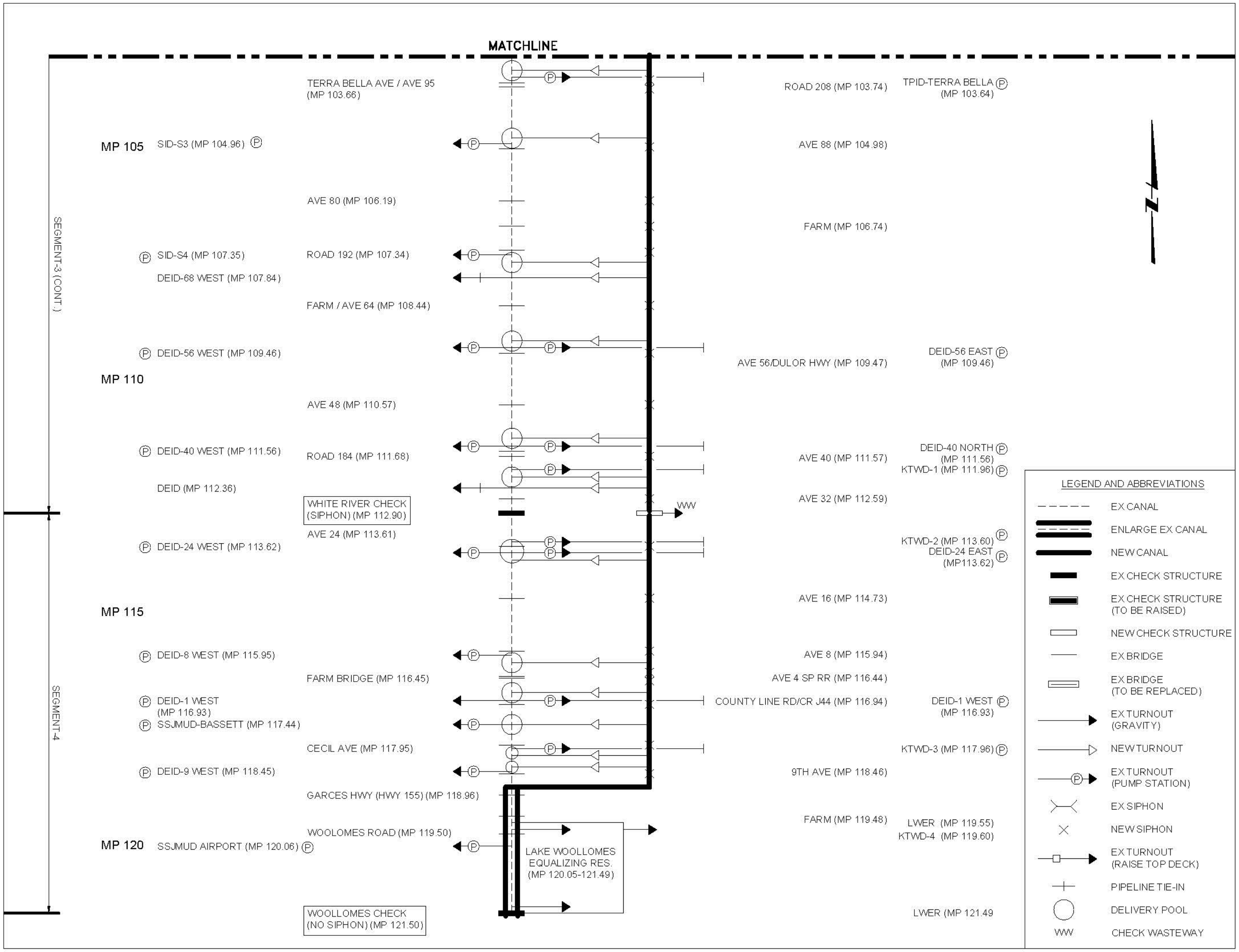

Figure 4-1B. Parallel Canal Alternative Single-Line Diagram of Segments 3 and 4

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 4-2. 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 4-3. 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 4-2.

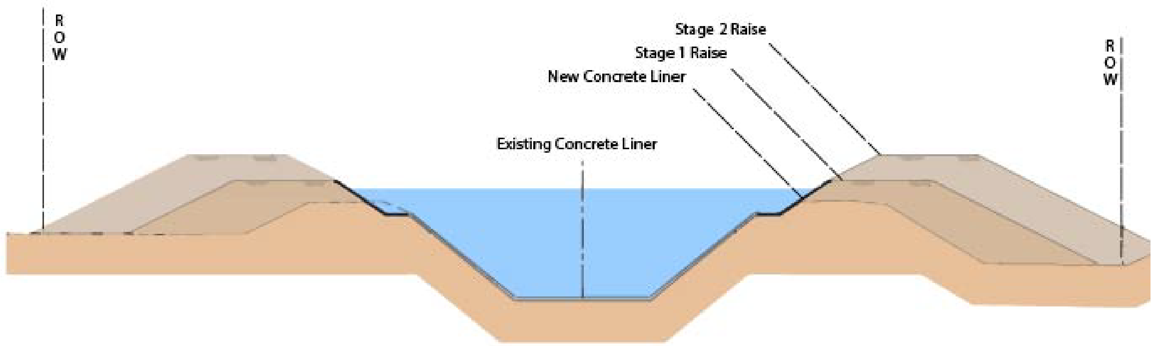

Figure 4-2. Compound Trapezoidal Cross Section in the Parallel Canal Alternative

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.

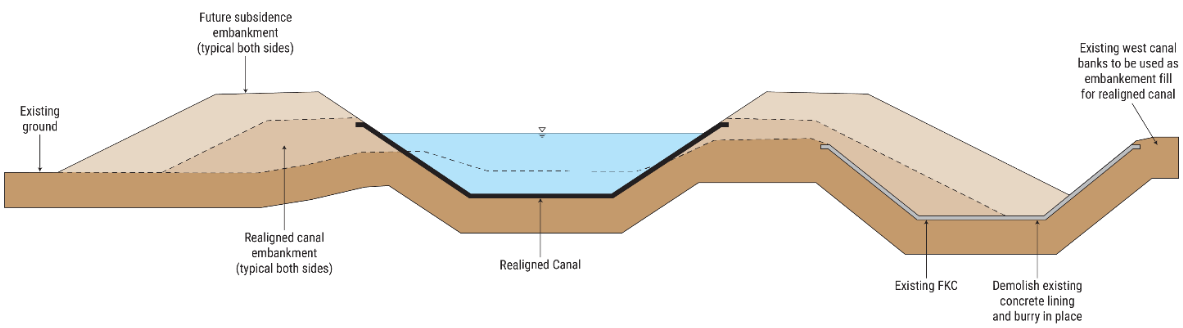

Figure 4-3. Trapezoidal Cross Section in the Parallel Canal Alternative

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. As shown in Figure 3-1, 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 the pump station turnouts in the Parallel Canal Alternative are summarized in Table 4-2.

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 actions for gravity turnouts under the Parallel Canal Alternative is provided in Table 4-2.

Table 4-2. 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	EID-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 4-4. 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 4-5.

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 4-3.

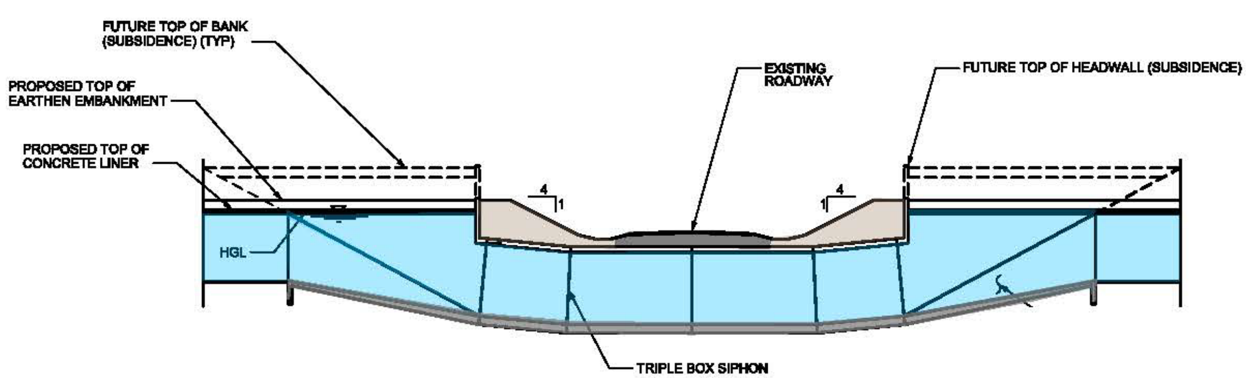

Figure 4-4. Typical Siphon A Road Crossing

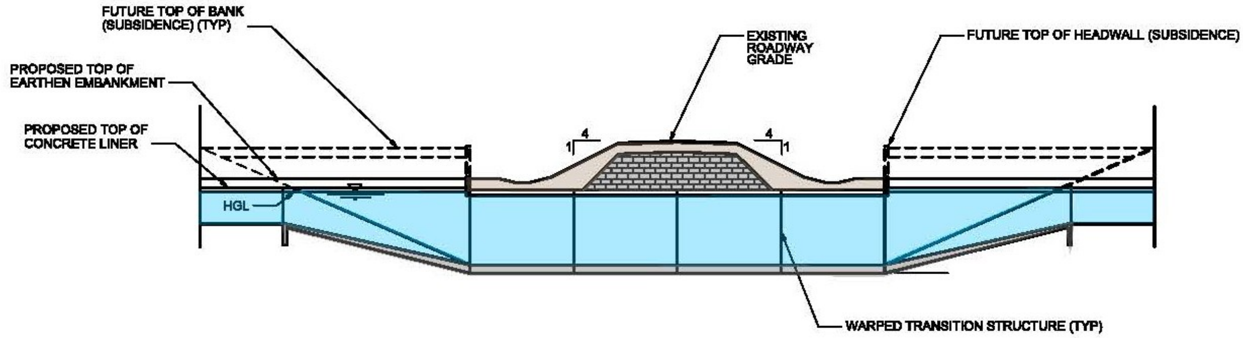

Figure 4-5. Typical Siphon B Road Crossing

Table 4-3. Road Crossing Actions 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

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 4-4. It is expected that additional utilities that would be affected by the Parallel Canal Alternative will be identified as design progresses.

Earthwork Computations and Borrow Source

Digital terrain models were prepared from the aerial surveying conduct in mid-2018. Building Information Model (BIM) using AutoCAD Civil 3D has been utilized to prepare earthwork computations for each canal segment (at 100-foot station intervals) in specific steps on how the canal would be constructed per the sequencing described above. The existing FKC right embankment has been used as a source of borrow material. Computations include earthwork tables (i.e. cut, fill, etc.) and mass haul diagrams.

Estimated Quantities

A list of items that will be included in the summary of quantities and costs is included in Table 4-4.

Table 4-4. 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	0	0	1,319,983	132,437	**1,972,318**
3-1/2" thick concrete lining	SY	384,213	396,505	632,657	366,827	0	**1,780,202**
Ladders	EA	105	99	144	92	0	**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	-	0	1	1	0	0	**2**
Existing Check Structures Demolition and Disposal	-	0	1	1	0	0	**2**
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions to Existing Bridges	EA	18	1	0	0	0	**19**
Bridge Replacement on Existing Canal – County or State Bridges	EA	0	0	0	0	0	**0**
Bridge Replacement on Existing Canal – Farm Bridges	EA	0	0	0	0	0	**0**
Existing Bridge Demolition	EA	0	6	12	8	0	**26**
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	0	6	11	8	0	**25**
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions on Existing Canal to Existing Turnouts	EA	7	2	0	0	3	**12**
Raise/Modify Existing Turnout Top Deck and Actuators	EA	0	0	0	0	0	**0**
Turnouts on New Canal	EA	0	9	8	6	0	**23**
Delivery Pools	EA	0	2	6	6	0	**14**

Table 4-4. 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	0	0	**13**
Pipeline Overcrossing Replacements (8" to 12")	EA	0	1	2	4	0	**7**
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	0	4	7	3	0	**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

Construction Sequencing Description

An initial high-level construction sequencing plan has been developed that will enable the new parallel canal to be constructed while keeping the existing FKC and associated turnouts in operation and using the existing FKC right embankment as a valuable source of borrow material. Table 4-5 below accompanies the sequencing steps shown in Figure 4-6.

Table 4-5. Parallel Canal Construction Sequencing Steps

Step	Description of Activities	Status of Existing FKC
1	Excavate existing FKC left embankment and recompact as compacted embankment. This excavation and recompaction is needed to ensure that a firm foundation for the new lining is provided. Construct a portion of the new west turnouts within this recompacted embankment.	Remains in operation.
2	Excavate material from new canal and combine with material from existing FKC left embankment to construct new canal left compacted embankment. Trim and place concrete lining in new canal section. Construct new east turnouts and connection piping to existing systems. Construct new concrete box siphons at roadway crossings and new Deer Creek and White River checks/wasteways/siphons.	Remains in operation.
3	Place new canal into operation while sequencing connection of new turnouts to existing system. Complete placement of new canal right and left embankment using existing FKC right embankment as borrow source. Decommission existing FKC, with minimal to no removal of old concrete lining (as needed to use borrow source) – to remain with ROW	Removed from operation
4	(Potential Future Subsidence). Construct potential future subsidence embankments using material within FKC ROW.	Not in operation

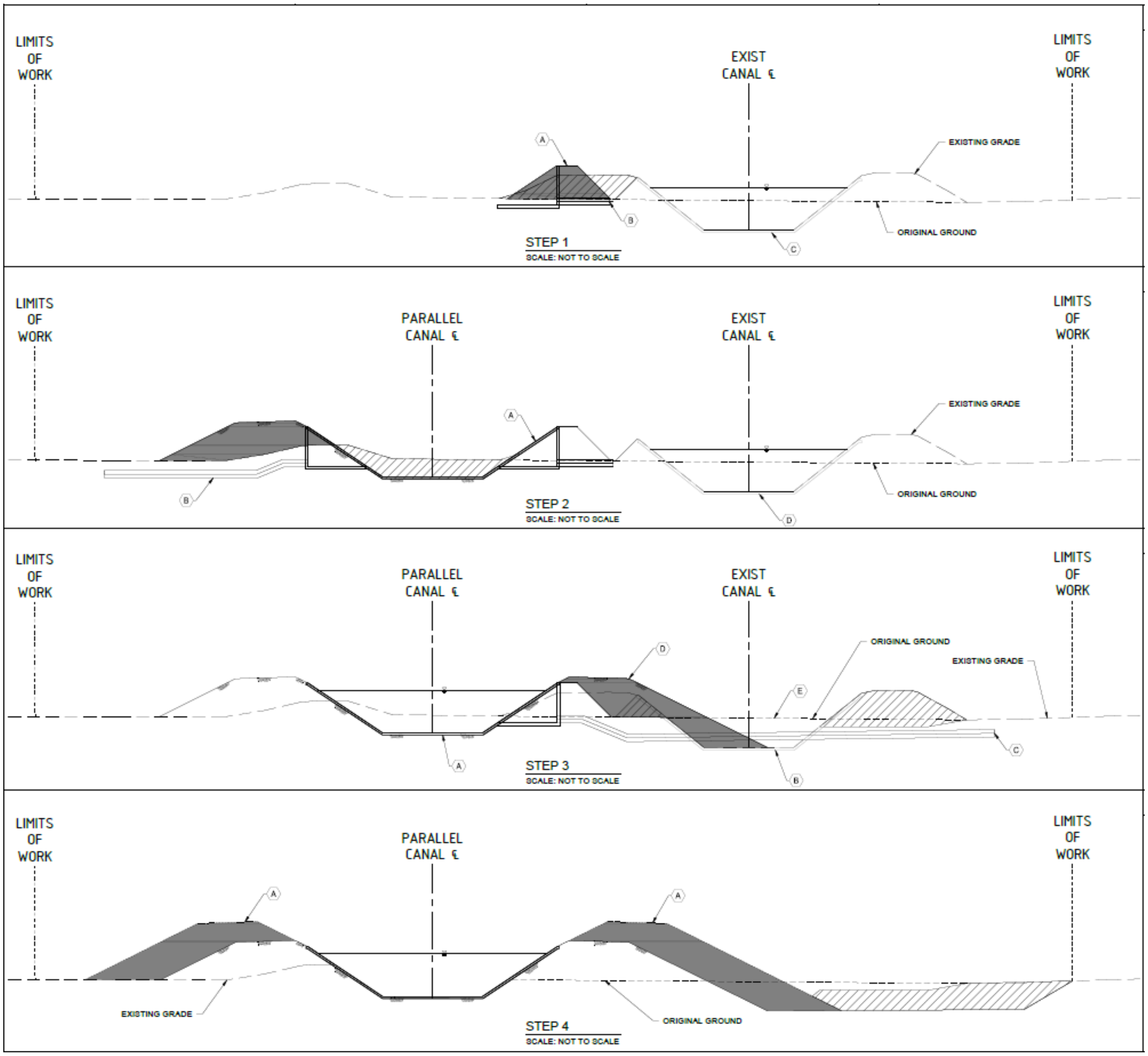

Figure 4-6. Construction Sequencing Steps

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 schematic showing features included in the Canal Enlargement Alternative is provided in Figure 4-8A and Figure 4-8B.

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 4-7.

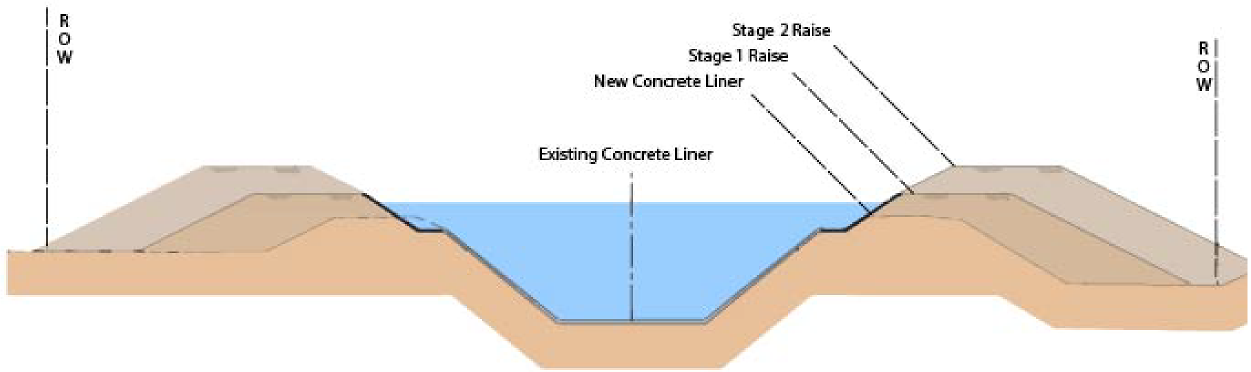

Figure 4-7. Typical Canal Enlargement Cross Section

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.

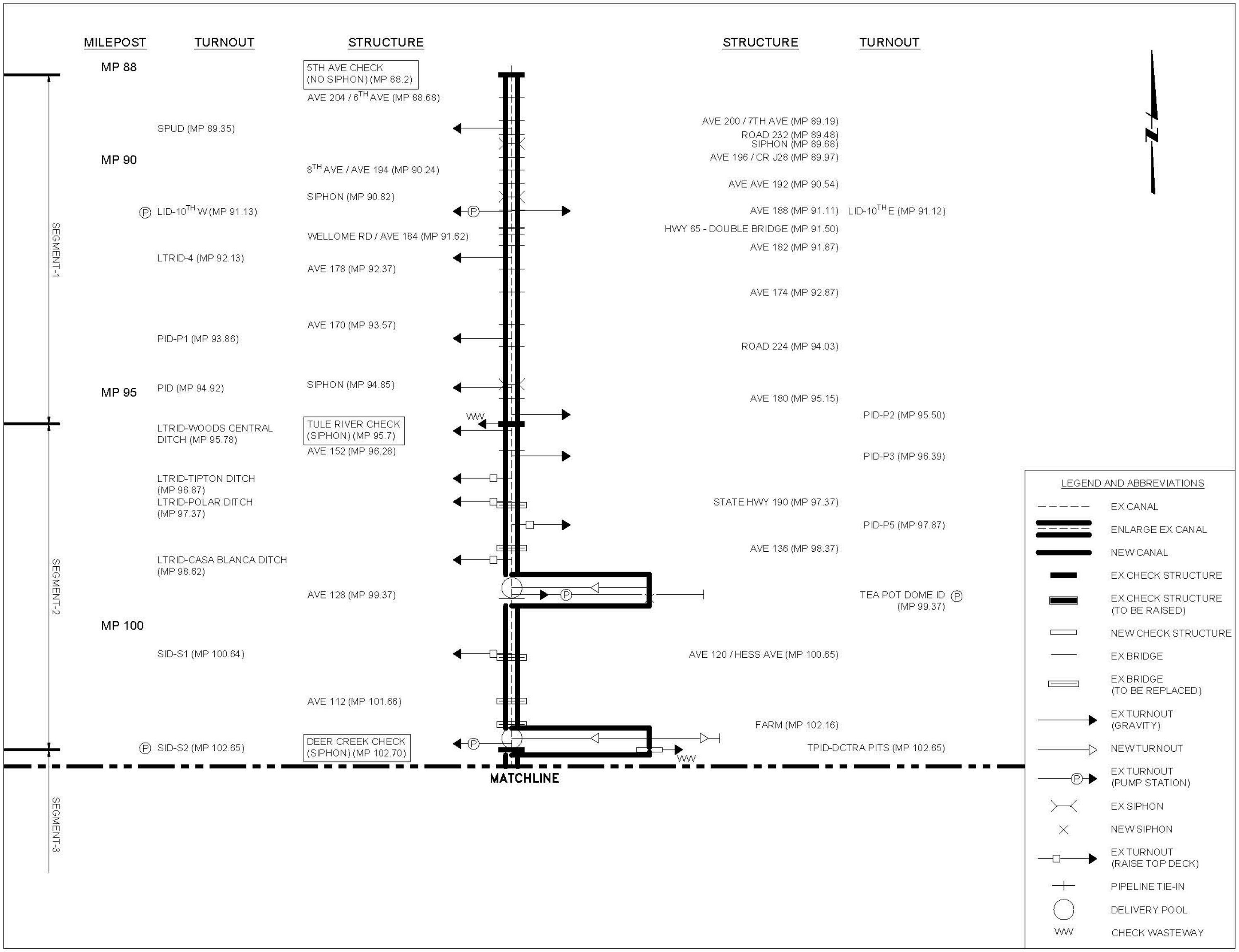

Figure 4-8A. Canal Enlargement Alternative Single-Line Diagram for Segments 1 and 2

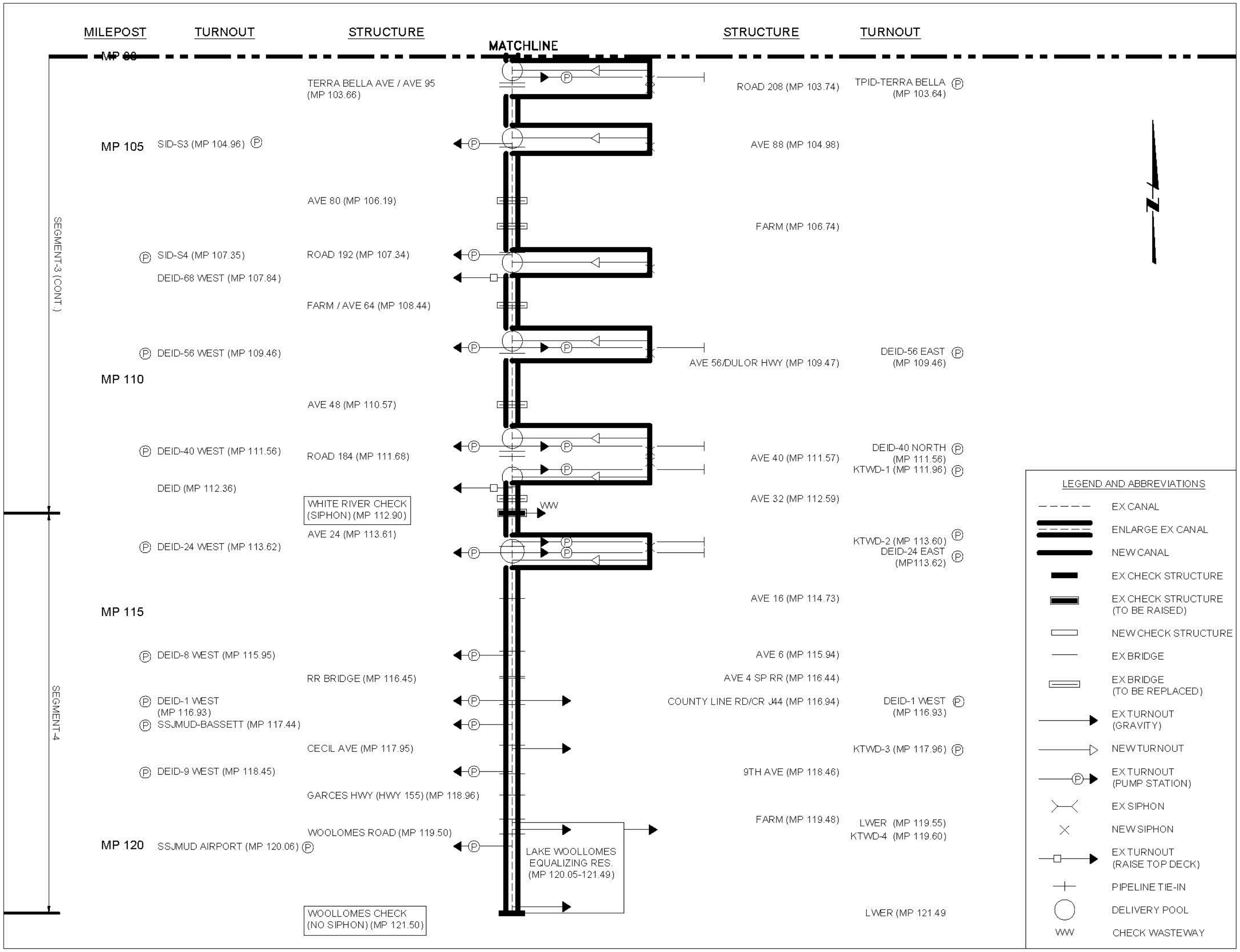

Figure 4-8B. Canal Enlargement Alternative Single-Line Diagram for Segments 3 and 4

As shown in Figures 4-8A and 4-8B, 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 Middle Reach of the FKC 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 3-1. A summary of modifications to pressurized turnouts under the Canal Enlargement Alterative is provided in Table 4-6.

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 4-6 and shown in Figure 4-9. Additional detail is provided in Appendix B Engineering Design and Cost.

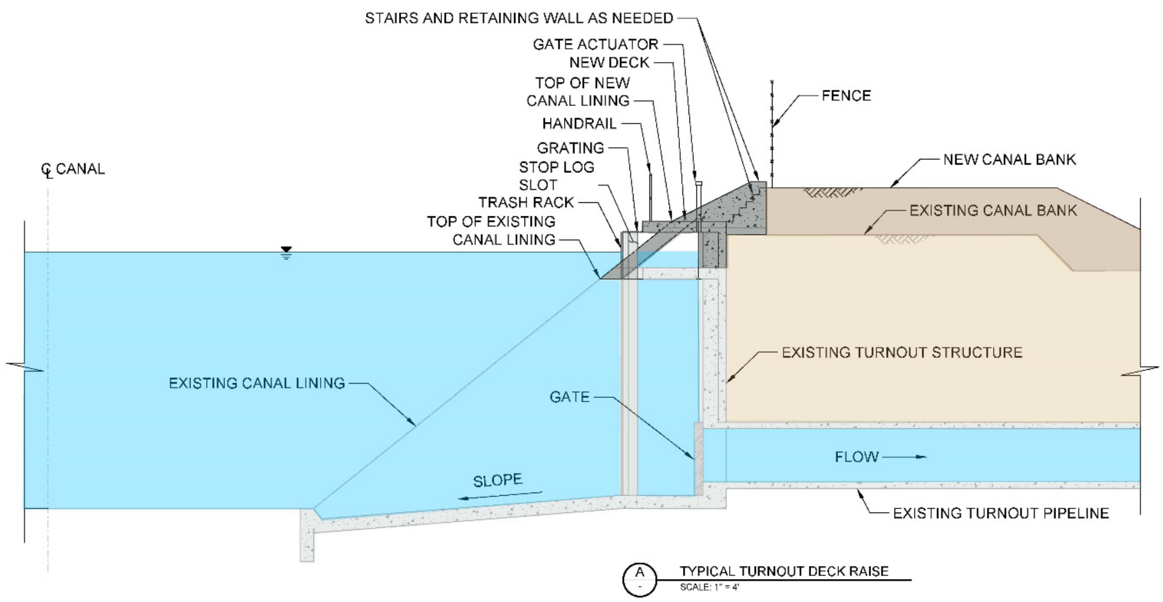

Figure 4-9. Typical Gravity Turnout Deck Raise

Table 4-6. 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	EID-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. A typical section for a trapezoidal bridge is shown in Figure 4-10. 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 4-7.

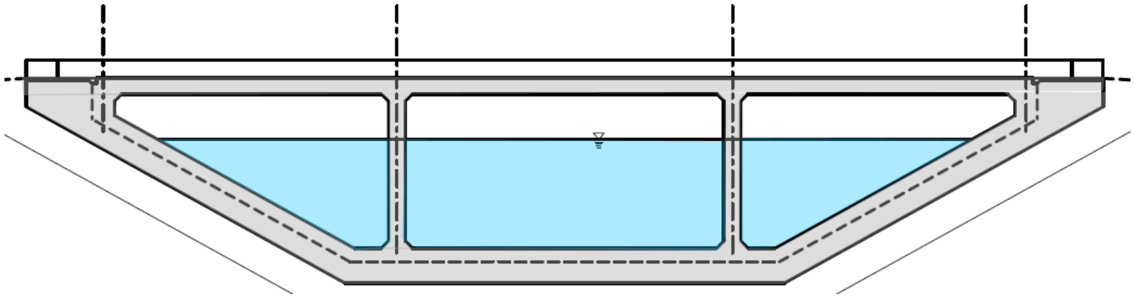

Figure 4-10. Trapezoidal Bridge Concept

Table 4-7. 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

Table 4-7. Road Crossing Modifications in the Canal Enlargement Alternative (contd.)

Segment	Name	Milepost	Modification
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

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.

Earthwork Computations and Borrow Source

Digital terrain models were prepared from the aerial surveying conduct in mid-2018. Building Information Model (BIM) using AutoCAD Civil 3D has been utilized to prepare earthwork computations. No investigations to locate borrow sources have been conducted at this time.

Estimated Quantities

A list of items that will be included in the summary of quantities is included in Table 4-8.

Table 4-8. 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	0	598,777	1,463,932	0	**2,062,709**
Spoil Material (Waste)	CY	716,966	0	0	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	-	0	1	1	0	**2**
Existing Check Structures Demolition and Disposal	-	0	1	1	0	2
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions to Existing Bridges	EA	18	0	1	2	**21**
Bridge Replacement on Existing Canal – County or State Bridges	EA	0	5	5	0	**10**
Bridge Replacement on Existing Canal – Farm Bridges	EA	0	1	2	0	**3**
Existing Bridge Demolition	EA	0	1	7	1	**9**
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	0	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	0	5	2	0	**7**
Turnouts on New Canal	EA	0	3	6	1	**45**
Delivery Pools	EA	0	2	6	1	**9**

Table 4-8. 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	0	**18**
Culvert Extensions (Each End)	EA	4	5	4	0	**13**
Pipeline Overcrossing Replacements (8" to 12")	EA	0	1	2	2	**5**
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	0	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

Chapter 5
Basis of Cost Estimates

Information presented in this Engineering Appendix was developed from prior studies, field reconnaissance, project designs and estimated costs,[1] professional experience with similar studies, and subsequent analysis. This chapter describes the methods and general approach used in developing designs and cost estimates for project features.

Reclamation Cost Estimate Levels

As described in Reclamation's Directive & Standards (D&S) FAC 09-01 (2016), different levels of cost estimates are required to plan and fund projects. As a project moves through its development, each subsequent estimate level reflects increasing detail and refinement of the project features. Reclamation recognizes six different levels of construction cost estimates, as follows:

- Preliminary
- Appraisal
- Feasibility
- Percent Final Design (Updated Feasibility)
- Pre-validation of Funds
- Independent Government (Award and Contract Modifications)

Cost estimates are typically developed in the chronological order shown, and each supersedes the previous estimate. They differ in degree of detail, maturity, refinement, use, and confidence, depending on the amount of certainty regarding the engineering and geological data that are available at the time the cost estimates are prepared. The cost estimates this report are considered to be between Reclamations appraisal level and feasibility level and follow the general methodology as described in FAC 09-01 as the basis for alternative comparison and total project cost budget communication.

[1] [1] Note that the designs and estimated costs presented herein are considered to be between USBR appraisal and feasibility levels. The cost estimating basis is discussed primarily at the appraisal level, with notes included as appropriate to identify limitations and/or exceptions. As project development progresses, additional information will be collected, including geotechnical data, to support advancing project design to a full feasibility level of detail. This note applies to the entirety of Chapter 5.

Appraisal Cost Estimates

Per D&S FAC 09-01:

> *Appraisal cost estimates are used in appraisal reports to determine whether more detailed investigations of a potential project are justified. These estimates may be prepared from cost graphs, simple sketches, or rough general designs that use the available site-specific design data. These estimates are intended to be used as an aid in selecting the most economical plan by comparing alternative features such as dam types, dam sites, canal or transmission line routes, and powerplant or pumping plant capacities*

Feasibility Cost Estimates

Per D&S FAC 09-01:

> *Feasibility-level cost estimates are based on information and data obtained during investigations for pre-authorization activity. These pre-construction investigations (i.e., site-specific data and limited field explorations) provide a sufficient level of information to permit the preparation of preliminary layouts and designs from which approximate quantities for each kind, type, or class of material, equipment, or labor may be obtained. These estimates are used to assist in the selection of a preferred plan, to determine the economic feasibility of a project, and to support seeking construction authorization from Congress. As such, the CCE and PCE will be at the feasibility level when used in support of the request for initial appropriated construction funds.*

AACEI Cost Estimate Maturity

Cost estimating personnel associated with this assignment are certified via the Association for the Advancement of Cost Engineering International (AACEI). As such, reference and documentation of AACEI standards as related to the afore mentioned Reclamation estimating guidance are presented to highlight compatibility and define overlapping nomenclatures.

Per Reclamation practice, feasibility level cost estimates are considered compatible with AACEI Class 3 criteria as defined in their Recommended Practice (RP) 18R-97. The RP outlines a prescriptive cost estimating classification system that relates cost estimate maturity to four criteria: level of project definition, end usage, methodology and level-of-effort. Specifically, the AACEI defines a Class 3 cost estimate as:

> ***Class 3 Estimates*** *are generally prepared to form the basis for the budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument drawings, plot plan, developed layout drawings and essentially complete engineered process and utility equipment lists.*
>
> ***Level of Project Definition****: 10% to 40%*
>
> ***End Usage****: Support project funding requests; serve as the control estimate*

Estimating methodology*: deterministic, high degree of unit priced items utilizing assemblies vs. Detailed individual components.*

Level-of-Effort*: as little as 150 hours to more than 1,500 hours depending on the project scope*

Expected Accuracy Range*: -10% to –20% on the low side; +10% to +30% on the high side*

Note: The expected accuracy range is used to communicate the relative uncertainty inherent in the cost opinion based on the above noted criteria. While the indicated point-value of the cost estimate is considered the expected value, the low and high values express best-case and worst-case conditions respectively. Monte Carlo analysis can be used, if desired, to model the relative probability of all three conditions based on three-point estimating techniques. While high and low range values communicate the underlying range uncertainty to decision makers they are not utilized in any substantive manner in the course of this study.

Alternatives Cost Estimate Methodology

Cost estimates or Opinions of Probable Project Cost (OPPC) presented in this Appendix are developed at an appraisal level. As such, standard facility or structure types, consistent with current engineering principles and practices, were considered and refined to project specific criteria. All design layouts, sections, and dimensions are based on standard practice and experience with similar facilities. The facilities presented in this Appendix are technically viable and constructible based on available information. The following sub-sections will highlight the specific appraisal level methodology for determining costs for the project alternatives under consideration.

Analysis Inputs

The Alternatives OPPCs are based on the following project inputs as shown in Table 5-1.

Table 5-1 Input Information to Alternatives Opinions of Probable Project Cost

No.	Date	Description
1	March 2019	Friant-Kern Canal Alternative Designs/Concepts
2	March 2019	Friant-Kern Canal Alternative Quantity Summaries
3	October 2018	Friant-Kern Canal Alternative Appraisal Level Opinions of Probable Project Cost
4	February 2019	Friant-Kern Canal Plan Formulation Report

Pricing Basis

Pricing reflects the estimator's opinion as to the probable costs that a "prudent" contractor would include in his tender to construct the defined facilities. The OPPC is intended to be an indication of fair market value of a construction project and is not necessarily a predictor of lowest bid. Fair market value is considered to be a mid-range tender considering three or more competitive bids. Finally, OPPC pricing is predicated on the contractor's compliance with all contract specifications and design parameters during field execution activities. The OPPCs do capture allowances for framework costs borne by the owner for pre-construction activities and for expenses related to the management and support of field construction activities.

Costing Methodology

For the Appraisal Level costing study, a detailed crew analysis or “bottom-up" approach for the cost estimate, for developing the pricing of the major civil or earthwork items to better account for known variables (e.g., haul distance, etc.) to override standard database values. Consistent with Class 3 methodology, minor items or undetailed scope was priced using a combination of methods including semi-detailed unit pricing and historical units. Specific quotes were not solicited as material and equipment items are limited and the design basis too early to obtain responsive vendor feedback. Standardized commercial cost estimating databases (i.e., Means, etc.) were not utilized. Historical units were escalated in accordance with the Cost Escalation subsections below. General conditions type expenses were factored off direct costs at 6 percent of running totals.

Scope Quantification

As a major earthworks project, excavation and embankment volumes were calculated using Civil 3D software. Developed earthwork quantities were then plotted relative to project stationing to determine average haul distances per mass-haul diagram techniques. Earthwork embankment quantities were adjusted (increased) by 20 percent to account for compaction shrinkage. When designs were not progressed for certain structures or facilities consistent with feasibility-level definition, relevant go-by designs (e.g., design drawings for the original construction) were utilized to quantify the components on a detailed basis.

Direct Cost Development

Direct costs representing the project’s fixed physical scope are estimated against a work breakdown structure (WBS) to organize the cost estimate details. Software or spreadsheet functionality allows the direct cost detail to be decomposed to multiple sub-levels, which are referred to as item activities or sub tasks. Direct costs are those directly associated with construction activities, and generally consist of the cost of labor, construction equipment and materials required to construct a feature. Management, engineering, contractor’s overheads and other such costs are excluded from the direct cost.

Indirect Cost Development

Indirect costs representing the contractor’s time related variable field management expenses or general conditions costs are typically factored in Class 3 OPPCs in a top-down approach as a function of the running direct cost total. For the OPPCs, indirect costs were “factored” in or considered by adding an allowance expressed as a percentage of the direct cost. The factor selected is based on Stantec’s experience in building up indirect costs for other similar type projects.

Estimate Adders

Estimate add-ons representing the contractor’s allowances for home office overhead expenses, sales taxes, insurance costs, risk provision and fee are added to the cost estimate as a function of running direct costs and are spread back (i.e., prorated) to the established main pay items via factoring. Non-Pay Items are typically organized in a separate account to ensure costs for important support and setup activities are captured and ultimately included as a component of the main item bid prices.

Labor Rate Development

Labor rates are used in the detailed crew analysis direct cost build-up methodology. All-inclusive craft labor rates are built-up from local Davis-Bacon wage determinations to include all applicable fringes (i.e., health and welfare, vacation, training and union dues,) and tax burdens (i.e., workers compensation, payroll taxes). Shift differentials are applied in accordance with expected contractor means and methods and known schedule constraints. Finally, allowances for per-diems are included to account for remote project conditions and the need to attract skilled labor resources.

Equipment Rate Development

Equipment rates are used in the detailed crew analysis direct cost build-up methodology. All-inclusive rolling equipment rates are built-up using depreciation schedules and calculated hourly operating costs. Developed equipment rates are calibrated against published rental rate schedules such as Equipment Rate Blue Book and are adjusted for 80% of the ownership cost. Software functionality allows the default fuel rate to be adjusted to account for fluctuating fuel costs or and overall adjustment of the equipment rate per suspected market conditions.

Cost Escalation

The OPPCs include an allowance for cost escalation for the period of construction. As such, the estimated construction duration is divided by two to provide theoretical mid-point of construction expressed terms of years and then multiplied by a 4 percent (see next subsection's discussion) yearly escalation rate to calculate the allowance.

In keeping with Reclamation practice, escalation from the indicated pricing level (Q1 2019) to the Notice-to-Proceed (NTP) is not included as the duration is currently unknown and not determinable. Reclamation typically requests legislative language be included with Congressional authorization to ensure adequate funding is provided for the planning period leading up to NTP.

California Cost Escalation

The feasibility-level cost estimates include, as mentioned above, cost escalation exclusive to the period of construction. For economic analysis and future project budgeting, a preliminary escalation rate of 4 percent per year is used to calculate the escalation allowance to the estimated midpoint of construction. For the feasibility-level estimate for Alternative 1, a 10-year project duration was assumed, and for the feasibility-level estimate for Alternative 5, a 2.5-year project duration was assumed. Stantec relied on local cost escalation data as opposed to relying on Reclamation's cost trends index to determine the yearly escalation rate. The rational for reliance on localized data vs. standardized data is based on the robust nature of the local data and the variance for which that data supports a higher yearly escalation recommendation.

The preliminary escalation value of 4 percent annual rate of inflation is based primarily on reliance on cost escalation data from the Caltrans Price Index (California Department of Transportation). The Caltrans Price Index demonstrates that California is experiencing price inflation in highway and heavy civil construction infrastructure work above nominal CPI.

Under linear regression techniques, both the Federal Highway Administration (FHWA) California and Caltrans Price indices confirm a fundamental positive shift away from long-term escalation trend lines, beginning in 1999. Figure 5-1 shows FHWA National and California price trends from 1972 to present. Figure 5-1 also shows Caltrans highway construction price trends from 1986 through the present. From these data, expected long-term price trends have been projected through 2027.

While future inflation trends are difficult to predict, new market forces (e.g., higher material commodity pricing, energy costs, lack of competition) will likely continue to have considerable impacts on heavy civil infrastructure construction costs for the foreseeable future. Future studies and coordination should be undertaken to determine the appropriate escalation factor to be used for budgetary approval.

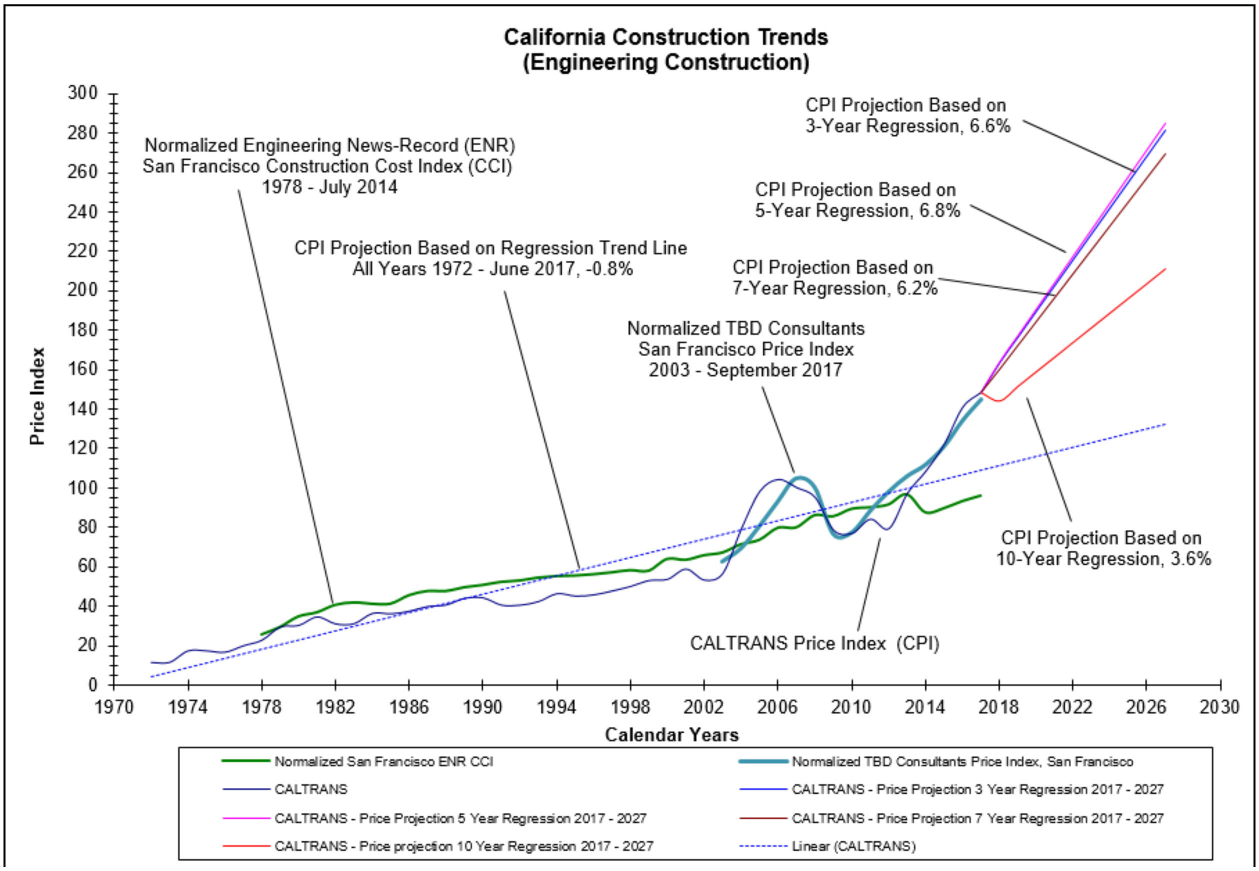

Figure 5-1. California Construction Price Trends (Engineering Construction)

General Estimating Assumptions

The developed OPPCs consider the following general standard estimating assumptions:

- Unlimited construction resources (i.e., agency and contractors)
- Contractor and agency resources are trained and competent

- Competitive market conditions will prevail
- Cash flow will accommodate the contracting strategy
- Stable market conditions will prevail
- Standard industry commercial terms will attach to all procurements
- Normal weather conditions will prevail
- Major natural disasters will not impact the project's critical path (CP)
- New regulatory legislation or EIS/Record of Decision directives will not impact the CP
- Unknown claim issues or procurement protests will not impact the CP
- Unknown legal challenges will not impact the CP
- Contractors will be mobilized once per contract
- Contractor interference issues or traffic impacts will be mitigated
- Staging space will be optimized to maximize concurrent operations
- The chosen contracting strategy will realize competitive conditions

Specific Estimating Assumptions

The developed OPPCs consider the following specific estimating assumptions:

- A 10-year (Alternative 1) and a 2.5-year (Alternative 5) execution duration pending detailed scheduling
- Contractors will be mobilized once per contract
- Davis-Bacon wage rate determination CA20170032
- FWA will acquire pre-construction necessary borrow and spoils pits/areas
- Costs associated with the loss of water due to construction requirement affecting customer deliveries is not included
- Single shift field execution basis (8-10 hours /day)
- Required permitting and land acquisition activities will not delay the CP
- Contractor will take the lead for project QC responsibilities, and the FWA will support (e.g., verify/ validate and/or QA).

- Viable water sources will support construction per required needs
- Annualized capital costs are estimated over 50 years at the current 2.875 percent Federal discount rate (Fiscal Year 2019)

Specific Estimating Exclusions

The developed OPPCs exclude the following:

- Contractor responsibility for dewatering or shutting down existing facilities
- Undefined historical, cultural or environmental mitigations
- Costs escalation from the pricing level to NTP
- Unknown required agency fees and/or inspections

Cost Estimate Allowances

Feasibility-level cost estimates sometimes include an allowance for Associated Procurement Strategies (APS). An APS allowance is used when full and open competition is not expected to be realized for the procurement. Here, the working assumption is that project will not be subject to special Hub Zone, LBE goals, or sole source requirements and will not be using alternative delivery methods. In other words, a conventional contracting strategy of design-bid-build was assumed. Thus, the APS allowance was left at 0 percent of estimated direct costs.

Cost Estimate Contingency Factors

Contingency is a percentage that is applied to the estimated direct cost details to account for unforeseen market conditions and/or scope unknowns. Contingency allocations are generally higher with lower level cost estimates and typically decrease over time with increasing design definition. The feasibility-level cost estimates under this analysis consider two contingency components relative to Reclamation policy: design and construction.

The first contingency component is a ***design*** contingency used to offset scope variations and unknown site conditions. For the feasibility-level cost estimates, the design contingency is applied at 17 percent of direct costs to account for unlisted items, planning phase design and scope changes, cost estimating refinements, and constructability.

Unlisted items include minor undetailed items (e.g., details required for the ancillary facilities to be constructed and/or installed). Design and scope changes include minor new project requirements (e.g., subsurface removals, vineyards, other facilities within the acquired lands). Cost estimating refinements include minor price and quantity variations. Lastly, constructability includes costs associated with known, but currently undefined issues (e.g., temporary roads, dewatering, dust mitigation, winterization, road bypasses during bridge construction and similar costs to support on-going construction operations which will not be paid directly by the owner as in-place work items).

A second contingency component covers ***construction*** related issues or changed field conditions. For these cost estimates, the construction contingency was set at 20 percent of direct costs.

Non-Contract Costs

Non-contract costs include work or services provided by agency personnel, or acquisitions to facilitate project development, such as land acquisition, environmental mitigation, and distributive costs for planning, engineering, design, and construction management.

Engineering, Permitting, and Construction Management

The allowance for planning, engineering, design, and construction management is estimated to be about 10 percent of the field cost.

Environmental Mitigation

NEPA and CEQA require an assessment of environmental impacts of major projects. The environmental impact analyses determine the significance of the impact based on the degree of resource impact in relationship and context of the local and regional resource setting. An impact assessment has not yet been performed; rather the preliminary analysis included as an Appendix to the PFR presents generalized impacts for each alternative. Moreover, potential impacts of other project elements not yet defined could result in additional impacts. These elements include borrow pits, construction staging areas, and installation of construction access roads.

Compensation for habitat losses may include an array of measures including replacement habitat (i.e., preservation of off-site habitat) to compensate for lost ecosystem functions and values. The mitigation value of replacement habitat may be augmented by habitat enhancements, restoration, and creation. Baseline mitigation to offset these losses would likely require habitat replacement at a minimum ratio of 2:1 but may include a ratio as high as 4:1 to fully mitigate project impacts and comply with NEPA and CEQA. The actual ratio employed for any given project is a result of interagency negotiations. Ratios are generally higher for wetland and riparian habitats and habitat for special-status species than it is for general wildlife habitat.

Conceptually, compensation for the loss of upland habitats that have been shown to not support special-status species is likely to be in the range of 2:1 to 3:1. Compensation for wetlands and riparian habitat is more typically in the 3:1 to 4:1 range. The California Department of Fish and Game considers the functional capacity replacement for wetlands and riparian habitats to be 4:1. Habitat for special-status species generally carries at least a 3:1 ratio, but is species dependent.

For these cost estimates, an allowance for environmental mitigation (and which includes cultural resources mitigation) is estimated to be about 5 percent of the field cost.

Legal and Administrative

The allowance for legal and administrative costs is estimated to be about 2 percent of the field cost.

Project Area Lands

To create a value estimate for private lands potentially affected by the FKC alternatives, a geographic information system (GIS) search was used to identify properties potentially affected by each alternative. Parcel information for the affected parcels and comparable sales in nearby counties was obtained.

The project area lands include lands to be acquired in fee for Right of Way including the embankment areas and overflow reservoirs (where applicable), as well as for construction phase activities, including staging areas, borrow pits, and stockpile/dump sites. Values for private lands within or near the project area were estimated to average $30,000 per acre.

Cost Summary Terminology

- Contract Cost = Expected bid tender amount including the design contingency
- Field Cost = Contract cost plus the construction contingency
- Non-contract Costs = Project support costs
- Total Project Cost = Field Cost plus Non-contract costs

Total Annual Costs

The total estimated capital cost was annualized, and estimated annual costs were also included for operations, maintenance, and replacement (OM&R) to obtain the estimated annual cost for each alternative configuration.

Annualized Capital Costs

The total estimated capital costs of each alternative were annualized to facilitate comparison to annual benefits. Total annual costs for each alternative were estimated by interest and amortization of the capital cost over 50 years and at the current Federal discount rate of 2.75 percent (Fiscal Year 2020).

Present Worth Additional OM&R Cost

Estimates for canal OM&R costs were developed for the alternatives. The OM&R costs for the canal represent additional costs resulting from the new structures to be built, on top of FWA's existing annual OM&R budget. All costs were estimated at the September 2018 price level and were estimated by interest and amortization of the total OM&R cost over 50 years at the current Federal discount rate of 2.75 percent (Fiscal Year 2020).

Construction Costs

Tables 5-2 and 5-3 summarize the components of the OPPC including field cost, non-contract costs, total capital cost, annualized capital costs assuming a 50-year project lifespan, and annual costs for operations, maintenance, repair, and replacement for each of the two FKC alternatives. Table 5-4 is a compiled summary of the appraisal-level/Class 4 OPPCs for each alternative. All costs shown are March 2019 price levels. The costs summarized in these tables are based on the worksheets presented in Attachment B.2. Note that the costs have been rounded according to Reclamation guidelines, so the numbers within a table may not directly add up to the total depicted on that table.

Table 5-2. Appraisal-level Cost Estimates for the Parallel Canal Alternative 1

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

Table 5-3. Appraisal-level Cost Estimates for Canal Enlargement Alternative

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		**$460,000,000**	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

Chapter 6 References

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Feasibility Report
Attachment B.1
Feasibility Alternatives Basis of Design Report

Friant-Kern Canal Middle Reach Capacity Correction Project Feasibility Study

Technical Memorandum

Submitted to: Friant Water Authority

November 2019

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Project Friant-Kern Canal Subsidence Correction Project

Subject Feasibility Alternatives Basis of Design Report

Date: March 2019

File: FR_BODR_DRAFT.docx

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Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ac-ft	acre feet
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society of Testing and Materials
AWG	American Wire Gauge
AWS	American Welding Society
BODR	Basis of Design Report
Caltrans	California Department of Transportation
CCR	California Code of Regulations, Title 24
CCTV	Closed Circuit Television
CEC	California Electrical Code
CEQA	National Environmental Quality Act
cfs	Cubic Feet Per Second
CPT	Cone Penetration Test
FKC	Friant-Kern Canal
FWA	Friant Water Authority
ft	Feet
ft/s	Feet Per Second
HGL	Hydraulic Grade Line
HI	Hydraulic Institute
hp	Horsepower
HSS	Hollow Structural Shapes
h:v	horizontal:vertical
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
ksi	Kips Per Square Inch
lbs	Pounds
LiDAR	Light Detection and Ranging
LRFD	Load and Resistance Factor Design
mA	Milliamp
MP	Milepost
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NETA	National Electrical Testing Association

NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
pcf	Pounds Per Cubic Foot
PLC	Programmable Logic Controller (PLC) and
plf	Pounds Per Linear Foot
POE	Power Over Ethernet
Project	Friant-Kern Canal Subsidence Correction Project
psf	Pounds Per Square Foot
psi	Pounds Per Square Inch
PVC	Polyvinyl chloride
RCPP	Reinforced Concrete Pressure Pipe
Reclamation	United States Department of the Interior, Bureau of Reclamation
ROW	Right-of-Way
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison
SSRV	Solid-State Reduced Voltage
TEFC	Totally Enclosed, Fan-Cooled
TOL	Top of Liner
UL	Underwriters' Laboratories, Inc
VAC	Volts of Alternating Current
VFD	Variable Frequency Drive

1. INTRODUCTION

1.1 Purpose

The intent of this Feasibility Report Basis of Design Report is to:

- Present the design criteria that was used as the basis for the preparation of Feasibility-level designs and cost estimates for the Friant-Kern Canal (FKC) Subsidence Correction Project (Project).
- Document the engineering design alternatives developed to support the Feasibility Report.

1.2 Background

The designed conveyance capacity of the FKC has been compromised by various factors since it began operation in 1951. Limitation in the original design, increased roughness in the canal, vegetation, land subsidence, and other issues have all lead to a reduction in capacity. Subsidence, which is the surface expression of compacted land surface, has negatively affected the FKC's ability to convey water because the canal was designed as a gravity conveyance feature. The FKC was designed with a constant fall of approximately 6 inches per mile for its 152-mile journey. The rapid and severe land subsidence in the Corcoran/Tulare Basin area, which underlies a portion of the FKC has caused an estimated 60% reduction in capacity.

In coordination with United States Department of the Interior, Bureau of Reclamation (Reclamation), FWA is developing solutions to address reduced capacity in the FKC, and identified the general objectives of FKC modifications based on the canal reaches (see **Figure 1-1** on the following page) identified below:

Upper Reach – Milepost (MP) 29 (Downstream of Kings River Siphon) to MP 88 (5th Avenue Check): The primary objective is to address capacity reductions resulting from changes in design standards.

Middle Reach – MP 88 (5th Avenue Check) to MP 121 (Lake Woollomes Check): The primary objective is to address capacity reductions that result from subsidence and changes in design standards. This portion of the FKC has an estimated conveyance capacity of 1,900 cubic feet per second (cfs) in a reach that was originally designed for 3,500 cfs.

Lower Reach – MP 121 (Lake Woollomes Check) to MP 152 (Kern River Check): The primary objective is to provide pump back capability to convey water from the Cross-Valley Canal through the lower reaches of the FKC and address capacity reductions resulting from changes in design standards as may be appropriate.

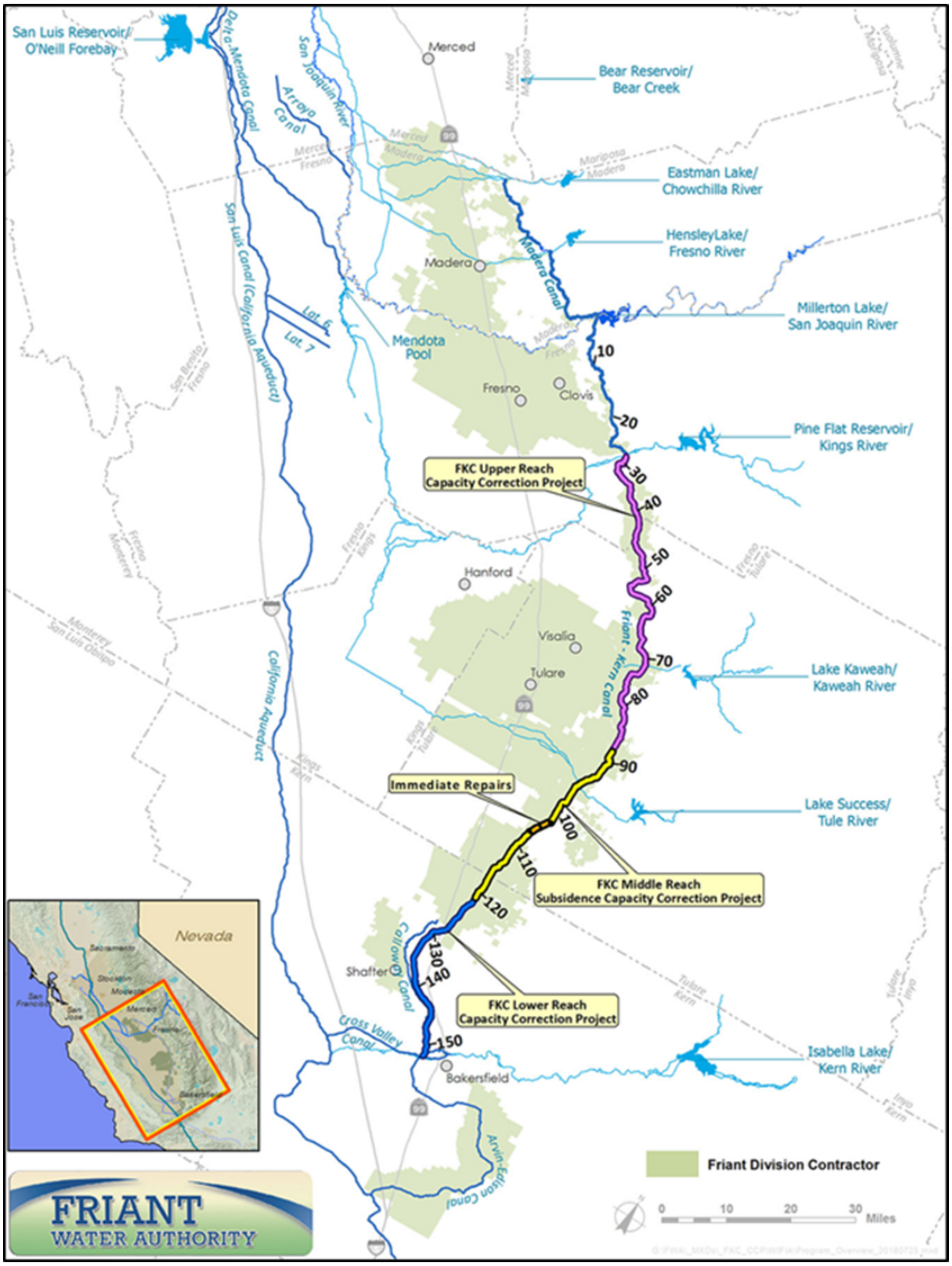

Figure 1-1 - Friant-Kern Canal Capacity Correction Program Map

Work to restore FKC capacity has been divided into four projects that will accomplish the goals and objectives of the Friant-Kern Canal Capacity Correction Program. These projects are separated by location and by the nature of corrective work to be accomplished. All corrective work will increase canal capacity compared with the current condition. Some work (Immediate Repair) has a goal to meet immediate needs with a short-term fix that is not intended as a long-term solution, and other work (Subsidence Correction) has a goal to fix issues directly caused by subsidence. The four projects currently identified to complete the FKC Capacity Correction Program are:

- FKC Upper Reach (MP29 to MP88) – Capacity Correction Project
- FKC Middle Reach (MP103 to MP107) – Immediate Repair Work Project
- FKC Middle Reach (MP88 to MP121) – Subsidence and Capacity Correction Project
- FKC Lower Reach (MP121 to MP152) – Capacity Correction Project

This document addresses only the Subsidence and Capacity Correction Project in the FKC Middle Reach.

1.3 Feasibility Level Drawings

Attachment B.1a to this document provides Feasibility Level Drawings for the two alternatives. Several drawings from **Attachment B.1a** are used as figures in this Basis of Design Report.

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2. DESIGN PARAMETER DEVELOPMENT

2.1 General

This section documents the work done as part of the Initial Alternatives Formulation and draws from Exhibit A.1.a Initial Alternatives Basis of Design Report, to facilitate transparency and communication regarding the establishment of the hydraulic principals and the alternatives design parameter development.

2.2 Friant-Kern Canal Original Design Parameters

It is important to understand the original design parameters to reestablish the original canal function and to establish new boundary conditions for rehabilitation of the subsided canal. The original design of the FKC consisted of seven different canal (geometric) cross sections for its entire 152-mile length. This Subsidence Correction Project is focused on evaluating the original design for the segment of canal from the 5th Avenue Check (MP 88.2) to the Kern River Check (MP 151.8). This segment was designed and constructed with concrete-lined canal Section Nos. 4 through 7 and earthen canal Section No. 2. **Table 2-1** and **Table 2-2** provide geometric data for these canal sections for two design flow scenarios: (1) Normal Design Flow and (2) Max Design Flow. The Normal Design Flow represents the largest planned operational flows. The Max Design Flow represents the largest allowed short-term flow for transfer and release of flood flows captured at cross drainage inlets.

Table 2-1 - Original Design Canal Section Data for “Normal Design Flow”

Canal Data	Design Q (cfs)	Design V (ft/s)	Manning’s n	Bottom slope	B (ft)	d (ft)	Side slope (h:v)	D (ft)	Fb (ft)
Section 2*	2503	2.64	0.020	0.000055	40	14.50	2.00:1		
Section 4	3500	4.32	0.014	0.000082	36	14.66	1.25:1	17.3	2.64
Section 5	2998	4.04	0.014	0.000060	36	14.73	1.25:1	17.5	2.77
Section 6	2502	3.61	0.014	0.000060	30	14.43	1.25:1	17.5	3.07
Section 7	2001	3.44	0.014	0.000060	24	14.01	1.25:1	16.0	1.99

Key:
cfs – cubic feet per second
ft – feet
ft/s – feet per second
h:v – horizontal:vertical

Table 2-2 - Original Design Canal Section Data for "Max Design Flow"

Canal Data	Design Q (cfs)	Design V (ft/s)	Manning's n	Bottom slope	B (ft)	d (ft)	Side slope (h:v)	D (ft)	Fb (ft)
Section 2	3502	2.90	0.020	0.000055	40	17.22	2.00:1		
Section 4	4500	4.61	0.014	0.000082	36	17.04	1.25:1	17.3	0.26
Section 5	3999	4.04	0.014	0.000060	36	17.21	1.25:1	17.5	0.29
Section 6	3502	3.94	0.014	0.000060	30	17.24	1.25:1	17.5	0.26
Section 7	2500	3.64	0.014	0.000060	24	15.73	1.25:1	16.0	0.27

Key:
cfs – cubic feet per second
ft – feet
ft/s – feet per second
h:v – horizontal:vertical

When the FKC was originally designed, Reclamation used the Manning's equation with an "n" value ranging from 0.014 to 0.0143 for the concrete-lined sections. In the 1960's, Reclamation conducted field tests as part of an extensive study of hydraulic losses in about a dozen large concrete-lined canals including FKC. That study concluded that flow resistance in the five largest canals in the study (including FKC) was larger than anticipated. Values of Manning's n computed from the field tests ranged from 0.015 to 0.019 and were about 10% to 25% higher than design values.

A Manning's n-value of 0.016 has been adopted for design of the FKC rehabilitation projects. Applying this n-value (instead of 0.014) to the original canal geometry results in approximately one foot of increased normal flow depth for the Normal Design Flow condition.

2.3 Existing Canal Condition and Immediate Repairs

Present conditions were established based on new survey data, field testing by FWA, and observations and knowledge from operations personnel. These data were used to update and validate the previous version of a HEC-RAS model of the FKC, and to identify areas for immediate repairs. The following existing conditions were quantified:

- Current (subsided) canal invert and top-of-lining (TOL) elevations
- Canal HGL elevation profile for design conditions
- Flow restrictions or limitations

  a. Bottlenecks that restrict capacity

  b. Maximum existing capacities

  c. Existing freeboards

  d. Delivery restrictions

The FKC was originally designed with canal gradients of 0.000082 ft/ft from 5th Avenue Check to Tule River Check and 0.00006 ft/ft from Tule River Check to the canal terminus at the Kern River. Due to subsidence, the elevation profile of the existing canal is now different and lower than the original profile. **Figure 2-1** shows a profile comparison of the existing canal to the original design for the FKC from 5th Avenue to the Kern River. The red lines are the existing data for invert and top-of-lining from the 2018 Towill survey.

From inspection of **Figure 2-1**, it is apparent that a significant portion of the subsided FKC can be rehabilitated to operate as originally designed at a hydraulic grade line that is approximately 1.5 to 2 feet lower and parallel to the original design hydraulic grade lines (i.e. slopes of 0.000082 and 0.00006 for reaches of the canal upstream of Tule River and downstream of Tule River, respectively).

Since the FKC essentially functions as a gravity delivery canal in that its primary deliveries are westerly and downhill into the valley and the valley has generally more subsidence than the FKC, it is anticipated to perform as designed when rehabilitated to operate at full capacity at this slightly lower elevation. Some larger turnouts have a Parshall Flume for flow measurement. Measurement with this type of structure requires availability of significant head. Should any of the turnouts need to be modified, it may be possible to replace them with a more efficient flow measurement structure (e.g. long-throated flume).

Figure 2-2 shows this concept of a lower canal section invert and TOL projected onto the existing condition. Note the line on the graph labeled "Trial Invert" is not an actual canal invert except in lengths along the canal where it is coincident with the current existing invert. It is described later in the report as a "Theorical Bottom" when used as part of the geometry for the alternative to enlarge the existing canal.

Current operations of the canal at the check structure locations along the canal are listed and briefly described below.

- **Tule River Check** – although this check structure has subsided nearly 2 ft, initial data suggests that it is capable of maintaining a checked water surface sufficient to make all upstream turnout deliveries at full normal design capacity under all flow conditions. This will require confirmation during the final design phase of the selected alternative.
- **Deer Creek Check** – this facility is normally operated with the radial gates in a "full checked" state in order to maintain upstream deliveries.
- **White River Check** – Due to subsidence, the White River Check is operated with its radial gates fully opened and raised out of the water. The structure is not currently used for flow control.
- **Lake Woollomes Check** – the Lake Woollomes Check forms the boundary where the flow control method changes. The FKC automated water level control above this check structure is "upstream controlled" while FKC flow control below this check structure is "downstream

controlled". This facility must be operated to hold a minimum water depth of 14 ft to maintain upstream deliveries.

- **Poso Creek Check** – this check structure is normally operated with the radial gates out of the water. The configuration of this check and siphon as originally designed and constructed appears to include an error in the HGL. As a result, the structure introduces up to one foot or more upstream water level necessary to overcome losses through the structure. In that regard, it includes an element of "self-checking" even with the gates out of the water.
- **Kern River Check** – a depth of 14 feet is normally maintained at this canal terminus check structure.

2.3.1 Subsidence Low Point

The subsidence-related "low point" exists in an approximate two-mile length of the canal starting at approximately MP 104. This length of canal restricts flow and creates levels that are detrimental to the Friant Division long-term contractors. This is an area that will be addressed in the immediate repairs project.

2.3.2 Existing Bridges that Require Correction – Located in Middle Reach

Approximately nineteen bridges located between MP 96 and MP 114 must be raised, modified, or replaced.

2.3.3 Subsidence near Kimberlina Road

Although beyond the current project area, the length of the FKC between the Poso Creek Check and the Shafter Check (MP 130 to MP 138) has subsided greater than 2 ft. This area will require additional subsidence correction at some point in the future when capacity correction is undertaken for the lower section of the FKC. This will also require raising or replacing four or five bridges.

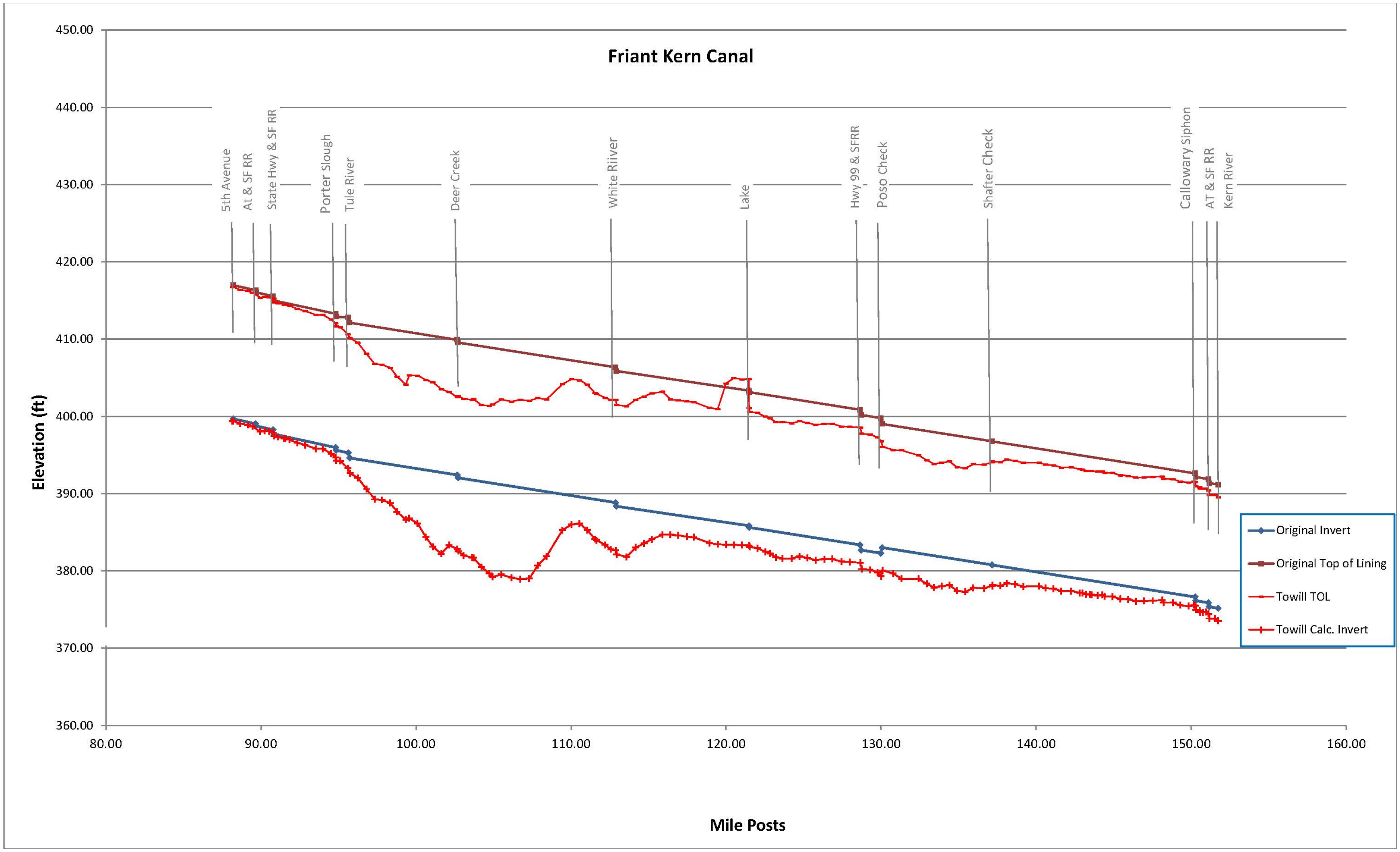

Figure 2-1 - Profile of Existing Canal vs. Original Canal

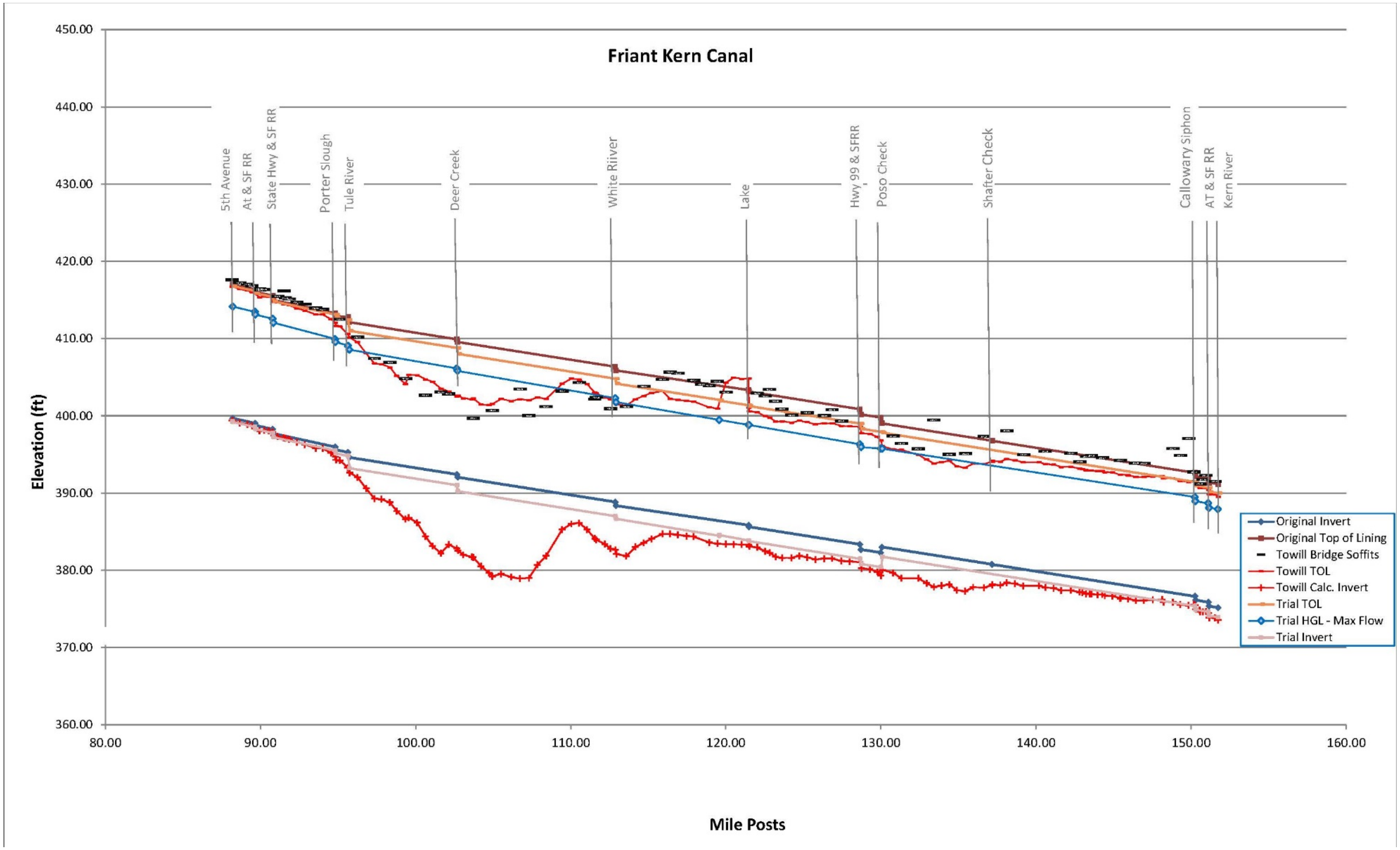

Figure 2-2 - Profile of Existing Canal, Original Canal, and Proposed Rehabilitation

2.4 Boundary Conditions and Other Design Parameters

When designing either a new canal or modifications to an existing canal, the first step is to clearly identify the boundary conditions. Boundary conditions are not always apparent and can change significantly with relatively minor changes to the facility or operations. Therefore, evaluation of boundary conditions during the FKC Subsidence Correction design should consider both the currently existing condition and potential changes that could occur after implementation of the project (e.g. subsidence). Key boundary conditions, elevations, and depths are shown in **Table 2-3**.

Table 2-3 - Boundary Conditions, Elevations, and Depths

Location	Design Invert Elevation (ft)	Current Invert Elevation (ft)	Present Subsidence Amount (ft)	Design Water Depth (ft)	Design Water Surface Elevation (ft)	Target Water Surface Elevation (ft)
5th Ave Check Outlet Transition	399.67	399.38	0.29	14.66	414.33	414.43
Tule River Inlet Transition	395.28	393.27	2.01	14.66	409.94	410.05
Tule River Outlet Transition	394.62	392.63	1.99	14.73	409.35	408.71
Woollomes Check Inlet Transition	385.84	383.3	2.54	14.43	400.27	399.13
Kern River Check Inlet Transition	375.17	373.55	1.62	14.01	389.18	387.92

Key:
ft – feet

2.4.1 Available Head

Quantifying the available head is an important first step in evaluating trial canal designs. From **Table 2-3** above, the original design consisted of **25.15 feet** of water surface change from the 5th Avenue Check to the Kern River Check. Note that the design gradient for normal flow in the canal pools consumes most of this available head differential as follows:

- 38,492 ft of canal pools at 0.000082 ft/ft = 3.15 ft
- 293,596 ft of canal pools at 0.00006 ft/ft = 17.62 ft
- Total for canal pools 20.77 ft

This leaves **4.38 ft** for all other losses. Using the values shown in **Table 2-3** for the current enlargement design, the remaining (after subtracting the same 20.77 ft for pool gradients) is **5.74 ft**. However, the current design must account for new losses resulting from canal constrictions at existing bridges, the large turnouts, and potentially new bridge/culverts. Thus, the head available for use in structure losses must be carefully managed.

2.4.2 HGL Required at Lake Woollomes Check – Key "Balance Point"

A water surface control elevation of **399.13 ft** was established on the upstream side of the Woollomes check structure. This elevation is the key balance point for the system. This elevation can be held without significant modifications to the existing Lake Woollomes Check or the Lake Woollomes Regulating Reservoir.

As a result of analysis, this level was chosen for the following reasons:

- This HGL elevation of 399.13 ft is 1.14 ft lower than the original design water surface elevation at Woollomes. There has been 2.54 ft of subsidence at that location, so the control elevation of 399.13 is 1.4 ft higher than the original level relative to canal invert. Thus, the normal depth at the Lake Woollomes check will also be 1.4 ft higher than the normal depth shown for the original design.
- The additional 1.4 ft of relative HGL provides valuable head to supply flow downstream to Kern River in the future.
- This HGL also significantly reduces cost in the canal upstream from Woollomes by maintaining water levels throughout the Middle Reach that reduced canal cost (e.g. new canal size, enlarged canal size, and/or pump head).
- This HGL permits full use of regulatory storage in Woollomes Reservoir, which is a major benefit to canal operations.

2.4.3 Conditions and Requirements in the Upper Reach

The following conditions were required upstream from the Tule River Check Structure:

- Correction alternatives for the Middle Reach must not create negative effects in the Upper Reach.
- For all flow conditions studied, the resulting HGL upstream from Tule River needed to meet design criteria for conveyance capacity, delivery criteria, freeboard, and flow velocity.
- A water surface control elevation of 410.05 ft was established on the upstream side of the Tule River check structure.
- Because the large subsidence between Tule River and White River created an enlarged canal section (see **Section 5** below), the HGL at Tule River remained low enough to meet requirements in the Upper Reach.
- Some excess head was available at Tule River for most of the design alternatives, allowing the Tule River check gates to be less than wide open while creating a checked water surface at elevation 410.05 ft. Further design optimization may be able to lower cost by reducing the excess head at Tule River.
- The target elevation for the 5th Avenue Check is 414.43 ft which will match and not impact upstream reaches. It is noted that Reclamation has evaluated capacity improvements for the

FKC from M.P. 28 to M.P. 88. Holding this target elevation may provide opportunities reevaluate Reclamation's preliminary design to reduce costs for upstream improvements.

2.4.4 Conditions and Requirements in the Lower Reach

The following conditions were required downstream from the Lake Woollomes Check Structure:

- Subsidence in the Lower Reach from Woollomes to Kern River has been relatively uniform, so a future enlargement solution should have a uniform change in the HGL elevation profile.
- A water surface control elevation of 387.92 ft was established on the upstream side of the Kern River check structure.
- This control water surface is 1.26 ft lower than the original design water surface elevation and there has been 1.62 ft of subsidence in the area. Therefore, relative to the canal invert, the control elevation of 387.92 ft is 0.36 ft higher than the original level. Thus, the normal depth at the Kern River check will also be 0.36 ft higher than the normal depth shown for the original design.
- The new control elevation provides additional head for increased flow capacity through the turnouts located near the Kern River.
- This boundary condition improves the feasibility to increase capacity to Kern River, but details of an enlarged design from Woollomes to Kern River are left for future work.

2.4.5 Bridges and Related Hydraulic Losses

Due to the number of affected bridges and the potential costs of newly constructed bridges the total project cost will be influenced by the decision to modify, raise, or replace bridge structures. Evaluation of alternative designs included the following issues related to bridges:

- Minimize bridge replacement and raises
- Develop efficient designs for replacement bridges:
    a. trapezoidal culvert bridge
    b. build new bridges wide enough for future maximum flow and subsidence conditions
- Establish criteria for freeboard clearance between water surface and bridge girders
- Establish criteria for bridge tie-ins, widening, transitions, and hydraulic losses
- Determine which bridges should be replaced for each flow condition and design alternative

Trapezoidal bridge structures show promise to be a cost-effective replacement choice. This design is a trapezoid-shaped culvert structure designed for bridge loading. The structure can flow full with top seal inlet submergence, with headwalls to contain upstream canal water levels above the roadway elevation. This design would permit a bridge to withstand future subsidence with minimal cost for modifications. The bridges will be designed with more flow area than that of the canal immediately upstream and downstream from each new bridge to minimize head losses should the bridges become submerged due to future subsidence.

Criteria may yet need to be clarified for the minimum allowable clearance between existing bridge substructures and the maximum water surface level. Logically, these criteria should vary for different bridge designs and different types of road crossing. For the purpose of this Feasibility-level design alternative analysis, it was assumed that minimum bridge level for **existing** bridges would equal top-of-lining level.

2.4.6 Siphons and Related Hydraulic Losses

Hydraulic losses through siphons were evaluated and updated to improve accuracy compared with original design values. The original design of the Poso Creek Siphon did not correctly balance head loss across the siphon with the change in water surface elevation from the upstream canal to the downstream canal. For the normal flow condition with 2,000 cfs through the siphon, head loss through the siphon should be about 0.6 ft. Existing downstream canal invert is 0.73 ft higher than the upstream canal invert, so upstream canal depth needs to be 1.33 ft greater than downstream canal depth. Original design depths were 14.43 ft in the upstream canal and 14.01 ft in the downstream canal, so there is an error of 0.9 ft in the original design. Depth in the upstream canal needs to be 0.9 ft higher than the original design value to get 2000 cfs through the siphon.

With the present "new normal" condition, flow through Poso Creek Siphon will be 2,500 cfs. This will create a head loss of 0.9 ft across the siphon, so depth in the upstream canal must be 1.63 ft greater than downstream canal depth. Hydraulic analysis explored the effect of replacing Poso Creek Siphon with an open flume to eliminate siphon loss. Cost associated with a replacement structure would be offset by savings in the canal upstream, such as from fewer bridge modifications and reduced canal enlargement, so the possibility of replacing Poso Creek Siphon should be explored as the design progresses.

At most of the other siphons in the middle reach, head loss estimated in the original design appears to be appropriate or even a little on the conservative side for the original normal flow condition. However, increasing the flow rate to the "new normal" flow through siphons will increase head losses and require that head be conserved elsewhere.

2.4.7 Hydraulic Losses at Transitions

A significant portion of the total head loss through the project area occurs in open channel transition structures at bridges, siphons, and check structures. Generally, these structures are a type classified as *straight warp transitions*. However, the length-to-width ratio for convergence and divergence varies from structure to structure. Based on historical data and Reclamation design criteria references, transition head loss coefficients are estimated as follows:

Converging (inlet) transitions: C = 0.15 to 0.25

Diverging (outlet) transitions: C = 0.2 to 0.35

Where: Head Loss = C * $(V1-V2)^2$

(V1 and V2 are flow velocities upstream and downstream from transition)

For preliminary analysis and design, a reasonable conclusion is to use ***C=0.2 for converging transitions*** and ***C=0.3 for diverging transitions***. As the level of design progresses, individual transitions can be analyzed and specific transition lengths can be used to develop more precise coefficient values.

2.4.8 Common Hydraulic Grade Line

All project alternatives were modeled with a common hydraulic grade line. Maintaining the common HGL that has been established is important in order to meet the required boundary conditions but, it also allows considerable flexibility to interchange measures within alternatives for economic and/or sequencing benefits.

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3. ALTERNATIVES CONSIDERED IN THE FEASIBILITY REPORT

3.1 Initial Alternatives Formulation Development

Appendix A – Initial Alternatives Formulation documented the development and evaluation of seven alternatives listed in **Table 3.1** below.

Table 3-1 - Initial Alternatives Formulation Report Alternatives

Alternative Number	Description
1	Canal Enlargement
2	Pump Station at Milepost 109
3	Pump Station at Woollomes
4A	Bypass Canal from Tule River to White River
4B	Bypass Canal from Tule River to Woollomes
5A	Parallel Canal from Tule River to White River
5B	Parallel Canal from Tule River to Woollomes

3.2 Capacity Alternatives [Revised]

Alternatives 1 and 5 (combined 5A and 5B) were retained for further analysis and additional evaluations were performed for these two alternatives to explore potential opportunities for project sequencing, or phasing under different criteria. Sequencing refers to both the ability to phase construction by segment or further increase the capacity of constructed improvements at some time in the future. The four options below represent a range of design capacities to which the FKC could be restored, ranging from historical deliveries to maximum flow capacity:

- Option 1 – Maximum Historical Flow with Flood Freeboard;
- Option 2 – Design Normal Flow with Standard Freeboard;
- Option 3 – Design Maximum Flow with Flood Freeboard; and
- Option 4 – Design Maximum Flow with Standard Freeboard.

Table 3-2 provides a summary of these four options for Alternatives 1 and 5. Alternative 1, Canal Enlargement – Option 1 and Alternative 5, Parallel Canal – Option 3 are the two alternatives selected by FWA for further evaluation and development.

Table 3-2 - Alternatives Summary for Four Options

Alternative Features by Segment		Alternative 1 - Canal Enlargement				Alternative 5 - Parallel Canal			
Segment	Feature	Option 1 Historical Max Flow Flood Freeboard	Option 2 Design Normal Flow Design Standard Freeboard	Option 3 Design Max Flow Flood Flow Freeboard	Option 4 Deisgn Max Flow Design Standard Freeboard	Option 1 Historical Max Flow Flood Freeboard	Option 2 Design Normal Flow Design Standard Freeboard	Option 3 Design Max Flow Flood Flow Freeboard	Option 4 Deisgn Max Flow Design Standard FB
Segment 1 5th Ave. to Tule River	Design Flow (cfs)	4,008	3,500	4,500	4,500	4,008	3,500	4,500	4,500
	Design Freeboard (ft)	1.12	2.23	1.12	2.35	1.12	2.23	1.12	2.35
	Canal Cross Section			Widen and Raise FKC	Widen and Raise FKC			Widen and Raise FKC	Widen and Raise FKC
	Length of New or Modified Canal (miles)			7.40	7.40			7.40	7.40
Segment 2 Tule River to Deer Creek	Design Flow (cfs)	3,497	3,000	4,000	4,000	3,497	3,000	4,000	4,000
	Design Freeboard (ft)	1.08	2.15	1.08	2.29	1.08	2.15	1.08	2.29
	Canal Cross Section	Raise FKC	Raise FKC	Widen and Raise FKC	Widen and Raise FKC	Parallel Canal	Parallel Canal	Parallel Canal	Parallel Canal
	Length of New or Modified Canal (miles)	6.90	6.90	6.90	6.90	6.92	6.92	6.92	6.92
Segment 3 Deer Creek to White River	Design Flow (cfs)	2,888	3,000	4,000	4,000	2,888	3,000	4,000	4,000
	Design Freeboard (ft)	1.08	2.15	1.08	2.29	1.08	2.15	1.08	2.29
	Canal Cross Section	Raise FKC	Raise FKC	den and Raise FKC	den and Raise FKC	Parallel Canal	Parallel Canal	Parallel Canal	Parallel Canal
	Length of New or Modified Canal (miles)	10.20	10.20	10.20	10.20	10.16	10.16	10.16	10.16
Segment 4 White River to Lake Woollomes	Design Flow (cfs)	2,490	2,500	3,500	3,500	2,490	2,500	3,500	3,500
	Design Freeboard (ft)	1.03	2.06	1.03	2.23	1.03	2.06	1.03	2.23
	Canal Cross Section		Raise FKC	Widen and Raise	Widen and Raise		Parallel Canal	Parallel Canal	Parallel Canal
	Length of New or		6.50	6.50	6.50		6.52	6.52	6.55

From this point forward these two alternatives will be referred to as Alternative 1 – Canal Enlargement and Alternative 5 – Parallel Canal. The following sections provide descriptions of these alternatives. Sections 3.4 and 3.5 summarize project features and design concepts that are applicable to both Alternative 1 and 5. Sections 3.6 and 3.7 are specific to Alternatives 1 and 5 respectively.

3.3 Canal Hydraulic Grade Line and Water Supply Deliveries to Turnouts [Revised]

As described in Section 2, a common hydraulic grade line (HGL)was established for the FKC that meets the required boundary conditions with upstream and downstream reaches of the FKC**.** This modification to the current HGL required investigations into the capability of the 39 turnouts within the project area to provide needed water supply deliveries; with minimum and maximum water surface elevations needed to ensure operational compatibility with the planned alternatives. The turnouts vary in size and configuration, supplying water to both gravity and pressurized systems, with the pump stations for the pressurized type systems mostly located immediately adjacent to the FKC. It is worth noting that the distribution systems served by the FKC turnouts have likely subsided different amounts than the FKC, that could lead to distribution systems being subjected to different (i.e. higher) head conditions to that which was originally planned. **Figures 3-1** and **3-2** provide HGLs for a range of operating conditions (i.e. approximate existing HGL, minimum flow and maximum flow) along with detailed information on the turnouts.

The water surface elevation of the design HGL would be above the top deck of many existing pump station turnouts and could result in overtopping of the existing pump wetwell decks, resulting in uncontrolled flooding of adjacent lands. Additionally, the increased head on existing distribution systems may cause over pressurization and result in pipe joint failures. The proximity of existing pumping stations to the FKC also presents design challenges, given that potential relocations of this type of infrastructure could lead to significant construction costs.

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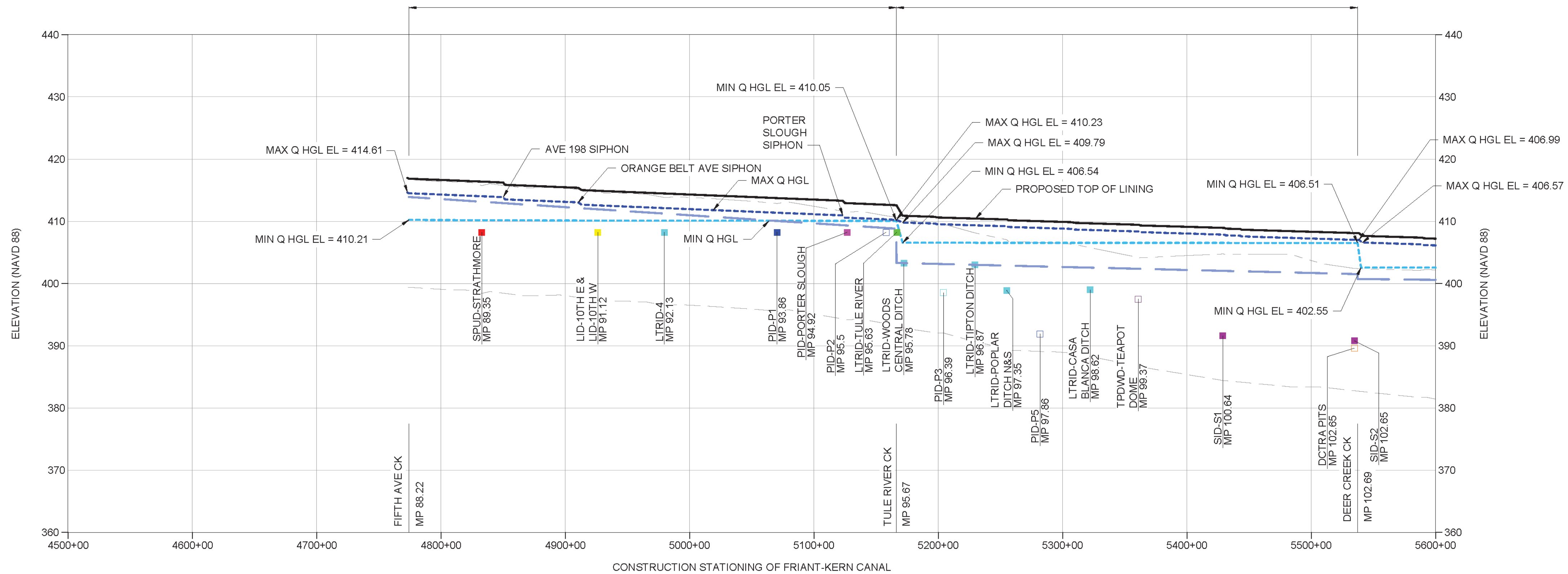


	FKC - EXISTING TURNOUTS											
	Color Code	T/O ID	Location			No of Gates and Sizes	Receiving Contractor	Peak Delivery (3)		Physical Elevations		
			Mile Post	Const STA	Direction			Q (cfs)	HGL	TOB	TOL	Floor
✳		SPUD-STRATHMORE	89.35	4832+85	West	1-20"	Strathmore New SPUD	3	408.2	419.98	415.73	
✳		LID-10th E	91.12	4926+17	East	4'x4'	Lindmore ID	22	408.2	418.32	414.41	
✳		LID-10th W	91.12	4926+17	West	2 - 4.5'x4.5'	Lindmore ID	72	408.2	418.21	414.55	
✳		LTRID-4	92.13	4979+67	West	2 - 7'x7'	Lower Tule River ID	557	408.2	418.20	413.82	
✳		PID-P1	93.86	5070+41	West	2 - 4.5'x4.5'	Porterville ID, Castle Ditch	25	408.2	416.38	412.84	
✳		PID-Porter Slough	94.92	5126+75	West	2 - 5'x5'	Porter Slough	52	408.2	415.58	411.50	
✳		PID-P2	95.5	5157+99	East	1 - 4.5'x4.5'	Porterville ID	32	408.2	415.25	410.87	
✳		LTRID-Tule River	95.63	5166+77	West	Weir	Tule River Wasteway Parshall	764	408.2	414.20	410.60	
✳		LTRID-Tule River	95.64	5166+77	West	4 - 11'x10.75'	Tule River Wasteway		408.2	414.20	410.60	
		LTRID-Woods Central Ditch	95.78	5172+34	West	3-4'x4'	Lower Tule River ID, Wood Central Ditch	270	403.3	414.63	410.31	397.00
		PID-P3	96.39	5204+22	East	1-36"	Lower Tule River ID, Porterville ID	24	398.5	413.25	409.53	393.29
		LTRID-Tipton Ditch	96.87	5229+51	West	2-4.5'x4.5'	Lower Tule River ID, Tipton Ditch	203	403.0	411.82	408.12	396.08
		LTRID-Poplar Ditch N&S	97.35	5255+02	West	2 - 4.5'x4.5'	Lower Tule River ID, Porterville ID, Popular Ditch	40	398.9	410.81	407.02	392.09
		PID-P5	97.86	5281+91	East	1-36"	Porterville ID	8	391.9	410.25	406.57	386.61
		LTRID-Casa Blanca Ditch	98.62	5322+16	West	3 - 4.5'x4.5'	Lower Tule River ID, Casa Blanca Ditch	237	399.0	409.70	405.76	392.53
		TPDWD-Teapot Dome	99.37	5360+89	East	1 - 3'x3'	Tea Pot Dome ID	38	397.5	408.28	404.18	392.06
		SID-S1	100.64	5428+88	West	2 - 4'x4'	Saucelito ID	82	391.6	407.25	404.74	385.12
		DCTRA Pits	102.65	5534+69	East	1 - 3'x3'	Terra Bella ID	52	389.6	405.10	402.41	383.94
		SID-S2	102.65	5534+69	West	2 - 4.5'x4.5'	Saucelito ID	102	390.8	405.19	402.70	383.99

✳ THESE TURNOUTS WERE NOT SURVEYED. HGL IS ASSUMED.

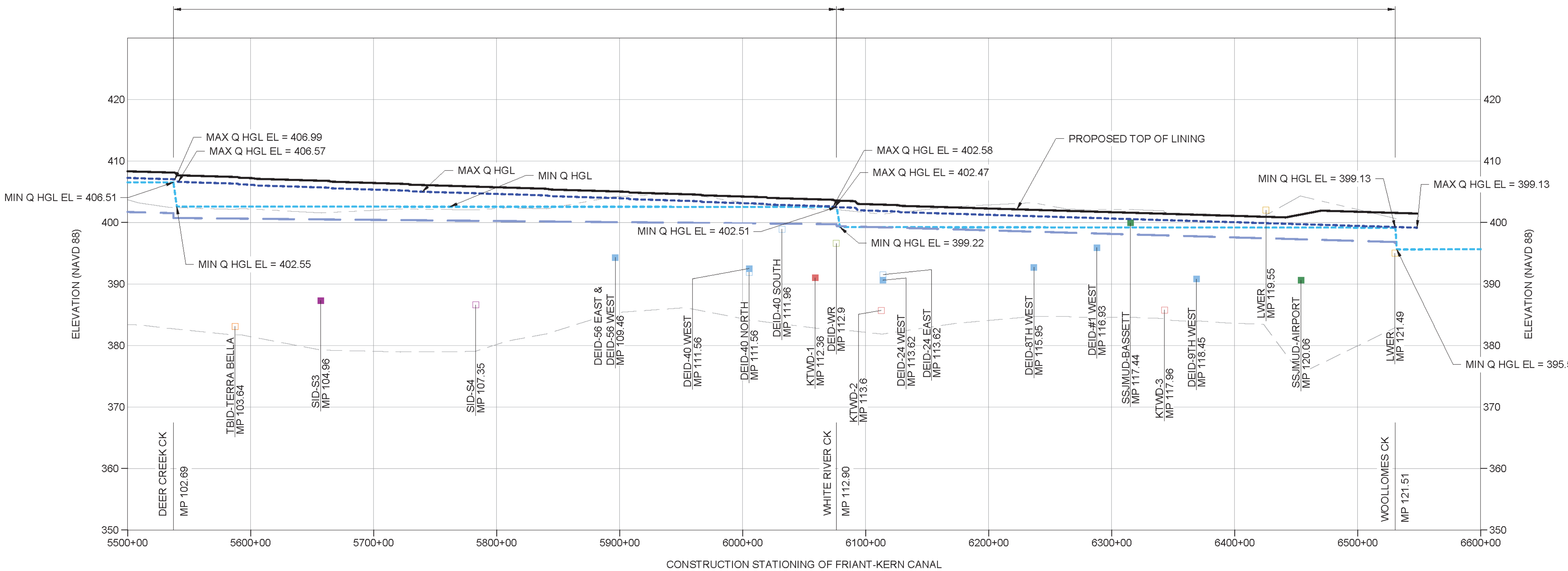
LEGEND AND ABBREVIATIONS

HGL	HYDRAULIC GRADE LINE
FLOOR	TURNOUT FLOOR ELEVATION
TOB	TOP OF EMBANKMENT
TOL	TOP OF LINING
	TOP OF LINING PER 2018 TOWILL SURVEY
	APPROX INVERT
	PROPOSED TOP OF LINING
	MAX Q HGL
	MIN Q HGL
	APPROXIMATE EXISTING HGL @ EXISTING Q SHOWN
WSEL	OPERATIONAL REQ WSEL @ CHECK STRUCTURE
□	ESTIMATED REQ HGL @ TURNOUT TO EAST
■	ESTIMATED REQ HGL @ TURNOUT TO WEST

NOTES:

1. TURNOUT ELEVATION SHOWN REPRESENT AN ELEVATION 2' ABOVE THE TOP OF GATE ELEVATION SURVEYED IN 2018.
2. HYDRAULIC GRADE LINES AND FLOWS SHOWN CORRESPOND TO BYPASS CANAL - ALTERNATIVE 5 OPTION 3.
3. PEAK DELIVERY FLOW RATE BASED ON HISTORICAL MAXIMUM DAILY DELIVERY RECORDED BETWEEN JANUARY 2003 AND AUGUST 2017.

Figure 3-1 - Hydraulic Profile from 5th Avenue to Deer Creek



FKC - EXISTING TURNOUTS

Color Code	T/O ID	Location			No of Gates and Sizes	Receiving Contractor	Peak Delivery (3)		Physical Elevations		
		Mile Post	Const STA	Direction			Q (cfs)	HGL	TOB	TOL	Floor
	TBID-Terra Bella	103.64	5587+33	East	Pumping plant	Terra Bella	111	400.5	403.71	402.10	383.09
	SID-S3	104.96	5656+99	West	2 - 4'x4'	Saucelito ID	77	387.3	404.28	401.73	380.98
	SID-S4	107.35	5782+98	East	2 - 3.5'x3.5'	Saucelito ID	13	386.6	404.59	402.18	380.40
	DEID-56 East	109.46	5894+58	East	1 - 4.5'x4.5'	Delano-Earlimart ID	29	394.3	406.78	403.95	386.45
	DEID-56 West	109.46	5894+60	West	2 - 4.5'x4.5'	Delano-Earlimart ID	110	394.3	406.64	404.02	386.47
	DEID-40 North	111.56	6005+41	East	1 - 4'x4'	Delano-Earlimart ID	22	391.9	405.49	403.00	385.40
	DEID-40 West	111.56	6005+43	West	2 - 4.5'x4.5'	Delano-Earlimart ID	86	392.5	405.16	403.09	385.58
	DEID-40 South	111.96	6031+98	East	1 - 4'x4'	Delano-Earlimart ID	22	398.9	405.33	402.71	392.64
	KTWD-1	112.36	6058+95	West	2 - 4.5'x4.5'	Kern Tulare	42	391.0	404.27	402.15	384.06
	DEID-WR	112.9	6076+77	East	Weir	White River Wasteway Parshall	29	#VALUE!	404.23	402.06	396.88
	KTWD-2	113.6	6112+61	East	1 - Unknown	Kern Tulare WD	52	#VALUE!	403.90	401.70	385.68
	DEID-24 East	113.62	6114+09	East	1 - 4.5'x4.5'	Delano-Earlimart ID	39	391.5	405.46	401.65	383.93
	DEID-24 West	113.62	6114+10	West	2 - 4.5'x4.5'	Delano-Earlimart ID	113	390.6	405.48	401.69	383.10
	DEID-8th West	115.95	6236+79	West	2 - 4'x4'	Delano-Earlimart ID	110	392.7	407.44	401.89	385.82
	DEID-#1 West	116.93	6288+03	West	3 - 4.5'x4.5'	Delano-Earlimart ID	23	395.9	405.53	401.96	388.76
	SSJMUD-Bassett	117.44	6315+39	West	2 - 4.5'x4.5'	SSJMUD	39	399.1	410.78	402.07	402.84
	KTWD-3	117.96	6342+98	East	1 - Unknown	Kern Tulare WD	59	398.6	407.14	401.63	385.74
	DEID-9th West	118.45	6369+07	West	1 - 3'x3'	Delano-Earlimart ID	30	390.8	406.78	401.32	385.09
	LWER	119.55	6425+52	East	4 - 2.5'	Lake Woollomes Equalizing Reservoir		402.0	405.39	Unlined Section	398.03
	SSJMUD-Airport	120.06	6453+98	West	2 - 4.5'x4.5'	SSJMUD Airport and Hiett	82	390.6	405.32	Unlined Section	383.91
	LWER	121.49	6530+32	East	2 - 3'x3'	Lake Woollomes Equalizing Reservoir		395.0	404.91	Unlined Section	389.63

LEGEND AND ABBREVIATIONS

- HGL — HYDRAULIC GRADE LINE
- FLOOR — TURNOUT FLOOR ELEVATION
- TOB — TOP OF EMBANKMENT
- TOL — TOP OF LINING
- TOP OF LINING PER 2018 TOWILL SURVEY
- APPROX INVERT
- PROPOSED TOP OF LINING
- MAX Q HGL
- MIN Q HGL
- APPROXIMATE EXISTING HGL @ EXISTING Q SHOWN
- WSEL — OPERATIONAL REQ WSEL @ CHECK STRUCTURE
- ESTIMATED REQ HGL @ TURNOUT TO EAST
- ESTIMATED REG HGL @ TURNOUT TO WEST

NOTES:

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3. PEAK DELIVERY FLOW RATE BASED ON HISTORICAL MAXIMUM DAILY DELIVERY RECORDED BETWEEN JANUARY 2003 AND AUGUST 2017.

Figure 3-2 - Hydraulic Profile from Deer Creek to Lake Woollomes

To address some of these concerns, delivery pools for existing turnouts would be created in the FKC by constructing embankments in the existing canal and on either side of the existing turnouts. Delivery pool turnouts would be constructed on the new canal to convey water to the delivery pools. This concept would be used for both alternatives, although the length of this new canal for Alternative 1 – Canal Enlargement would be enough only to meet minimum radius of curvature criteria. Refer to **Figure 3-3** for an example of this concept.

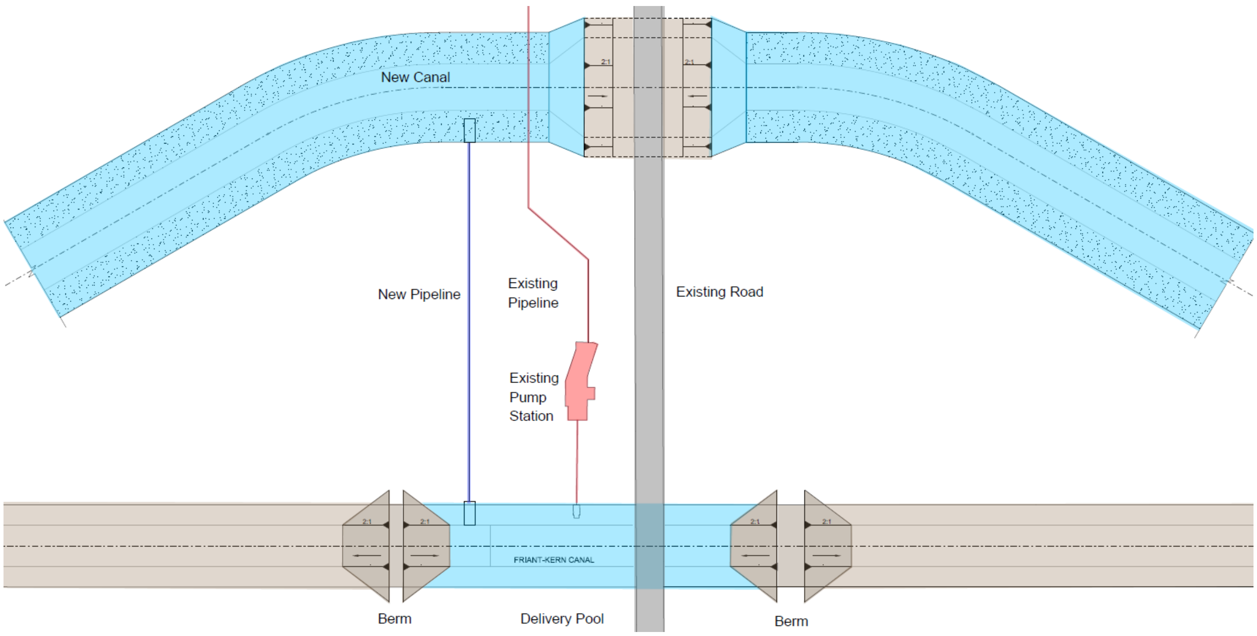

Figure 3-3 - Delivery Pool Turnout Concept

Specific advantages to the turnout delivery pools include the following:

- Operational flexibility - each pool can be designed to meet the needs/concerns of each District
- Flood control – Pools significantly reduces risk of pump station overflow that would not only damage pump stations but flood and damage adjacent land owner property.
- Cost effectiveness - Avoids cost impacts of replacing 9 pump stations on the east side of the canal and modifying 9 pump stations on the west side of the canal, for Alternative 5. Avoids the cost of replacing 7 pump stations on the east and modifying 6 pump stations on the west for Alternative 1.
- Constructability – Since existing turnouts are remaining at pools, sequencing cut overs from new canal to existing turnouts will be more seamless as opposed to having to hard pipe to existing wet wells and take existing turnouts offline one by one.

Because the locations of the pressurized turnouts often coincides with roadway crossings, the development of the delivery pool concept was coordinated with the development of concrete box siphon at the numerous roadway crossings, as discussed in Section 3.4. A concrete box siphon is shown in **Figure 3.3** on the new canal alignment.

3.4 Roadway Crossings

3.4.1 Existing Features

The Middle Reach of the FKC has approximately 44 bridges that are mostly County bridges, along with several State bridges and a few farm bridges. The bridges are primarily located in Tulare County, with Garces Highway (i.e. State Highway 155) delineating between Tulare County to the north and Kern County to the south. Many of the bridges are conventional type bridges 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. **Table 3-3** provides a summary of the existing bridges on the FKC. It is also pertinent to note that several bridges and their associated roadway approaches were raised varying amounts as part of the 1977 Subsidence Correction Project. These previous modifications are located at Avenue 112, Road 208, Avenue 88, Avenue 80, Avenue 76, and Road 192.

Table 3-3 - Summary of Existing Bridges

Milepost	Description	Type	Size	Name
88.67	Bridge, County	Conc	26' Rdwy	Ave 204/7th Ave.
89.17	Bridge, County	Conc	26' Rdwy	Ave 200/7th Ave.
89.45	Bridge, County	Conc	26' Rdwy	Road 232
89.95	Bridge, County	Conc	26' Rdwy	Ave 196/CR J28/Frazier Hwy
89.95	Bridge, County	Conc	26' Rdwy	Ave 194/8th Ave.
90.23	Bridge, County	Conc	26' Rdwy	Ave 192
91.10	Bridge, County	Conc	26' Rdwy	Ave 188
91.47	Bridge, State	Conc	40' Rdwy	State Hwy 65 (Westbound)
91.50	Bridge, State	Conc	40' Rdwy	State Hwy 65 (Eastbound)
91.60	Bridge, County	Conc	26' Rdwy	Ave 184/ Welcome Rd
91.85	Bridge, County	Conc	20' Rdwy	Ave 182
92.35	Bridge, County	Conc	20' Rdwy	Ave 178/ Mt View Ave
92.85	Bridge, County	Conc Bbl	20' Rdwy	Ave 174/ Linda Vista
93.55	Bridge, County	Conc	26' Rdwy	Ave 170/ W. North Grand Ave
94.01	Bridge, County	Conc	26' Rdwy	Road 224/ N Westwood St
95.12	Bridge, County	Conc	26' Rdwy	Ave 180/ Henderson
96.26	Bridge, County	Conc	36' Rdwy	Ave 152/ Olive Ave
97.35	Bridge, State	Conc	36' Rdwy	State Hwy 190, Ave 144
98.38	Bridge, County	Conc	26' Rdwy	Ave 136
99.37	Bridge, County	Conc	26' Rdwy	Ave 128
100.64	Bridge, County	Conc	26' Rdwy	Ave 120, Hesse Ave
101.64	Bridge, County	Conc	26' Rdwy	Ave 112
102.14	Bridge, Farm	Timber	20' Rdwy	
103.65	Bridge, County	Conc	26' Rdwy	Ave 96, Terra Bella Ave
103.72	Bridge, County	Conc	26' Rdwy	Road 208
104.95	Bridge, County	Conc	26' Rdwy	Ave 88
106.72	Bridge, County	Conc	26' Rdwy	Ave 80
106.75	Bridge, Farm	Conc	16' Rdwy	Ave 74
107.32	Bridge, County	Conc	26' Rdwy	Road 192
108.42	Bridge, Farm	Timber	16' Rdwy	Ave 64
109.45	Bridge, County	Conc	36' Rdwy	Ave. 56/ Ducor Hwy/Sierra Avenue
110.55	Bridge, County	Conc	26' Rdwy	Ave 48
111.55	Bridge, County	Conc	26' Rdwy	Ave 40
111.66	Bridge, County	Conc	26' Rdwy	Road 184
112.57	Bridge, County	Conc	26' Rdwy	Ave 32
113.59	Bridge, County	Conc	26' Rdwy	Ave 24
114.71	Bridge, County	Conc	26' Rdwy	Ave 16/ SP RR
115.91	Bridge, County	Conc	26' Rdwy	Ave 8
116.41	Bridge, Farm (2)	Timber	26' Rdwy	4th Ave/Old RR Crossing
116.91	Bridge, County	Conc	26' Rdwy	County Line Rd / CR J44
117.92	Bridge, County	Conc	36' Rdwy	Cecil Ave
118.44	Bridge, County	Conc	26' Rdwy	9th Ave
118.94	Bridge, State	Conc	26' Rdwy	Garces Hwy/Hwy 155

Table 3-3 - Summary of Existing Bridges cont'd

Milepost	Description	Type		Size	Name
119.46	Bridge, Farm	Timber		16' Rdwy	H - 10
120.02	Bridge, County	Timber		26' Rdwy	Woollomes Ave

Notes:
[1] timber bridges parallel to the existing FKC at Porter Slough and Tule River not included
Key:
Concr – concrete
Rdwy – roadway
Ave – avenue
Hwy – highway
RR – railroad

3.4.2 General Approach to Bridge Modifications

In 2018, field surveying was conducted at each bridge to identify the underside, or "soffit" of the bridge as critical input parameters to the hydraulic modeling conducted to ascertain what bridge modification work would be needed. As stated above the number of affected bridges and the potential costs of newly constructed bridges the total project cost will be influenced by the decision to modify, raise, or replace bridge structures. The general approach to bridge modifications included the following items:

- Minimize bridge replacement and raises;
- Develop efficient designs for replacement bridges that consider 1) trapezoidal type bridge and 2) consider future maximum flows and potential future subsidence conditions;
- Establish criteria for freeboard clearance between the water surface and bridge soffit;
- Establish criteria for bridge tie-ins, widening, tie-ins, and hydraulic losses; and
- Determine which bridges should be replaced for each alternative

3.4.3 Proposed Roadway Crossings [Revised]

Parallel Canal

In the most deeply subsided portion of the FKC the estimated bridge soffit raise ranged from just under 3 feet to approaching 8 feet. In other areas the bridge raise was less. A conventional type of bridge raise similar to what was constructed in 1977 was investigated; using standard roadway geomatics design to estimate the length of the approaches needed to accommodate the estimate bridge elevations needed. Initial estimates ranged from 700 feet to over 1,800 feet of total distance required, with the longer lengths associated with the bridges that have already been modified previously. This initial approach was deemed to not be practical and a concrete box siphon approach was developed that has yielded good results.

Concrete box siphons are typically used in canals crossing both waterways and roadways. The original FKC has several concrete box siphons crossing numerous waterways. In 1975, a relocation to the FKC at the intersection of Olive Drive and Calloway Drive (MP 148.08 to 148.08) used a double box siphon (2 each - 17 feet tall by 23 feet wide) approximately 390 feet in length to diagonally cross the intersection and relocate the FKC. For the Middle Reach Project our initial estimate is that a triple box siphon (3 each – 19 feet tall by 19 feet wide) would be needed to equate to the same hydraulic losses as that of the typical trapezoidal canal lining section. Warped transitions 50 feet in length would be provided at the siphon entrance and exit. Length of the siphon would vary by location and would account the existing roadway crossing skews to the FKC. The concrete box siphons could be designed to accommodate future potential subsidence by taking into account future soil loading and extension of the concrete headwalls at the entrance and outlet. These elements will be further refined during the design development. **Figure 3-4** depicts a plan and section view of the concrete box siphon.

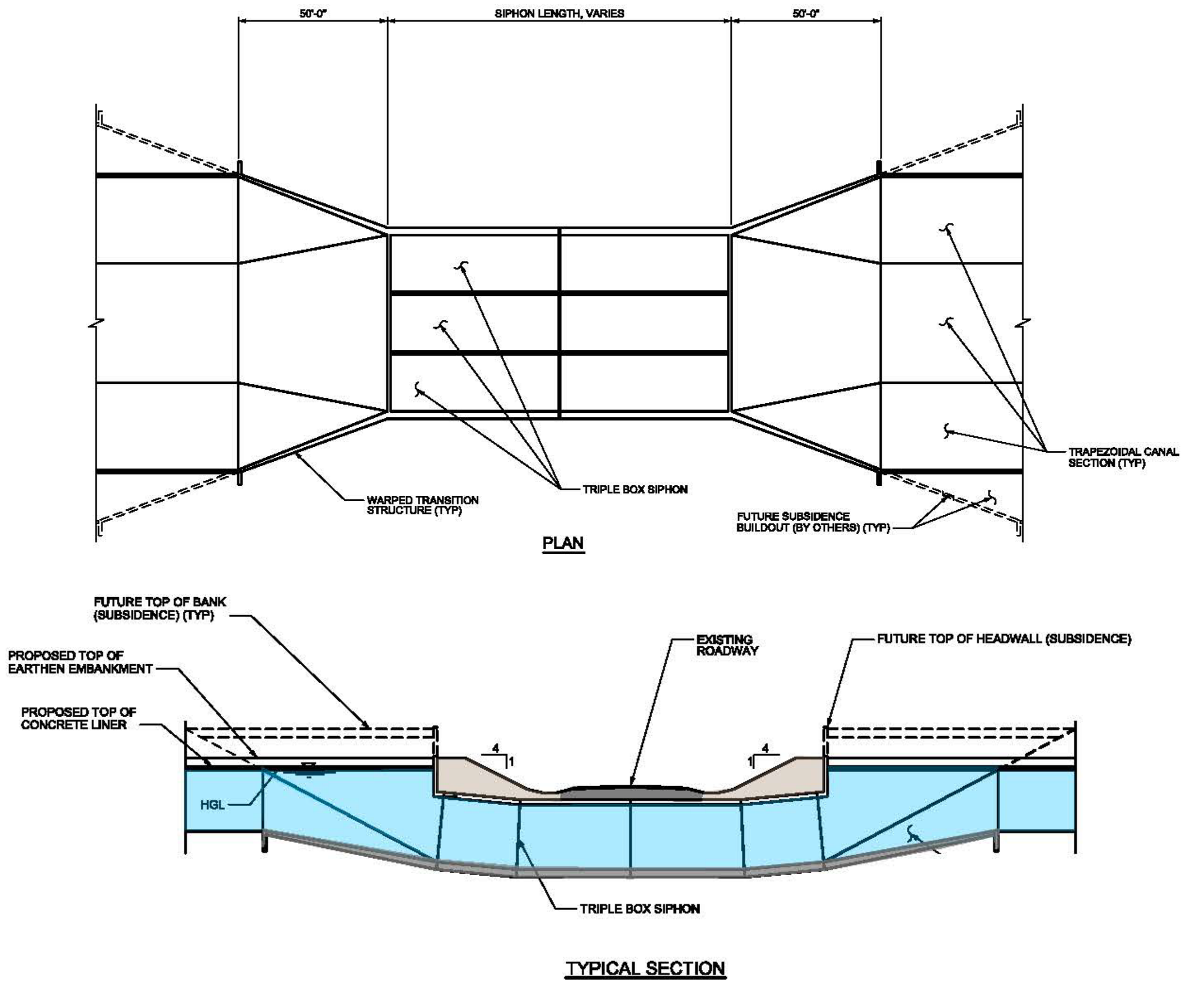

Figure 3-4 - Concrete Box Siphon

Upstream of Tule River the canal section will be enlarged, and no bridge modifications are needed. Canal lining inlet and outlet transitions will be provided at these bridges to minimize hydraulic losses.

We assume that the existing bridges on the FKC will need to be demolished upon completion of the new parallel canal. We also assume that the existing roads will be able to be closed with detours provided during construction. Coordination with Tulare County will be needed during design to confirm these assumptions as well as to establish a common understanding of the roadway crossing requirements.

A few of the advantages of the concrete box siphon as compared to conventional bridge and associated roadway raise include the following:

- Significantly reduced road work with not having to build all of the approaches to new bridges
- Constructability – Each siphon can be built in parallel while existing canal in operation. For Alternative 1, do not have to build a new bridge in an existing operational canal.

Canal Enlargement

As previously mentioned in Section 2.4.5 trapezoidal bridge structures promise to be a cost - effective bridge replacement option for where the existing FKC is being enlarged. **Figure 3-5** depicts a section view of a trapezoidal bridge structure.

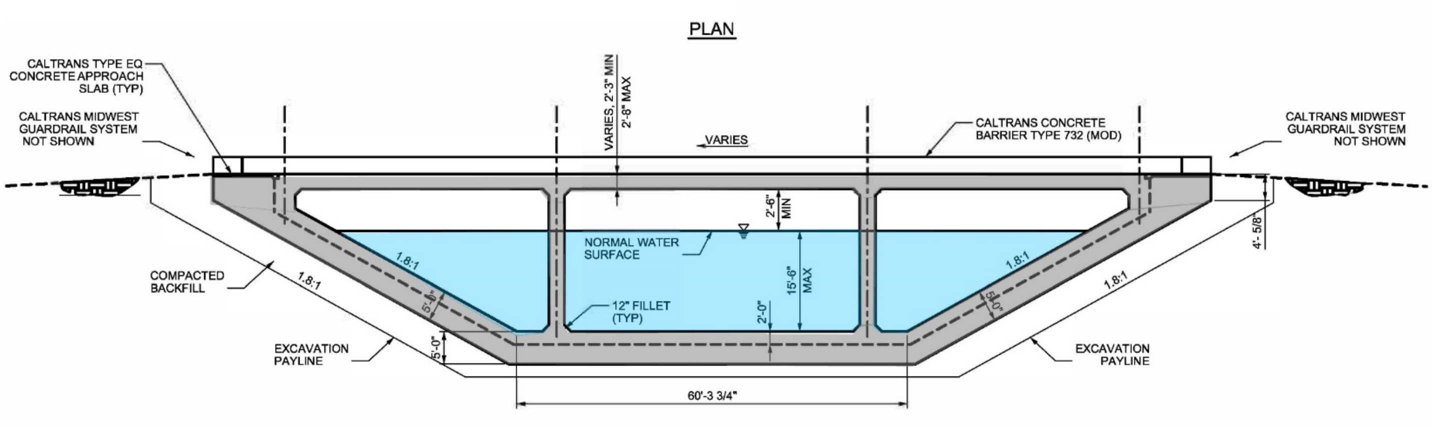

Figure 3-5 - Trapezoidal Bridge

For portions where short sections of the FKC require a new parallel canal for turnout delivery pools, we anticipate using the concrete box siphon discussed in the Alternative 1 – Parallel Canal discussion above.

We assume that the existing bridges on the FKC will need to be demolished upon completion of the portions of this alternative that implement short segments of new parallel canal and associated concrete box siphon. We also assume that the existing roads will be able to be closed with detours provided during construction. Coordination with Tulare County will be needed during design to confirm these assumptions as well as to establish a common understanding of the roadway crossing requirements.

3.5 Feasibility Alternative 1 – Canal Enlargement [Revised]

3.5.1 General Alternative Description

Maximum historical flow capacity as shown in Table 3-4 can be achieved by raising the canal lining through the most subsided area of the FKC. Thus, this alternative would involve raising the existing FKC to re-establish the original design HGL. The original canal lining was constructed on a slope of 1.25:1 to a depth of about 17.5 feet. Continued raising of the lining foundation on this slope may lead to embankment instability and ultimately a lining failure in the lower portions of the original lining. To address this issue, a bench would be constructed to establish a setback that provides slope stability for the canal lining foundation after the lining raise.

Table 3-4 - Alternative 1- Canal Enlargement - Canal Capacity

Segment No.	Segment Description	Capacity (cfs)
1	5th Avenue to Tule River	4,008
2	Tule River to Deer Creek	3,497
3	Deer Creek to White River	2,888
4	White River to Lake Woollomes	2,490

The current geotechnical recommendation is to completely remove the 1970’s lining raise from approximate MP 99 to MP 116 and construct a new concrete-lined bench starting at the top of the original canal lining. This recommendation is based, in part, on observed seepage in this section of the canal. The structural integrity of FKC embankments has been reduced over the years from several factors, including animals that have created burrows in the embankment. When water levels in the canal are elevated, FWA closely watches for signs of seepage and undertake mud-jacking as needed to stop seepage and protect embankment stability. Replacing the existing horizontal cold joint with a new joint with an improved water stop joint would reduce but not avoid seepage risks. Raising the FKC lining by as much as seven additional feet would increase water pressure on the lower portion of the canal prism and increase seepage risk. Additional mud-jacking to stop seepage and stabilize the embankments would be required, however the extent of embankment rehabilitative measures is not known at this time. In addition, the original concrete liner that forms the deepest portion of the FKC would be approximately 70 years old when the canal raise is constructed and would need to function through a service life of an additional 100 years.

Figure 3-6 depicts how the capacity improvements would be accomplished as described above. The canal lining could extend to the top of the raise to accommodate future subsidence. In the future, the “Stage 2” embankment raise could be implemented to mitigate for subsidence. Refer to Attachment B1.a for a more detailed typical canal section.

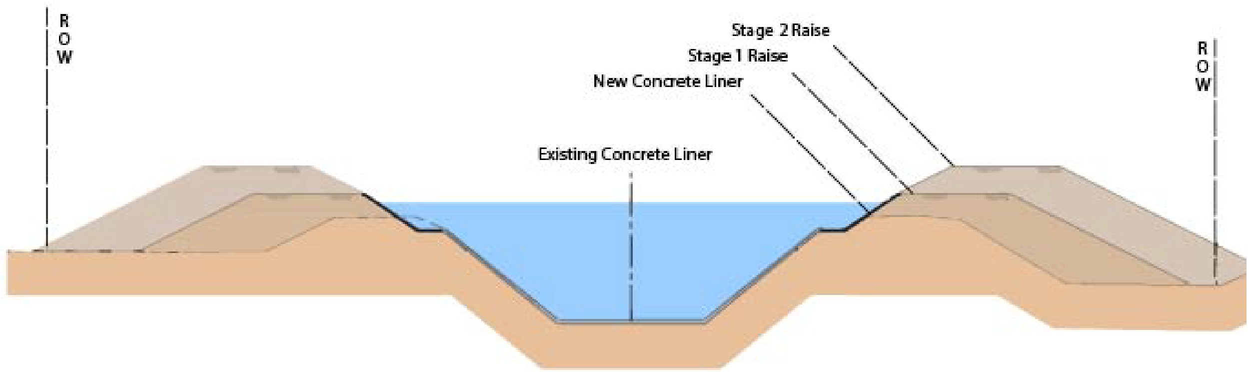

Figure 3-6 - Alternative 1 – Canal Enlargement Conceptual Section

The canal enlargement starts downstream of the Tule River siphon and extends to approximate MP 115.94 at Avenue 6, approximately 20 miles. It is worth noting that the turnout delivery pool concept will require that a new canal be constructed adjacent to the existing FKC for short distances at several locations resulting in an approximate length of 4 miles of new canal.

The Deer Creek check and wasteway structures and siphon would require replacement, along with a new control building and associated electrical, mechanical and controls equipment. The White River check and wasteway would need to be raised by approximately 1.5 feet with potential modifications to the radial gates and associated equipment. Refer to **Section 4.3.19** for additional information regarding the check structures.

This alternative involves replacing approximately 19 county/state bridges. **Figures 3-7** and **3-8** depict the Alternative 1 system schematic and associated legend, respectively.

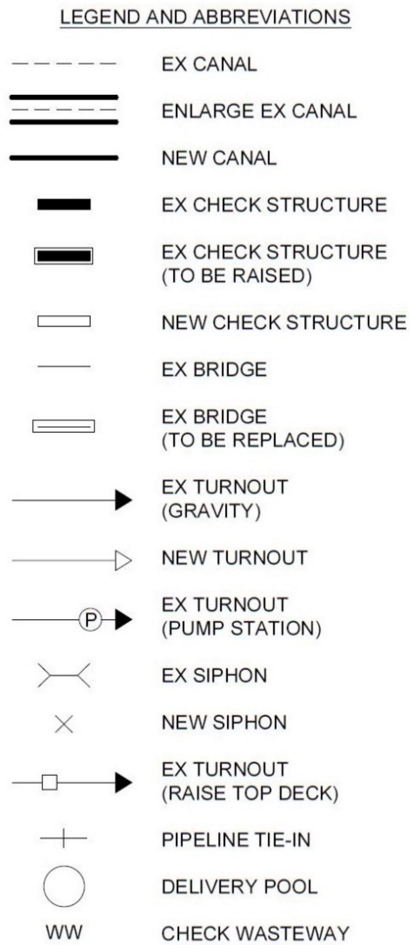

Figure 3-8 - Legend and Abbreviations

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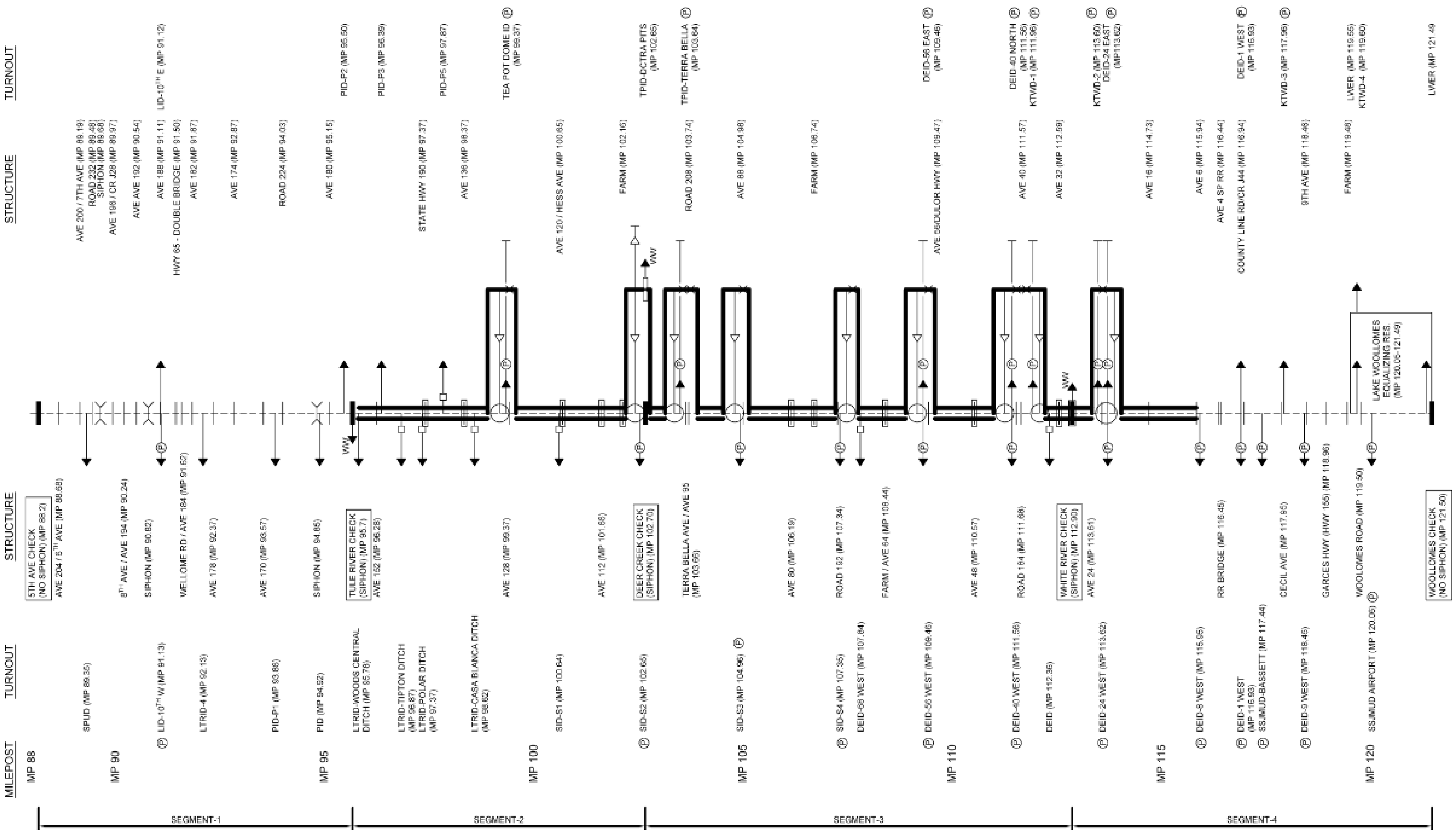

Figure 3-7 - Alternative 1 - Canal Enlargement System Schematic

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3.5.2 Canal Alignment

For the most part, the canal alignment for this alternative will use the existing FKC centerline. However, the turnout delivery pool concept will require that short segments of a new parallel canal extend out to the east to accommodate compatibility to maintaining water supplies to turnouts, and include new roadway crossing in most instances. The alignment offset was established by minimum radius of curvature in conjunction with conflict avoidance with existing infrastructure and existing FKC alignment.

This alternative includes a bench on either side of the canal to increase the canal conveyance capacity. It is worth noting that there are options to which side of the existing FKC and the length of the bench could be placed on either side, as long as the overall desired cross sectional area is obtained. This could vary along the length of the canal enlargement needed and would be refined and developed during design to minimize the additional ROW needed and lessen potential impacts to adjacent infrastructure.

3.5.3 Turnouts

Measures to accommodate the existing turnouts can be grouped into three methods 1) no modifications needed, 2) raise the top deck and modify appurtenant mechanical equipment to accommodate the lining raise, and 3) construct a new turnout and associated delivery pool and new canal. **Table 3-5** provides information on each turnout along with the method proposed.

Table 3-5 - Alternative 1 – Canal Enlargement – Turnout Details

Milepost	Location	Material	Size	Type	Name	Alternative 1 Measure
89.35	West	Conc Bbl	**20"**	G	SPUD	None
91.12	East	Conc Bbl	4' x 4'	G	LID-10	None
91.12	West	Conc Bbl	2 - 4.5' x 4.5'	PP	LID-10	None
92.13	West	Conc Bbl	2 - 7' x 7'	G	LTRID-4	None
93.85	West	Conc Bbl	2 - 4.5' x 4.5'	G	PID-P1	None
94.92	West	Conc Bbl	2 - 5' x 5'	G	PID-P2	None
95.50	East	Conc Bbl	4.5' x 4.5'	G	PID-P2	None
95.78	East	Conc Bbl	2 - 4.5' x 4'	G	LTRID-Woods Central Ditch	None
96.39	East	Conc Pipe	36"	G	LPID-P3	None
96.87	West	Conc Bbl	2 - 4.5' x 4.5'	G	LTRID-Tipton Ditch	Raise Top Deck
97.37	West	Conc	2 - 4.5' x 4.5'	G	LTRID-Poplar Ditch	Raise Top Deck
97.86	East	Conc Pipe	36"	G	PID-P5	Raise Top Deck
98.62	West	Conc	3 - 4.5' x 4.5'	G	LTRID-Casa Blanca Ditch	Raise Top Deck
99.35	East	Conc Bbl	3' x3'	P	Tea Pot Dome ID	New Delivery Pool Turnout
100.64	West	Conc Bbl	2 - 4' x 4'	G	SID-S1	Raise Top Deck

Table 3-5 - Alternative 1 – Canal Enlargement – Turnout Details cont'd

Milepost	Location	Material	Size	Type	Name	Alternative 1 Measure
102.65	East	Conc Bbl	3' x 3'	G	TBID-DCRA Pits	Raise Top Deck
102.65	West	Conc Bbl	2 - 4.5' x 4.5'	P	SID-S2	New Delivery Pool Turnout
103.64	East	Conc Bbl	2 - 4.5' x 4.5'	P	TBID-Terra Bella	New Delivery Pool Turnout
104.96	West	Conc Bbl	2 - 4' x 4'	P	SID-S3	New Delivery Pool Turnout
107.35	West	Conc Bbl	2 - 3.5' x 3.5'	P	SID-S4	New Delivery Pool Turnout
107.84	West	Conc Bbl		G	DEID-68 West	
109.46	West	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-56 East	New Delivery Pool Turnout
109.46	East	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-56 West	New Delivery Pool Turnout
111.56	West	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-40 North	New Delivery Pool Turnout
111.56	East	Conc Bbl	4' x 4'	P	DEID-40 West	New Delivery Pool Turnout
111.96	East		4' x 4'	P	KTWD-1	New Delivery Pool Turnout
112.36	West	Conc		G	DEID	
113.60	East	Steel Pipe	5 - 24"	P	KTWD-2	New Delivery Pool Turnout
113.62	West	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-24 East	New Delivery Pool Turnout
113.62	East	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-24 West	New Delivery Pool Turnout
115.95	West	Conc Bbl	2 - 4' x 4'	P	DEID-8	None
116.93	East	Conc Bbl	3 - 4.5' x 4.5'	P	DEID-1	None
117.44	West	Conc	2 - 4.5' x 4.5'	P	SSJMUD Bassett	New Delivery Pool Turnout
117.96	East	Steel	7 - 10"	P	KTWD-3	New Delivery Pool Turnout
118.45	West	Conc Bbl	3' x 3'	P	DEID-9	None
119.55	East	Conc Pipe	2 - 24"	G	LWER	None
120.06	West	Conc	2 - 4.5' x 4.5'	P	SSJMUD Airport	None
121.49	East	Conc Bbl	2.5' x 6'	G	LWER	None

Key:
G = Gravity Turnout
P = Pressurized Turnout
Conc = Concrete

3.5.4 Roadway Crossings

Refer to **Section 3.4** for an overview of the approach to roadway crossings. **Table 3-6** provides a summary of the measures proposed for the roadway crossings for this alternative.

Table 3-6 - Alternative 1 – Canal Enlargement - Roadway Crossing Details

Milepost	Description	Name	Alternative 1 Measure
88.67	Bridge, County	Ave 204/7th Ave.	None
89.17	Bridge, County	Ave 200/7th Ave.	None
89.45	Bridge, County	Road 232	None
89.95	Bridge, County	Ave 196/CR J28/Frazier Hwy	None
89.95	Bridge, County	Ave 194/8th Ave.	None
90.23	Bridge, County	Ave 192	None
91.10	Bridge, County	Ave 188	None
91.47	Bridge, State	State Hwy 65 (Westbound)	None
91.50	Bridge, State	State Hwy 65 (Eastbound)	None
91.60	Bridge, County	Ave 184/ Welcome Rd	None
91.85	Bridge, County	Ave 182	None
92.35	Bridge, County	Ave 178/ Mt View Ave	None
92.85	Bridge, County	Ave 174/ Linda Vista	None
93.55	Bridge, County	Ave 170/W. North Grand Ave	None
94.01	Bridge, County	Road 224/N Westwood St	None
95.12	Bridge, County	Ave 180/Henderson	None
96.26	Bridge, County	Ave 152/Olive Ave	None
97.35	Bridge, State	State Hwy 190, Ave 144	Concrete Trapezoidal
98.38	Bridge, County	Ave 136	Concrete Trapezoidal
99.37	Bridge, County	Ave 128	Concrete Box Siphon
100.64	Bridge, County	Ave 120, Hesse Ave	Concrete Trapezoidal
101.64	Bridge, County	Ave 112	Concrete Trapezoidal
102.14	Bridge, Farm		Concrete Trapezoidal
103.65	Bridge, County	Ave 96, Terra Bella Ave	Concrete Box Siphon
103.72	Bridge, County	Road 208	Concrete Box Siphon
104.95	Bridge, County	Ave 88	Concrete Box Siphon
106.72	Bridge, County	Ave 80	Concrete Trapezoidal
106.75	Bridge, Farm	Ave 74	Concrete Trapezoidal
107.32	Bridge, County	Road 192	Concrete Box Siphon
108.42	Bridge, Farm	Ave 64	Concrete Trapezoidal
109.45	Bridge, County	Ave 56/Ducor Hwy/Sierra Avenue	Concrete Box Siphon
110.55	Bridge, County	Ave 48	Concrete Trapezoidal
111.55	Bridge, County	Ave 40	Concrete Box Siphon
111.66	Bridge, County	Road 184	Concrete Box Siphon
112.57	Bridge, County	Ave 32	Concrete Trapezoidal
113.59	Bridge, County	Ave 24	Concrete Box Siphon
114.71	Bridge, County	Ave 16/SP RR	None
115.91	Bridge, County	Ave 8	None

Table 3-6 - Alternative 1 – Canal Enlargement - Roadway Crossing Details cont'd

Milepost	Description	Name	Alternative 1 Measure
116.41	Bridge, Farm (2)	4th Ave/Old RR Crossing	None
116.91	Bridge, County	County Line Rd/CR J44	None
117.92	Bridge, County	Cecil Ave	None
118.44	Bridge, County	9th Ave	None
118.94	Bridge, State	Garces Hwy/Hwy 155	None
119.46	Bridge, Farm	H - 10	None
120.02	Bridge, County	Woollomes Ave	None

Notes:
[1]timber bridges parallel to the existing FKC at Porter Slough and Tule River not included

Key:
Rdwy = roadway
Ave = avenue
Hwy = highway
RR = railroad

3.5.5 Utilities

There are numerous utilities in, along, and across the canal that need to be addressed. The utilities include parallel irrigation canals, fly overs, overhead power, adjacent wells, drainage siphons and irrigation crossings that go 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. Replacement or relocation will depend on the final design, but a current estimate based on observations made during a site visit during February 2019 is provided in **Table 3-7**. This does not include the numerous utilities that are supported by the existing bridges that will need specific relocation methods depending upon the roadway crossing approach used.

Table 3-7 - Alternative 1 – Canal Enlargement – Utility Modifications

Type of Utility	Proposed Modification	Estimated Quantity
Overhead Powerline	Relocation of parallel utility	8 miles
Groundwater Well	Abandonment	9each
Culverts	Extension	5 each
Pipeline Overcrossings	Relocation	12 each

3.5.6 Geotechnical Slope Stability Analyses

Slope stability analyses were performed to evaluate the stability at three representative cross-sections for the Alternative 1 canal enlargement option. Cross sections at Mileposts 100.5, 102.7, and 104 were evaluated. The design embankment and the taller subsidence embankment were evaluated at these three locations. Both of these embankment geometries include an approximate 10-foot wide horizontal bench at the approximate location of the horizontal joint between the original concrete liner and the raised concrete liner.

The materials modeled within the embankments are assumed to consist entirely of compacted fill. The compacted fill within the existing embankment has been assumed to remain in place, and all uncompacted fill from the existing embankment would be removed and be replaced as compacted fill. All additional fill required to construct the embankments is assumed to be compacted. Canal water levels were taken as 2 feet below the top of the concrete liner. As described in Exhibit A1c Geotechnical Interpretive Report (GIR), the embankments were modeled as dry, without internal saturated zones, which is consistent with the dry conditions encountered in the borings performed on the Operations and Maintenance Road on top of the existing embankments. Additional details regarding the assumption of a dry embankment are provided in the GIR.

The material parameters such as unit weights and shear strengths used in these analyses were those developed for the original slope stability modeling presented in the GIR. The loading cases evaluated included Downstream Normal Water Level, Upstream Normal Water Level, Upstream and Downstream Seismic, and Upstream Dry and Low Water. More details on these loading conditions can be found in the GIR.

The results of the stability analyses indicate the factors of safety criteria provided by Reclamation are satisfied. In some cases, the seismic factor of safety is lower than the Reclamation criteria. However, results of simplified seismic deformation analyses indicate Reclamation criteria for seismic stability is also satisfied.

3.5.7 Construction Constraints

Although a detailed construction constraints and sequencing plan has not been developed for Alternative 1, there are several challenges that will need to be overcome, several associated with the fact that construction will need to occur within the prism of an operating canal:

- Reduction in Water Supply Deliveries - Constructing the new bench and reworking the existing embankment would require, at a minimum, lowering the water level in the FKC to a level of about 1.5 feet below the top of the original liner to provide a safe working environment. It is estimated that the operating capacity at this depth would be about 600 cubic feet per second (cfs) or less. This reduced water level and capacity would significantly limit water deliveries in the affected reach and to all portions of the canal downstream of the work area. It is possible that all canal operations would need to be suspended in the reach under construction and the remaining downstream reaches of the FKC. To mitigate this, it might be possible to provide reduced water deliveries during construction by using numerous temporary pumps and bypasses; however, the location, size, operational requirements, and cost of temporary pumps and bypasses to achieve this has not been evaluated. We estimate that during construction a maximum canal flow of 600 cfs would be possible and that numerous turnouts would be "out of the water". However, canal water seepage into the existing bank during bank construction may require that the canal operational water levels be dropped even lower to depths below existing grade at the canal bank toe. If this were to occur, operating capacity in the canal would be reduced to nearly no flow. Deliveries upstream of the work area would be maintained and it may be possible to use downstream portions of the FKC as well. For example, if the construction activity is underway in the reach of the canal between the Deer Creek Check and the White River Check, canal deliveries above the Deer Creek Check could be maintained. In addition, with the White River Check closed, deliveries would be possible by utilizing the proposed pump back facilities if they are completed and operational at the time, otherwise temporary pumping may be necessary.

- Lengthened Construction Schedule – It is currently assumed that construction of canal benches, banks, and in-canal features of Alternative 1 would occur during periods when canal operations are suspended. If it is assumed that no more than two months of canal shutdown could be tolerated each year, it is expected that construction of Alternative 1 would require a minimum of 4 to 6 years of incremental construction. Sequencing would commence with earthwork only the first year. The annual earthwork step would be completed such that the embankments would be re-worked and raised to the design elevation while leaving the canal lining intact until the canal lining step is undertaken during the following year. During the second year, the top portion of the existing lining would be removed, the bench would be excavated, and new canal lining operations would occur in the area that the earthwork was completed during year one. At the same time, earthwork would continue in preparation for third year canal lining operations, and so on until the project is completed. Completing 3.6 million cubic yards of earthwork over 4 to 6 two-month periods would require excavating and compacting over 10,000 cubic yards per day during the work periods. In addition, the extent of work that could be accomplished in any year would be dependent on hydrologic conditions, which could cause an increase in the overall construction duration. Extended wet and rainy weather would limit the ability to perform earthwork, and dry winters with higher than normal temperatures could reduce the duration of a shutdown that growers could tolerate. In summary, as compared to Alternative 5, Alternative 1 would have a longer construction duration given the above described challenges.
- Impacts of Required Borrow – This alternative will require significant borrow, with borrow sources ideally located on each side of the canal to limit hauling over the existing bridges, many of which have load restrictions on them. Depending on the location of borrow sources (which have not yet been identified), constraints on the larger equipment ideally suited to hauling large loads may be imposed.
- Additional Safety Risk During Construction – As compared to Alternative 5 – Parallel Canal, this alternative has a greater risk to construction staff given that the work is within an active water delivery system.
- Tie-ins – With a new check structure, wasteway and siphon planned at Deer Creek, upstream and downstream tie-ins to the existing canal. While this is certainly achievable, tie-ins require appropriate advance planning, reliable concepts, and carry some risk that water supply deliveries would be interrupted during construction.

3.5.8 Construction Sequencing Description

An initial high-level construction sequencing plan has been developed using the framework described in the section above. Table 3-8 accompanies the sequencing steps shown in Figure 3-9.

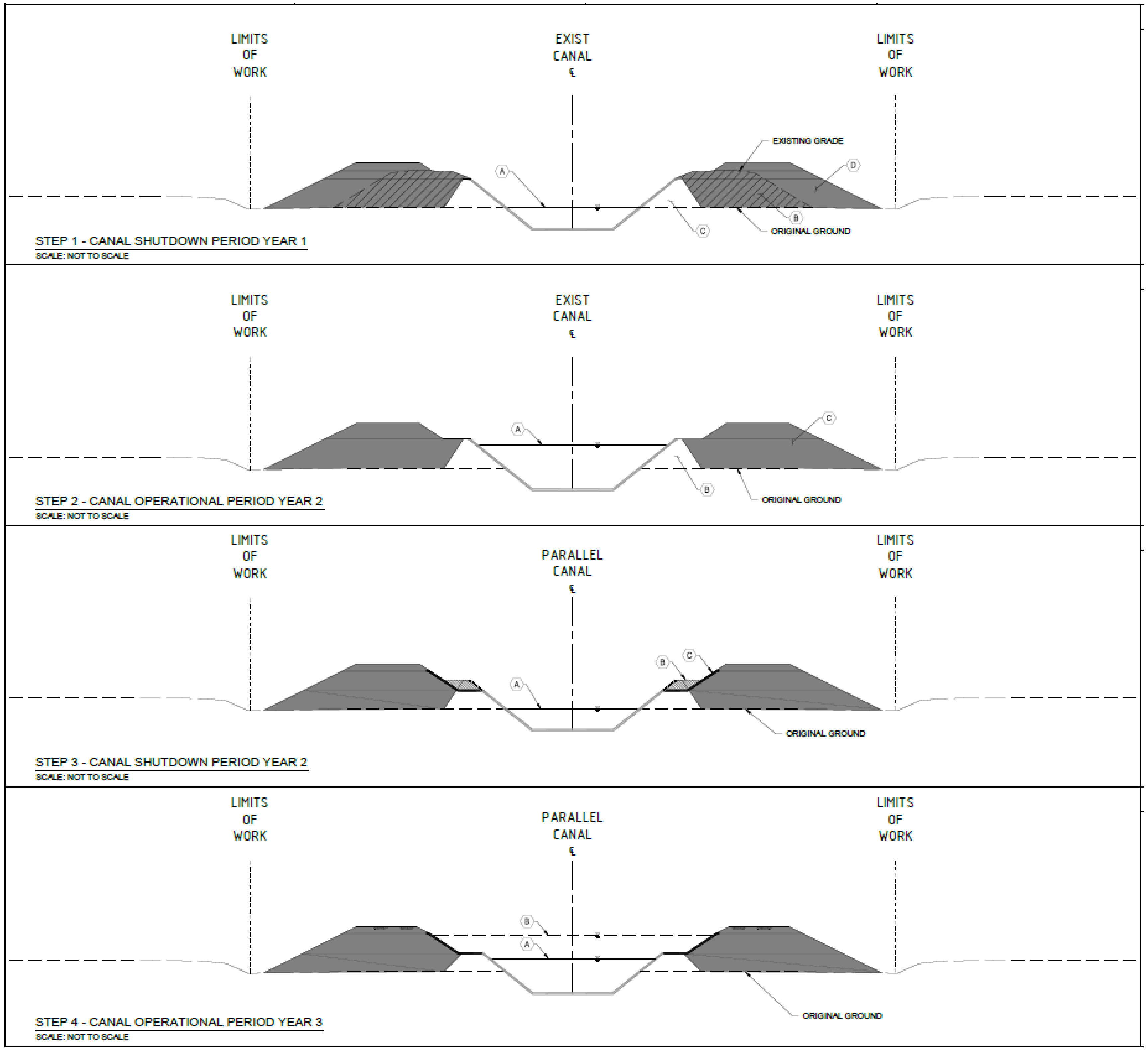

Figure 3-9 - Alternative 1 – Construction Sequencing

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Table 3-8 - Alternative 1 - Canal Enlargement – Construction Sequencing Steps

Step	Description of Activities	Status of Existing FKC
1	A – Draw down canal. B – Remove, process, and recompact existing bank material for re-use in new canal banks.	Canal is shutdown
2	A – Put canal back into operation at typical water surface elevations. B – Existing compacted bank and lining remain for operational period. C – New canal bank.	Canal is in operation.
3	A – Draw down canal. B – Remove 1977 concrete lining, excavate and trim for new lining. C – Place new canal lining.	Canal is shutdown
4	A – Put canal back into operation at typical water surface elevation. B – Canal can operate at new water surface elevation until an entire canal segment has been completed.	Canal is in operation

3.5.9 Earthwork Computations and Borrow Source

Digital terrain models were prepared from the aerial surveying conduct in mid-2018. Building Information Model (BIM) using AutoCAD Civil 3D has been utilized to prepare earthwork computations. Approximately 3.6 million cubic yards of excavation will be required for the construction of Alternative 1. No investigations to locate borrow sources have been conducted at this time.

3.6 Feasibility Alternative 5 – Parallel Canal [Revised]

3.6.1 General Alternative Description

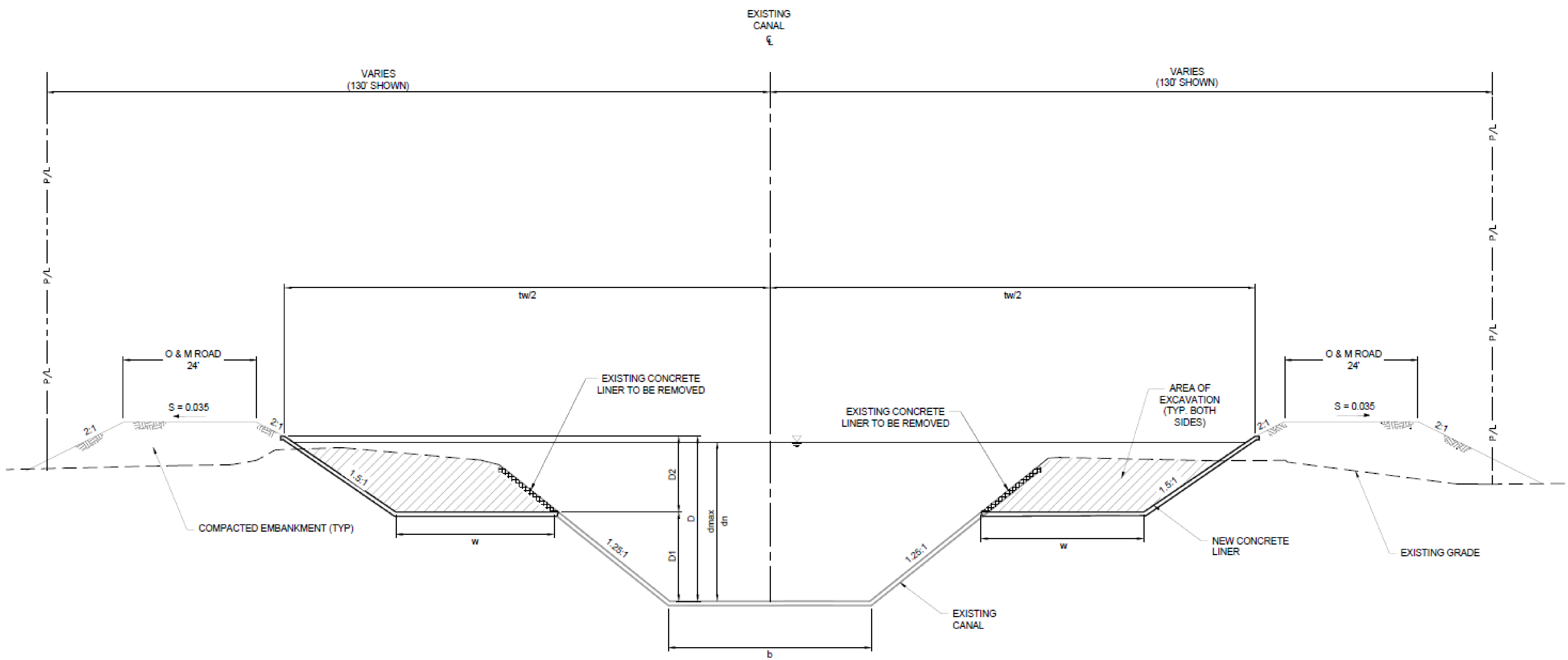
Alternative 5 includes both an enlargement to the existing FKC and a new parallel canal. The design maximum capacity per segment is shown in **Table 3-9** below.

Table 3-9 - Alternative 5 - Parallel Canal - Canal Capacity

Segment No.	Description	Design Maximum Capacity (cfs)
1	5th Avenue to Tule River	4,500
2	Tule River to Deer Creek	4,000
3	Deer Creek to White River	4,000
4	White River to Lake Woollomes	3,500

The existing FKC would be enlarged from the 5th Avenue check to just downstream of the Tule River siphon, approximately 7.4 miles. The canal enlargement would be similar to the canal enlargement planned for Alternative 1. The parallel canal would start downstream of Tule River siphon and tie back into the existing FKC approximately ½ mile downstream of Garces Highway (Highway 155), approximately 23.8 miles. From this point to the Woollomes check the FKC earthen section would be widened from 40 feet to 60 feet. **Figures 3-10** and **3-11** depict typical canal sections for the concrete lined widened portion and the new parallel canal portion, respectively for this alternative.

		STATION		A	V	Qmax	Qn	n	s	b	dmax	dn	D	D1	D2	w	S:S	tw
SECTION	SURFACE	BEGIN	END	(SQ FT)	(FT/S)	(CFS)	(CFS)	-	(FT/FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)
5TH AVE SIPHON		4773+23	4773+60			4500	3500											
4	CONCRETE	4773+60	5166+36	1258.63	3.58	4500	3500	0.016	0.00008	36	15.25	13.79	16.37	8.00	8.37	28.00	1.5:1	140.80
TULE RIVER SIPHON		5166+36	5171+28			4000	3000											



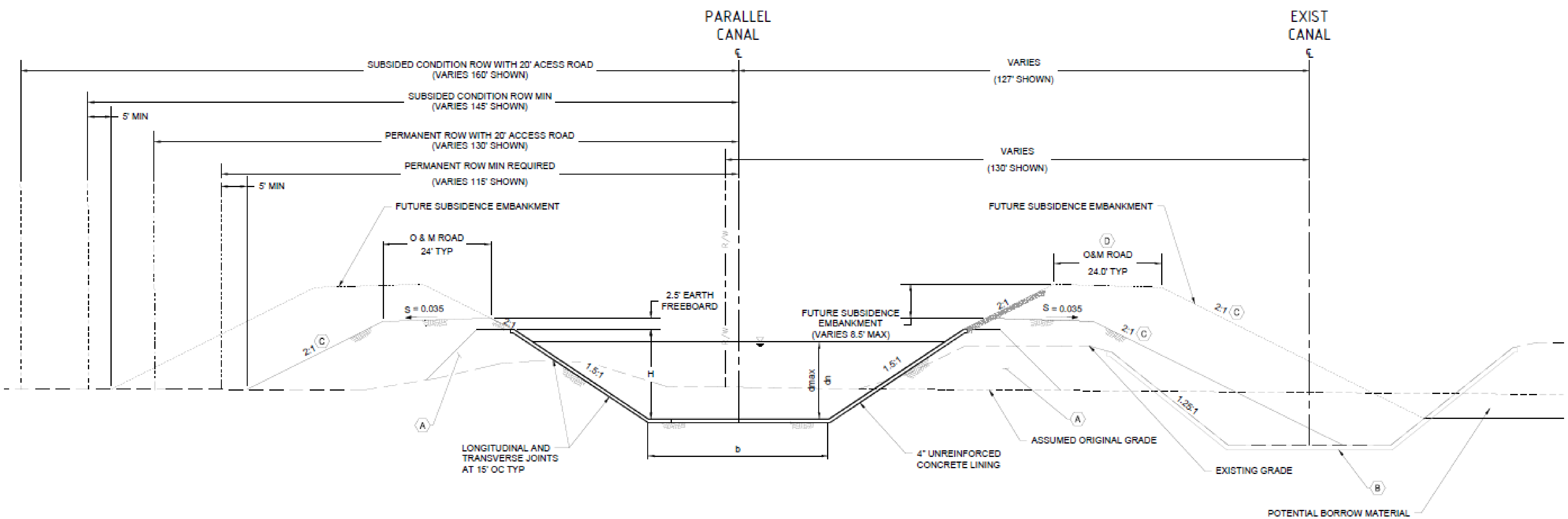
TYPICAL WIDEN CANAL SECTION - STA 4773+60 TO 5166+80
SCALE: 1" = 10'

Figure 3-10 - Typical Widen Canal Section

		STATION		A	V	Qmax	Qn	n	s	b	dmax	dn	H	s:s	r	wp	tw
SECTION	SURFACE	BEGIN	END	(SQ FT)	(FT/S)	(CFS)	(CFS)	-	(FT/FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)
TULE RIVER SIPHON		5166+36	5171+28			4000	3000										
5	CONCRETE	5171+28	5536+81	1121.63	3.57	4000	3000	0.016	0.00006	40	17.09	14.68	18.17	1.5:1	11.04	101.62	91.27
DEER CREEK SIPHON		5536+81	5539+95			4000	3000										
5	CONCRETE	5539+95	6076+37	1005.69	3.48	4000	3000	0.016	0.00006	40	17.09	14.68	18.17	1.5:1	11.04	101.62	91.27
WHITE RIVER SIPHON		6076+37	6079+11			3500	2500										
6	CONCRETE	6079+11	6423+31	1005.69	3.48	3500	2500	0.016	0.00006	32	17.34	14.59	18.37	1.5:1	10.64	94.51	84.01
2	EARTH	6423+31	6530+61			3500	2500	0.016		60							
WOOLLOMES CHECK		6530+92				3500	2500										

SHEET KEYNOTES

A. COMPACTED EMBANKMENT
B. EXISTING CANAL
C. BANK SLOPE SHOWN AS 2:1, A BANK SLOPE OF 1.5:1 MAY BE CONSIDERED TO MINIMIZE ROW REQUIREMENTS.
D. CANAL RIGHT O&M ROAD SHOWN AS 24', EMBANKMENT TOP WIDTH MAY BE ADJUSTED TO MINIMIZE ROW REQUIREMENTS.



PARALLEL CANAL SECTION - STA 5175+00 TO 6395+00
(ABANDON EXISTING CANAL WITH SUBSIDENCE CONSIDERATIONS)
SCALE: NOT TO SCALE

Figure 3- 11 - Parallel Canal Section

New checks, wasteways and siphons would be required for Deer Creek, and White River along with new control buildings and associated electrical, mechanical, and controls equipment. Refer to **Section 4.3.19** for additional information regarding the check structures.

This alternative requires 25 bridge replacements. **Figure 3-12** depicts the system schematic for Alternative 1, and utilizes the legend provided in **Figure 3-8.**

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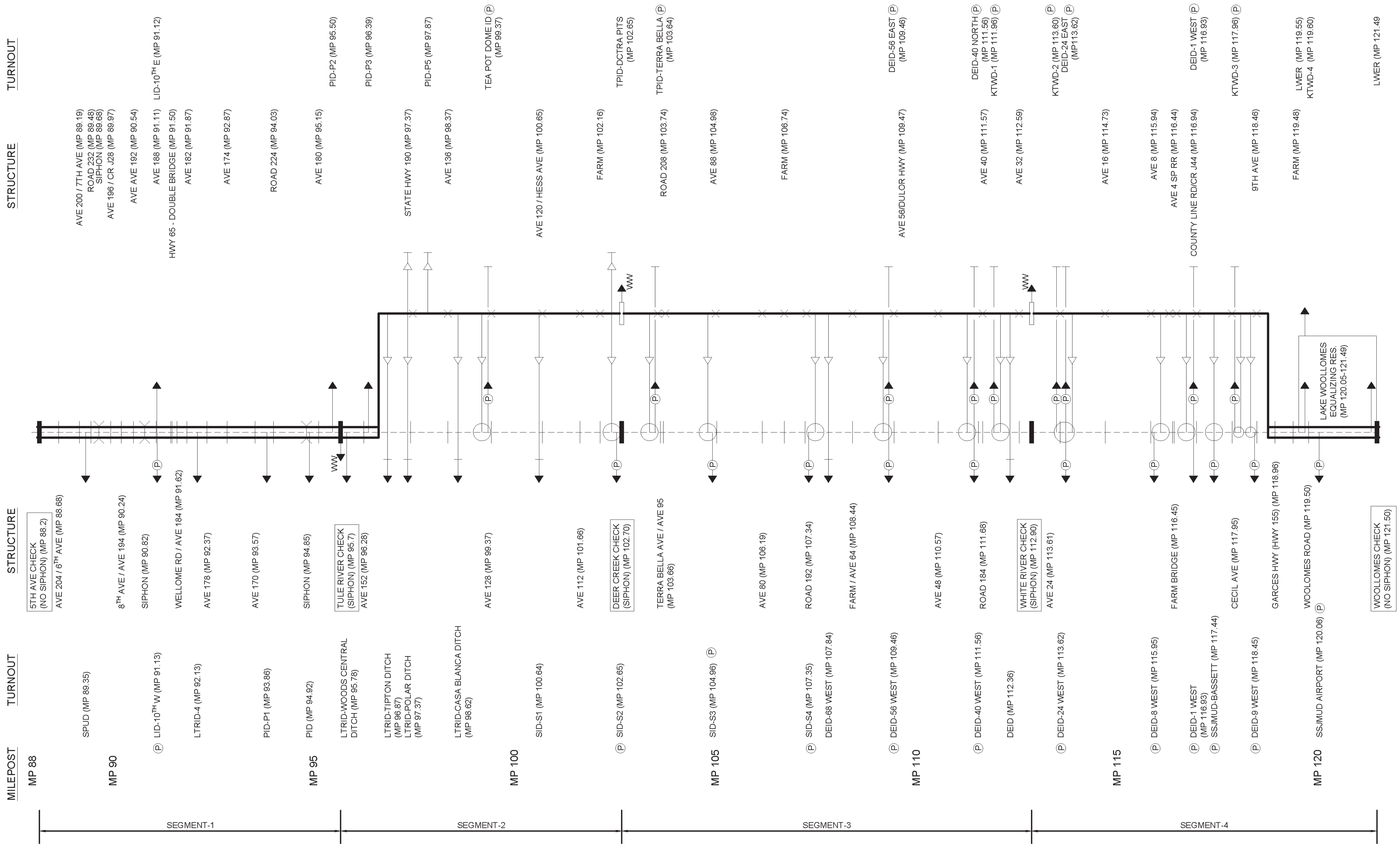

Figure 3-12 - Alternative 5 – Parallel Canal System Schematic

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3.6.2 Parallel Canal Alignment

There are several contributing factors to establishing the current new canal centerline alignment. The goal is to both minimize the additional right-of-way needed and place the new canal immediately adjacent to the existing FKC (to eliminate unusable lands between the canals). The specific locations of existing turnouts and roadways relative to the existing FKC were taken into consideration to establish the alignment as described below. It is anticipated that as the design progresses the alignment, as well as contributing factors will continue to be refined.

- Existing FKC Alignment - The existing alignment was the starting point for establishing the new centerline. Two alternatives were investigated that considered construction sequencing; 1) Keep the existing FKC in operation upon completion of construction. The projected future subsidence embankment toe of slope on new canal right (i.e. existing FKC left) was set to be 5 foot offset from the hinge point on the existing canal-side O&M road. The centerline distance varies along the alignment but is nominally 175 feet. and 2) Abandon use of the existing FKC (use right embankment as a borrow source to construct new canal embankments), construct the compacted new right embankment with the embankment toe of slope intersecting with the line projected from the existing FKC top of canal lining at a 1:1 slope (needed to maintain deliveries in the existing FKC during construction of the new parallel canal). The centerline distance varies along the alignment but is nominally 127 feet. The second alternative results in a needed source of borrow for the new canal, and eliminates potential operational challenges associated with keeping the existing FKC in operation and was therefore selected for establishing the new centerline alignment.
- Turnout Delivery Pools – Refer to **Section 3.5.2** above.
- County Road 192 Parallel to existing FKC – The existing FKC parallels County Road 192 near MP 115.3 for approximately 1.7 miles. There is not enough room for a new parallel canal between the existing FKC and County Road 192, so the new parallel canal alignment is situated to the east of County Road 192.
- Minimum Radius of Curvature – This criteria is described in **Section 4.3.7**.
- Potential Future Subsidence – This was included in considering the centerline alignment as described above. Also refer to **Section 4.3.5** for additional information regarding subsidence criteria.

3.6.3 Turnouts

Measures to accommodate the existing turnouts can be grouped into three methods 1) no modifications needed, 2) construct a new turnout and associated delivery pool in the existing FKC, and 3) construct a new turnout. **Table 3-10** provides information on each turnout along with the method proposed.

Table 3-10 - Alternative 5 - Parallel Canal Turnout Details

Milepost	Location	Material	Size	Type	Name	Alternative 5 Measure
89.35	West	Conc Bbl	**20"**	G	SPUD	None
91.12	East	Conc Bbl	4' x 4'	G	LID-10	None
91.12	West	Conc Bbl	2 - 4.5' x 4.5'	PP	LID-10	None
92.13	West	Conc Bbl	2 - 7' x 7'	G	LTRID-4	None
93.85	West	Conc Bbl	2 - 4.5' x 4.5'	G	PID-P1	None
94.92	West	Conc Bbl	2 - 5' x 5'	G	PID-P2	None
95.50	East	Conc Bbl	4.5' x 4.5'	G	PID-P2	None
95.78	East	Conc Bbl	2 - 4.5' x 4'	G	LTRID-Woods Central Ditch	None
96.39	East	Conc Pipe	36"	G	LPID-P3	None
96.87	West	Conc Bbl	2 - 4.5' x 4.5'	G	LTRID-Tipton Ditch	New Turnout
97.37	West	Conc	2 - 4.5' x 4.5'	G	LTRID-Poplar Ditch	New Turnout
97.86	East	Conc Pipe	36"	G	PID-P5	New Turnout
98.62	West	Conc	3 - 4.5' x4.5'	G	LTRID-Casa Blanca Ditch	New Turnout
99.35	East	Conc Bbl	3' x3'	P	Tea Pot Dome ID	New Delivery Pool Turnout
100.64	West	Conc Bbl	2 - 4' x 4'	G	SID-S1	New Turnout
102.65	East	Conc Bbl	3' x 3'	G	TBID-DCRA Pits	New Turnout
102.65	West	Conc Bbl	2 - 4.5' x 4.5'	P	SID-S2	New Delivery Pool Turnout
103.64	East	Conc Bbl	2 - 4.5' x 4.5'	P	TBID-Terra Bella	New Delivery Pool Turnout
104.96	West	Conc Bbl	2 - 4' x 4'	P	SID-S3	New Delivery Pool Turnout
107.35	West	Conc Bbl	2 - 3.5' x 3.5'	P	SID-S4	New Delivery Pool Turnout
107.84	West	Con Bbl		G	DEID-68 West	New Turnout
109.46	West	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-56 East	New Delivery Pool Turnout
109.46	East	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-56 West	New Delivery Pool Turnout
111.56	West	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-40 North	New Delivery Pool Turnout
111.56	East	Conc Bbl	4' x 4'	P	DEID-40 West	New Delivery Pool Turnout
111.96	East		4' x 4'	P	KTWD-1	New Delivery Pool Turnout
112.36	West	Conc		G	DEID	New Turnout
113.60	East	Steel Pipe	5 - 24"	P	KTWD-2	New Delivery Pool Turnout
113.62	West	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-24 East	New Delivery Pool Turnout

Table 3-10 - Alternative 5 - Parallel Canal Turnout Details cont'd

Milepost	Location	Material	Size	Type	Name	Alternative 5 Measure
113.62	East	Conc Bbl	2 - 4.5' x 4.5'	P	DEID-24 West	New Delivery Pool Turnout
115.95	West	Conc Bbl	2 - 4' x 4'	P	DEID-8	New Delivery Pool Turnout
116.93	East	Conc Bbl	3 - 4.5' x 4.5'	P	DEID-1	New Delivery Pool Turnout
117.44	West	Conc	2 - 4.5' x 4.5'	P	SSJMUD Bassett	New Delivery Pool Turnout
117.96	East	Steel	7 - 10"	P	KTWD-3	New Delivery Pool Turnout
118.45	West	Conc Bbl	3' x 3'	P	DEID-9	New Delivery Pool Turnout
119.55	East	Conc Pipe	2 - 24"	G	LWER	None
120.06	West	Conc	2 - 4.5' x 4.5'	P	SSJMUD Airport	None
121.49	East	Conc Bbl	2.5' x 6'	G	LWER	None

Key:
G – Gravity Turnout
P – Pressurized Turnout

3.6.4 Roadway Crossings

Refer to **Section 3.4.3** for an overview of the approach to roadway crossings. **Table 3-11** provides a summary of the measures proposed for the roadway crossings for this alternative.

Table 3-11 - Alternative 5 - Parallel Canal Roadway Crossing Details

Milepost	Description	Name	Alternative 5 Measure
88.67	Bridge, County	Ave 204/7th Ave.	None
89.17	Bridge, County	Ave 200/7th Ave.	None
89.45	Bridge, County	Road 232	None
89.95	Bridge, County	Ave 196/CR J28/Frazier Hwy	None
89.95	Bridge, County	Ave 194/8th Ave.	None
90.23	Bridge, County	Ave 192	None
91.10	Bridge, County	Ave 188	None
91.47	Bridge, State	State Hwy 65 (Westbound)	None
91.50	Bridge, State	State Hwy 65 (Eastbound)	None
91.60	Bridge, County	Ave 184/Welcome Rd	None
91.85	Bridge, County	Ave 182	None
92.35	Bridge, County	Ave 178/Mt View Ave	None
92.85	Bridge, County	Ave 174/Linda Vista	None
93.55	Bridge, County	Ave 170/W. North Grand Ave	None
94.01	Bridge, County	Road 224/N Westwood St	None

Table 3-11 - Alternative 5 - Parallel Canal Roadway Crossing Details cont'd

Milepost	Description	Name	Alternative 5 Measure
95.12	Bridge, County	Ave 180/ Henderson	None
96.26	Bridge, County	Ave 152/ Olive Ave	None
97.35	Bridge, State	State Hwy 190, Ave 144	Concrete Box Siphon
98.38	Bridge, County	Ave 136	Concrete Box Siphon
99.37	Bridge, County	Ave 128	Concrete Box Siphon
100.64	Bridge, County	Ave 120, Hesse Ave	Concrete Box Siphon
101.64	Bridge, County	Ave 112	Concrete Box Siphon
102.14	Bridge, Farm		Concrete Box Siphon
103.65	Bridge, County	Ave 96, Terra Bella Ave	Concrete Box Siphon
103.72	Bridge, County	Road 208	Concrete Box Siphon
104.95	Bridge, County	Ave 88	Concrete Box Siphon
106.72	Bridge, County	Ave 80	Concrete Box Siphon
106.75	Bridge, Farm	Ave 74	Concrete Box Siphon
107.32	Bridge, County	Road 192	Concrete Box Siphon
108.42	Bridge, Farm	Ave 64	Concrete Box Siphon
109.45	Bridge, County	Ave 56/Ducor Hwy/Sierra Avenue	Concrete Box Siphon
110.55	Bridge, County	Ave 48	Concrete Box Siphon
111.55	Bridge, County	Ave 40	Concrete Box Siphon
111.66	Bridge, County	Road 184	Concrete Box Siphon
112.57	Bridge, County	Ave 32	Concrete Box Siphon
113.59	Bridge, County	Ave 24	Concrete Box Siphon
114.71	Bridge, County	Ave 16/SP RR	Concrete Box Siphon
115.91	Bridge, County	Ave 8	Concrete Box Siphon
116.41	Bridge, Farm (2)	4th Ave/Old RR Crossing	Concrete Box Siphon
116.91	Bridge, County	County Line Rd/CR J44	Concrete Box Siphon
117.92	Bridge, County	Cecil Ave	Concrete Box Siphon
118.44	Bridge, County	9th Ave	Concrete Box Siphon
118.94	Bridge, State	Garces Hwy/Hwy 155	None
119.46	Bridge, Farm	H - 10	None
120.02	Bridge, County	Woollomes Ave	None

Notes:
[1] timber bridges parallel to the existing FKC at Porter Slough and Tule River not included

Key:
Rdwy = roadway
Ave = avenue
Hwy = highway
RR = railroad

3.6.5 Utilities

There are numerous utilities in, along, and across the canal that need to be addressed. The utilities include parallel irrigation canals, fly overs, overhead power, adjacent wells, drainage siphons and irrigation crossings that go 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. Replacement or relocation will depend on the final design, but a current estimate based on observations made during a site visit during February 2019 is provided in **Table 3-12**. This does not include the numerous utilities that are supported by the existing bridges that will need specific relocation methods depending upon the roadway crossing approach used.

Table 3-12 - Alternative 5 - Parallel Canal Alternative – Utility Modifications

Type of Utility	Proposed Modification	Estimated Quantity
Overhead Powerline	Relocation of parallel utility	14 miles
Groundwater Well	Abandonment	23 each
Culverts	Extension	13 each
Pipeline Overcrossings	Relocation	14 each

3.6.6 Construction Sequencing Description

An initial high-level construction sequencing plan has been developed that will enable the new parallel canal to be constructed while keeping the existing FKC and associated turnouts in operation and using the existing FKC right embankment as a valuable source of borrow material. **Table 3-13** below accompanies the sequencing steps shown in **Figure 3-13**.

Table 3-13 - Alternative 5 - Parallel Canal – Construction Sequencing Steps

Step	Description of Activities	Status of Existing FKC
1	Excavate existing FKC left embankment and recompact as compacted embankment. This excavation and recompaction is needed to ensure that a firm foundation for the new lining is provided. Construct a portion of the new west turnouts within this recompacted embankment.	Remains in operation.
2	Excavate material from new canal and combine with material from existing FKC left embankment to construct new canal left compacted embankment. Trim and place concrete lining in new canal section. Construct new east turnouts and connection piping to existing systems. Construct new concrete box siphons at roadway crossings and new Deer Creek and White River checks/wasteways/siphons.	Remains in operation.
3	Place new canal into operation while sequencing connection of new turnouts to existing system. Complete placement of new canal right and left embankment using existing FKC right embankment as borrow source. Decommission existing FKC, with minimal to no removal of old concrete lining (as needed to use borrow source) – to remain with ROW	Removed from operation
4	(Potential Future Subsidence). Construct potential future subsidence embankments using material within FKC ROW.	Not in operation

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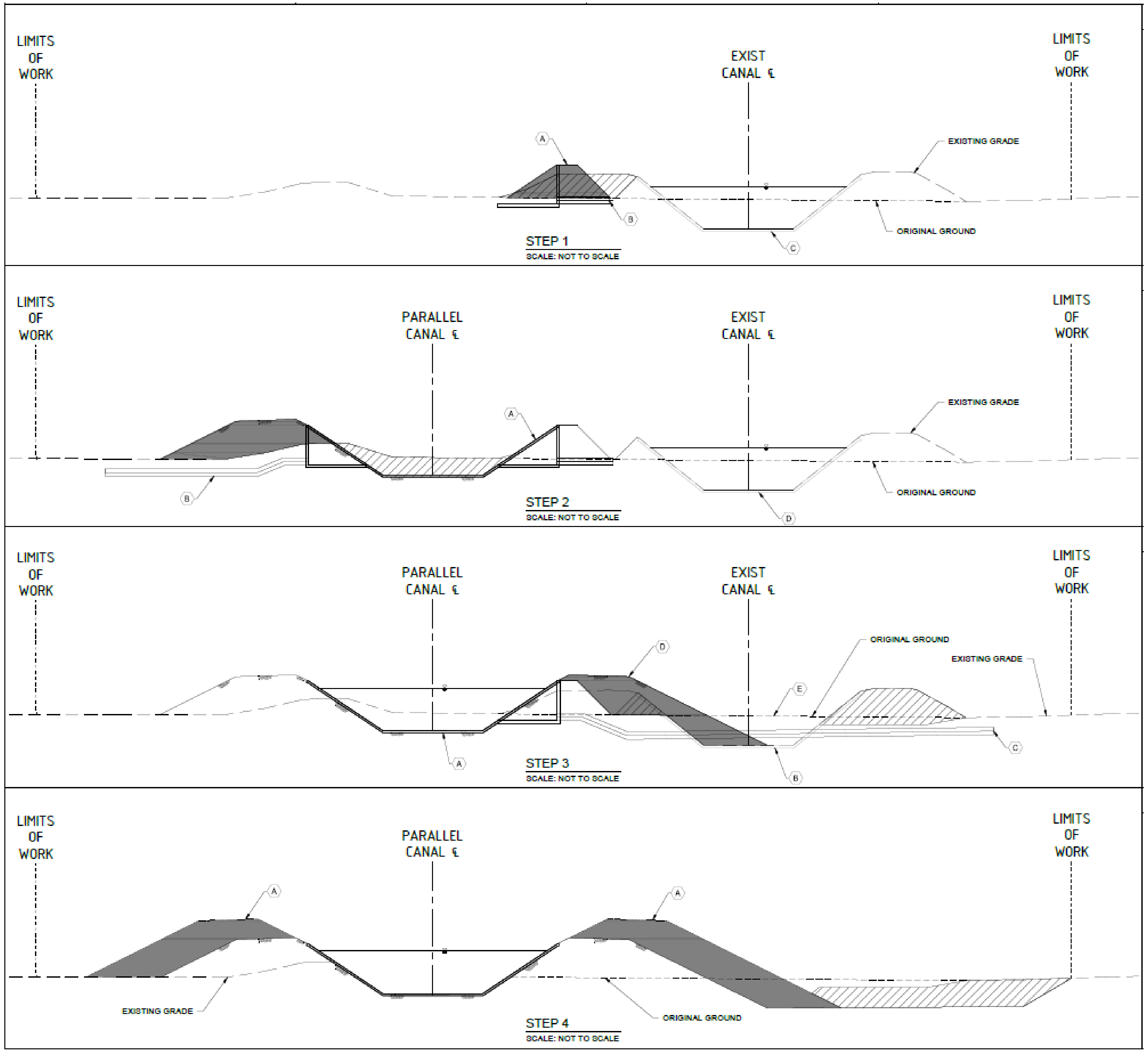

Figure 3-13 - Construction Sequencing Steps

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3.6.7 Earthwork Computations and Borrow Source

Digital terrain models were prepared from the aerial surveying conduct in mid-2018. Building Information Model (BIM) using AutoCAD Civil 3D has been utilized to prepare earthwork computations for each canal segment (at 100 foot station intervals) in specific steps on how the canal would be constructed per the sequencing described above. The existing FKC right embankment has been used as a source of borrow material. Computations include earthwork tables (i.e. cut, fill, etc.) and mass haul diagrams. Segments 2 and 3 balance and Segment 4 has approximately 20,000 cubic yard excess.

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4. DESIGN CRITERIA

4.1 SURVEY AND MAPPING

There is no additional information from that which was presented in Exhibit A.1.a Initial Alternatives Basis of Design Report.

4.2 GEOTECHNICAL INVESTIGATION

There is no additional information from that which was presented in Exhibit A.1.a Initial Alternatives Basis of Design Report.

4.3 CANAL DESIGN CRITERIA

4.3.1 Design References

Bureau of Reclamation design references include the following:

- Friant-Kern Canal Technical Record of Design and Construction, May 1958
- Design Standards No. 3, Water Conveyance Systems, DS-3-2 – 1994, Chapters 11 and 12
- Design Standards No. 3, Canals and Related Structures, DS-3-5 – December 8, 1967
- Technical Memorandum 661, Analysis and Descriptions of Capacity Tests in Large Concrete-Lined Canals, April 1964
- Concrete Manual, Eighth Edition, Revised 1981, Reprinted 1998
- Linings for Irrigation Canals, First Edition 1963, Second Printing 1976
- Earth Manual, Part 1, Third Edition, 1998
- Safety and Health Standards, 1993, Reprinted 2001
- Design of Small Canal Structures, 1978
- Water Measurement Manual, Third Edition, 1997
- Construction Activities, Reclamation Manual FAC 03-02

Other design references include the following:

- FKC Structures List, Friant Water Authority, November 2007

- Drawings for the Construction of FKC, Record Drawings, September 1947
- Drawings for the Construction of FKC Rehabilitation, Record Drawings, June 1976
- Friant-Kern Canal Technical Record of Design and Construction, Bureau of Reclamation, May 1958

4.3.2 Canal Capacity

The flow rates for the FKC original design and the two alternatives are shown in **Table 4-1**.

Table 4-1 - Design Flow Rates

Original Canal Section No.	Canal Reach (Milepost to Milepost)	Description (Check to Check)	Original Normal Flow Rate (cfs)	Original Design Maximum Flow Rate (cfs)	Alternative 1 Flow Rate [1](cfs)	Alternative 5 Flow Rate [2](cfs)
4	88 to 95.67	5th Ave. to Tule	3,500	4,500	4,008	4,500
5	95.67 to 102.70	Tule to Deer Creek	3,000	4,000	3,497	4,000
5	102.70 to 112.90	Deer Creek to White River	3,000	4,000	2,888	4,000
6.1	112.90 to 121	White River to Lake Woollomes	2,500	3,500	2,490	3,500

Notes:

[1]Historical maximum flow rate. FKC daily operations data for years 2003 to 2018 were reviewed to identify the maximum historical flows associated with Friant contract deliveries in each segment of the Middle Reach

[2]Original design maximum flow rate.

Key:
cfs – cubic feet per second

4.3.3 Lining Freeboard

The minimum operating freeboard provided for the concrete lining, from maximum water depth at the design flow to the top of the concrete lining is shown for each reach of the canal sections in **Table 4-2**.

Table 4-2 - Design Freeboard Requirements

CANAL REACH			ORIGINAL FREEBOARD[1] AT RECLAMATION FLOOD FLOW AND MAX FLOW		
Original Canal Section No.	**Canal Reach (Milepost to Milepost)**	**Description**	**Flood Flow Lining Freeboard (ft)**	**Max Flow Lining Freeboard (ft)**	**Alternatives 1 & 5 Lining Freeboard (ft)**
4	88 to 95.67	5th Ave. to Tule	1.18	2.35	1.12
5	95.67 to 102.70	Tule to Deer Creek	1.15	2.29	1.08
5	102.70 to 112.90	Deer Creek to White River	1.11	2.23	1.08
6.1	112.90 to 121	White River to Lake Wooloomes	1.03	2.06	1.03
Notes: [1]Concrete lining freeboard [2]Freeboard calculated per Reclamation canal design standards.					
Key: cfs – cubic feet per second ft – feet					

The flood flow lining freeboard at flood flow shown in Table 3-2 represents the minimum standard that Reclamation would require the canal prism to be designed to. This is the freeboard requirement that Reclamation has designed previous phases of FKC rehabilitation projects to. Reclamation allows for the reduction in max flow lined freeboard by one-half for short term flood flows that enter the canal from cross drainage and can be evacuated from canal by wasteways. However, the FKC max design flow freeboard includes water available during wetter hydrologic conditions (i.e. Class 2, 215, 16(b) or RWA water) that are conveyed over a long period of time, with no intention of evacuating the excess flows from the canal. Based on this, the design assumption is that minimum lined freeboard for the FKC alternatives will be as shown in the “Max Flow” conditions in **Table- 4-2**.

4.3.4 Earth Freeboard

In all cases the minimum earthen freeboard, from the top of the concrete lining to the top of the earthen embankment will be 2.5 feet per Reclamation standards.

4.3.5 Potential Future Subsidence

Exhibit A.1.b Selection of Future Subsidence Conditions provides a discussion on the selection of potential future subsidence conditions that was used in the evaluation of the initial project alternatives. It is anticipated that the numerical groundwater model used for the analysis will be recalibrated (with additional information) and additional scenarios will be analyzed in 2019 that will produce similar, but potentially different findings to that which resulted in 2018. For the

Feasibility Level design for Alternative 5 – Parallel Canal Alternative, the alignment of the new canal was established to accommodate potential future subsidence by considering the potential future subsidence embankment and concrete canal lining. However, it is not planned to include the additional earthwork and appurtenant features in the initial construction. The estimate of additional rights-of-way needed consider the potential future subsidence embankments. It is recommended that the numerical groundwater model analyses be revisited during design and that subsidence criteria be finalized.

4.3.6 Canal Stationing

The original canal stationing from the 1940's used many station equations. Station equations were very common in that time period since it was not very practical to re-station entire alignments when an alignment change was made that affected the stationing. Station equations oftentimes contributed to complexities during construction because equations are very tedious to account for and oftentimes led to errors due to equations not accounted for correctly. Today, our computer technology eliminates the need for complex station equations and allows for complex earthwork calculations to be performed very efficiently.

Use of original stationing with multiple station equations for the existing FK would add complexities to the earthwork calculations. Therefore, Stantec has established a stationing for the existing FKC with no equations to facilitate computer generated earthwork quantities. The project stationing starts at the beginning of the inlet transition to 5th Avenue Check Structure at Station 4773+00 and continues sequentially with no equations along the FKC. For Alternative 5, stationing also starts at the beginning of the inlet transition to 5th Avenue Check Structure and continues sequentially with no equations. During final design original FKC stationing can be included on the drawings as annotations to specific structures as reference information.

4.3.7 Canal Curve Radius

The minimum radius of curvature for new canal centerlines will be 250 feet except where there is a specific need to have a reduced radius. However, no radius will be less than 1.5 x TW, where TW is the width of the water surface at design flow.

4.3.8 Canal b/d Ratio

The minimum canal b/d ratio for the new parallel canal prisms will be 1.3, where "b" is the canal bottom width and "d" is the normal depth at the design normal depth flow rate.

4.3.9 Canal Prism

Alternative 1 - Canal Enlargement

The typical canal section for enlargement of the existing canal section will be via a compound trapezoidal section that will consist of a lined bench widened section. From the lined benches the concrete-lined side slopes will be 1.5 horizontal to 1 vertical (1.5:1). The compound trapezoid section may have excess flow area along lengths of the existing FKC where the deeper subsidence conditions exist. The bench portion of the trapezoidal section has been reduced from that previously considered in the alternative analyses. Refer to **Section 2** for a description of the compound trapezoidal section.

Alternative 5 - Parallel Canal

The typical canal section for new parallel canal will have a more traditional trapezoidal shape with concrete-lined side slopes of 1.5 horizontal to 1 vertical (1.5:1). The earthen freeboard portion of all canal sections whether enlargement of existing canal prisms or new canals will be sloped at 2:1. The typical canal cross sections for the new parallel is shown in **Section 2**. An earthen typical section for the existing FKC enlargement planned in Segment 4 will also be used.

4.3.10 Canal Banks and Operation and Maintenance Roads

Operation and maintenance are provided on both sides of the canal. Canal bank roads will have a road width of 24 feet. For the cost estimating purposes, it was assumed that an all-weather road with a 4 inch aggregate base finish course would be provided along one side of the canal and the other canal bank would not have an all-weather finish.

The inside radius of the travel way shall be a minimum of 20 feet at all intersections with public and private roads as well as all access ramps to the O&M road.

The outside slopes of the O&M road banks use a 2 horizontal to 1 vertical side slope. This will be confirmed by a slope stability analysis during design to evaluate factors of safety for different slope inclination and geometry. A final decision can then be made on bank slope design considering slope stability, acceptable factors of safety, and impacts on land acquisition. The bank slopes considered will likely range from 1.5:1 to 2:1. 2:1 slopes were assumed during this phase of alternative analysis.

4.3.11 Concrete Thickness

Reclamation standards for the minimum lining thicknesses for unreinforced concrete lining in canals with flow rates between 1,500 cfs and 3,500 cfs is 3.5 inches and between 3,500 cfs and 7,000 cfs will be 4.0 inches.

There will be significant cost implications when comparing lining costs associated with a 3.5 inch and 4.0-inch concrete lining. For this project, the minimum thickness for all machine-placed canal lining will be 3.5 inches, however further analysis will be performed during design comparing the cost impacts of 3.5 inch and 4.0-inch linings for canal sections greater than 3,500 cfs. The cost impacts may lead FWA to finalize the use of a 3.5-inch-thick concrete lining for all canal sections.

4.3.12 Canal Lining Joints

Transverse and longitudinal contraction joints will be spaced a maximum of 15 feet apart on centers. All joints will be standard PVC water stop, sealed type joints. For concrete canal lining it is the accepted practice to plan for anticipated shrinkage cracking and install contraction joints to induce and control crack location. By inducing cracking at the contraction joints, random cracking is controlled and the leakage from the lining is kept to a relatively small amount. Expansion joints will be used between siphon transition structures and check structures and adjacent canal lining.

4.3.13 Compacted Embankment

Depending on whether the existing canal modifications or new canal is in cut or fill, the sides of the canal will be formed from firm original earth or compacted embankment, respectively. For compacted embankments (in fill areas), earth materials will be placed and spread evenly in uniformly compacted horizontal layers. Each horizontal layer will not exceed 6 inches in compacted thickness. The compacted embankments will be homogeneous, free from lenses, pockets, streaks, laminations, or other imperfections. Prior to and during compaction operations, the earth materials will have a moisture content no greater than two percent wet or less than two percent dry of the optimum moisture content. Construction sequencing including the construction of the compacted embankments is described in Section 3.

4.3.14 Hydraulic Losses

The Manning's n-value for the project shall be n= 0.016.

4.3.15 Operating Velocity Range

The maximum velocity allowed for unreinforced concrete-lined canals per Reclamation standards is 6.0 ft/sec. The new canal operating velocity range will ideally be between 3.0 ft/sec and 5.9 ft/sec.

4.3.16 Sediment Transport

A sediment transport analysis for the canal system was not undertaken and none is anticipated to be needed. However, operating velocities in canal reaches should be designed to range between 3.0 ft/sec and 5.9 ft/sec. At these velocities, the canal sections will tend to reach various levels of equilibrium under varying flow conditions. Once in equilibrium, all new sediment entering the system will be passed through during low flows. During higher flows, the deposits will scour out.

4.3.17 Water Level Drawdown

The rate of water level drawdown is critical to ensure the longevity of canal lining. If the water within the canal prism drops more rapidly than groundwater in the soil behind the lining, hydrostatic backpressure can break and displace the lining. Therefore, drawdown rate is a function of drainage in the soil foundation material. Standard, conservative drawdown criteria should be used unless designers can be sure of good drainage behind the canal lining, either from naturally well-drained soil or from an engineered under-drainage system.

It is not yet clear where rapid drawdown will and will not be acceptable. More information on groundwater and soil drainage properties is needed before maximum drawdown rate can be finalized. The allowable drawdown rates may not be constant through the length of the selected project alternative, because soil properties may vary significantly.

Where the acceptability of more rapid drawdown cannot be ensured, design should be based on a maximum drawdown rate of 6 inches in one hour or 12 inches in 24 hours. Although this rate will be assumed during the design process, a higher rate of drawdown may prove to be acceptable during future operations of the canal.

4.3.18 Escape Ladders

Both existing canal modifications and new parallel canals will require escape ladders. For new canal construction escape ladders will be installed at 375-foot intervals on alternating sides of the canal with 750 feet between ladders on a given side. The escape ladders will be the expansion-anchored type, in accordance with current Reclamation standards and epoxy coated. For existing canal modifications, the ladder spacing, and design will match existing ladders. For cost estimating purposes the 750 feet between ladders on a given side criteria was assumed for all alternatives.

4.3.19 Check Structures

Table 4-3 below provides a description of the checks and associated wasteways associated with the Project. Several of the checks also have siphons associated with them.

Table 4-3 Existing Check Structures Summary

Milepost	Description	Gate Type	Size
88.22	Fifth Ave Check	Radial Gates	3 - 18' x 18'
95.64	Tule River Wasteway	Radial Gates	4 – 11’ x 10.75’
95.66	Tule River Check	Radial Gates	4 - 12' X 17.5'
102.69	Deer Creek Wasteway	Radial Gates	3 – 12’ x 7’
102.69	Deer Creek Check	Radial Gates	4 – 12’ x 17.5'
112.90	White River Wasteway	Radial Gates	2 - 12’ x 9’
112.90	White River Check	Radial Gates	2 - 18' x 19.5'
121.50	Reservoir Check (i.e. Lake Woolomes)	Radial Gates	3 - 14' x 20'

Only the Deer Creek, White River, and Lake Woollomes existing check structures may have to be modified or new check structures may have to be constructed depending on the alternative. Check structures will be designed to maintain water levels required to supply turnouts. Check structures will be designed to meet the most current governing codes and standards for structural design.

Deer Creek Check

The Deer Creek Check has already been modified in 1977.The Reclamation construction drawings show that the Deer Creek radial gate sill was raised 2.5 feet. For either alternative an approximate 5-foot elevation raise is needed for the Project (not accounting for potential future subsidence). The following describes a high-level structural assessment of the potential to modify the structure; no actual structural calculations were prepared.

There is no current condition assessment of this structure available. With limited information of the existing structure, it will be challenging to determine the capacity of the existing structure. Raising the existing check structure will add mass to the local structural elements such as the walls, slabs, and foundation. When making modifications or alterations to existing structures, standard practice is to consider the requirements outlined in Title 24 of the California Existing Building Code. There are two verifications that need to be considered when adding to or altering existing structure. The first verification is to limit the increase in mass. When making modifications to existing structural elements for which an addition and its related alterations cause an increase in the design gravity load of more than five-percent and lateral load of more than ten-percent, the existing structural element shall be strengthened, supplemented, replaced or otherwise altered as needed to carry the increased gravity and lateral loads required by code for new structure. The second verification is to limit the demand-capacity ratio of the existing structural element within five-percent for considerations due to gravity and ten-percent for considerations due to lateral to avoid a complete redesign to the new code.

By increasing the overall height of the check structure, the unbraced length of the walls will increase. Under static conditions, it appears that the wall elements will have enough capacity since there does not appear that any differential head will be acting on the wall. However, another increasing the wall segments will result in increasing the unbraced length of the wall and increase the hydrodynamic loading on the wall. With the existing check structure already have undergone an increase in wall height, it is anticipated that the existing structural walls will not have enough capacity to avoid a redesign to current code. From an initial structural assessment, it is likely not feasible to modify the existing structure to accommodate the additional raise needed to accommodate existing subsidence.

White River Check

For either alternative an approximate 1.7-foot elevation raise is needed for the Project (not accounting for potential future subsidence). For Alternative 1 - Canal Enlargement, it is anticipated that this raise can be accommodated simply because a slightly larger raise was implemented for the Deer Creek Check about 40 years ago. No structural calculations have been performed at this time.

Near White River Check the existing FKC is parallel to and immediately west of County Road 192. There is not enough room to place the Alternative 5 - Parallel Canal alignment between the existing FKC and County Road 192, and the new alignment is placed to the east of County Road 192. Modifying White River check would mean adding two new roadway crossings of County Road 192 (upstream and downstream of the existing check structure). At a high-level assessment it did not appear to be cost-effective to add two new concrete box culverts while investing additional improvements to a structure that is approximately 70 years in age. A new check structure, wasteway, siphon and associated control building and mechanical, electrical and controls equipment is recommended.

4.3.20 Safety Buoys

Where not already provided, safety buoys will be installed at the entrances to siphons and check structures. There are essentially two options for buoys, spherical and elongated cylindrical. The spherical buoys provide better clearance for passing floating debris.

4.3.21 Turnouts

Section 2 provides an overview of the approach to ensuring turnouts are compatible with the alternatives proposed along with details of existing turnouts and proposed modifications.

4.4 BRIDGE AND STRUCTURAL DESIGN CRITERIA [REVISED]

4.4.1 Governing Codes and Standards

The following documents will form the basis for design and construction of the bridge where they are applicable, as referenced in this document.

- AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017 for all elements except the cables
- AASHTO Standard Specifications for Highway Bridges, 17th Edition, 2002 for the cables.
- AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, 2nd Edition 2009 with 2015 Interim Revisions
- AASHTO Guide Design Specifications for Bridge Temporary Works, 2nd Edition, 2017
- California Amendments (to the AASHTO LRFD Bridge Design Specifications – 6th Ed.), March 2014
- Caltrans, Seismic Design Criteria Version 1.7, April 2013 (CA SDC)
- Caltrans, Seismic Design Specifications for Steel Bridges, 2nd Ed. 2016 (CA GSSDSB)
- Caltrans, Bridge Memo to Designers (Seismic Design Methodology per MTD 20-1)

- Caltrans, Bridge Design Aids, August 2016
- Caltrans, Bridge Design Practice, 4th Ed., 2015 (CA BDP)
- Caltrans Standard Specifications, 2018
- ACI 318-14 Building Code Requirements for Structural Concrete and Commentary, 2014
- AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Ed., 2011 (AASHTO Guide Specs)
- AASHTO Guide Specifications for Seismic Isolation Design, 4th Ed., 2014
- AISC Steel Construction Manual, 14th Ed., 2011 (AISC)
- ANSI / AASHTO / AWS D1.5, Bridge Welding Code (Bridge Welding Code)
- ANSI / AASHTO / AWS D1.1, Structural Welding Code (Structural Welding Code)
- ANSI / AASHTO / AWS D1.4, Rebar Welding Code (Rebar Welding Code)
- ANSI / ASCE 7-16, Minimum Design Loads for Buildings and Other Structures, 2016
- Tulare and Kern County Standards for Structural Materials

4.4.2 Structural Materials

Structural materials are anticipated to meet the following requirements. However, as preliminary design progresses material requirements may be revised.

4.4.3 Concrete

- Structural Reinforced Concrete – 3,600 lbs per square inch (psi) minimum
- Reinforcement – ASTM A706 Grade 60, fy= 60 ksi
- Prestressed Concrete – 4,000 psi minimum at release and final
- Prestressing Strand - ASTM A416 Grade 270 low-relaxation, fpu = 270 ksi

4.4.4 Bridge Design Criteria

The documents as presented herein will form our initial basis for design and construction of the bridges. This will need to be coordinated with Tulare and Kern County, and Caltrans to inform the criteria and process.

In general, the Load and Resistance Factor Design (LRFD) method as required by AASHTO will be used for the design of all bridges. Live load deflection, steel fatigue limits and concrete crack control shall be checked to ensure serviceability of the bridge. Design quality checks in accordance with Caltrans policy shall be performed to ensure design accuracy, as well as drawing and specification quality. Bridge design loads shall be based on unit weights of materials and the computed volumes of the structural elements as follows:

A. Dead Loads

- Concrete, Reinforced or Prestressed: Normal Weight Concrete = 150 pcf
- Structural Steel and Reinforcement = 490 pcf
- Steel Components = 490 pcf
- Concrete Curb/Barriers = 150 pcf
- 3 inch asphalt wearing surface (if applicable) = 36 psf
- Earth Fills = Actual Weight
- Maintenance facilities and utilities = Actual Weight
- Provision for future utilities = 25 plf

B. Live Loads

- The bridge will be designed for HL-93 standard truck and lane loads and other applicable permit live load as per the AASHTO LRFD Bridge Design Criteria. All design live loads shall be positioned both transversely and longitudinally so as to produce the maximum influence on the structure.

C. Pedestrian Live Loads

- Pedestrian loads of 90 psf shall be included in the design of pedestrian facilities.

D. Impact/Dynamic Load Allowance

- Dynamic load allowance will be applied in accordance with the Section 3.6.2 of AASHTO LRFD Bridge Design Specifications.

E. Seismic Demands on Structural Components: Seismic demand is represented using an elastic 5% damped response spectrum. In general, the Design Spectrum is defined as the greater of:

- A probabilistic spectrum based on a 5% in 50 years probability of exceedance (or 975-year return period.
- A deterministic spectrum based on the largest of median response resulting from the maximum rupture (corresponding to Mmax) of any fault in the vicinity of the bridge site
- A statewide minimum spectrum defined as the median spectrum generated by a magnitude 6.5 earthquake on a strike-slip fault located 12 kilometers from the bridge site.

Development of the design spectrum requires special knowledge related to the determination of fault location and interpretation of the site profile and geologic setter for incorporation of site effects. These aspects of the design spectrum will be coordinated with the geotechnical engineer for the project.

Two seismic design methodologies are available:

- Force Based Design Method: AASHTO LRFD Bridge Design Specifications
- Displacement Based Design Method: AASHTO Guide Specifications for LRFD Seismic Bridge Design & Caltrans Seismic Design Criteria

The seismic design requirements presented by Caltrans Seismic Design Criteria Version 1.7, April 2013 (CA SDC) will form the basis for seismic demands on all structural components, capacity of structure components, analysis, foundation performance, design and detailing of the bridges.

4.5 Rights-of-Way

4.5.1 Existing FKC Right-of-Way

Coordination with Reclamation to ascertain the existing FKC ROW has been occurring. Some parcel information is available in record books held by FWA, but this information is incomplete and does not have the configuration of a canal alignment with ROW offsets and ties to section corners.

In 2010 or thereabouts, Reclamation retained the Bureau of Land Management to conduct ROW surveys for the purposes of determining potential encroachments to the FKC. A map containing two layers concerning the ROW has been provided by Reclamation. The following disclaimer is provided with the map; "*This map contains information in two layers concerning the right-of-way for the Friant-Kern Canal. One layer called record ROW shows the right-of-way for the Friant-Kern Canal as described in the deed maps on record with the Bureau of Reclamation. Any misclosures or overlaps that occur reflect the problems contained within the legal description. The other layer called adjusted ROW shows the approximation of the right-of-way boundaries corrected and adjusted based upon minimal survey control. This information is not to be considered official or final and is only intended to show discrepancies and or problems between the deed and preliminary survey evidence recovered in the field. The layer adjusted ROW can be utilized to assist in determining potential trespass issues that need to be resolved. Anywhere along the canal where there is insufficient information to give an adequate adjustment to display only the record ROW is shown.*"

Efforts are underway to determine the party or parties responsible for determining the existing FKC ROW and make plans for implementation of this effort. For the purposes of the Feasibility level engineering designs, the map provided by Reclamation has been used as the preliminary basis for the existing ROW.

4.5.2 Additional Right-of-Way

Initial estimates of ROW limits were prepared for Alternative 5 – Parallel Canal using criteria of 1) potential future subsidence, to estimate maximum additional ROW needed; and 2) no potential future subsidence criteria, to estimate minimum additional ROW needed. The Feasibility Drawings in Exhibit B.1.a depict these approximate limits on the plan and profile drawings.

These should be considered as preliminary – for discussion purposes only and will change as the design progresses and formal criteria is established.

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5. REFERENCES

Stantec

2019 Initial Alternatives Basis of Design Report, March 2019

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RECLAMATION
Managing Water in the West

Feasibility Report Attachment B2. Feasibility Alternatives Cost Estimates

Friant Kern Canal Middle Reach Capacity Correction Project Feasibility Study

November 2019

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.

Friant-Kern Canal
Middle Reach Capacity Correction Project

Alternative 1 – Enlarge Existing Canal
Design Maximum Capacity

FEATURE:	**PROJECT:**
Canal Enlargement **MP 88.2 to 121.5**	**Friant-Kern Canal** **Middle Reach Capacity Correction**
	WOID:
	ESTIMATE LEVEL: **Feasibility**
Design Max Flow	**REGION:** **MP**
2018 Land Surface	**UNIT PRICE LEVEL:** **10/1/2019**
	FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Final Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 1 - 5th Ave to Tule					
		Removals					
	1	Score/Remove (e) Concrete Liner		39,373	lf	$44.00	$1,732,488
	2	Strip/Clear Vegetation at New Embankment Areas		41	ac	$4,336	$176,353
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for Truck Hauls		200	dys	$128	$25,539
		Excavation to Embankment or Waste		1,050,639	cys		
	4	Disk/Pre-Wet Excavation Areas		306,234	sy	$2.44	$747,083
	5	Excavation to Embankment - Scraper/Dozer (Balance)		483,273	cys	$5.45	$2,636,178
	6	Excavation to Spoil Embankment (Scraper/Dozer)		519,898	cys	$4.09	$2,126,971
	7	Excavation to Embankment - Short Truck Haul (Estimate - Qty under Dev)		50,000	cys	$7.83	$391,497
	8	Excavation to Embankment - Long Truck Haul (Estimate - Qty under Dev)		50,000	cys	$11.13	$556,623
	9	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3.44	$0
		Concrete Canal Liner					
	10	Trim/Compact Excavated Areas		384,213	sys	$3.92	$1,506,200
	11	Place 3.5" Concrete Liner		384,213	sys	$49.28	$18,934,105
	12	Final Cure for Concrete Liner		384,213	sys	$0.34	$130,830
	13	Trim/Point/Patch at (e) Liner Joint		78,746	lf	$3.41	$268,141
		Ancillary Facilities					
	14	New Ladders		105	ea	$5,959	$625,695
	15	Transition to (e) Bridges -112'		18	ea	$85,129	$1,532,315
	16	New Turnouts on New Canal		7	ea	$25,539	$178,770
		O&M Road					
	17	Prep/Compact Subgrade		105,011	sys	$2.94	$308,750
	18	Purchase/Deliver Aggregate Base Course - 4"		23,000	tns	$34.05	$783,183
	19	Place & Compact Aggregate Base		23,000	tns	$5.11	$117,477
	20	Blue top Aggregate Base		105,011	sys	$1.47	$154,375
		Subtotal Page 1 =>					**$32,932,573**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
11/18/19		11/19/19	

FEATURE:	PROJECT:
Canal Enlargement MP 88.2 to 121.5 *Design Max Flow* *2018 Land Surface*	Friant-Kern Canal Middle Reach Capacity Correction
	WOID:
	ESTIMATE LEVEL: Feasibility
	REGION: MP
	UNIT PRICE LEVEL: 10/1/2019
	FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Final Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Utilities					
	21	Parallel Overhead Powerline Relocation		5	mi	$595,900	$2,681,550
	22	Adjacent Groundwater Well Abandonments		6	ea	$12,769	$76,616
	23	Culvert Extensions		4	ea	$12,769	$51,077
	24	Pipeline Overcrossing Replacements (8"-12")		0	ea	$59,590	$0
	25	Impacted Utility Crossings (Attached to Bridges - 4"-24")		0	ea	$85,129	$0
		Miscellaneous					
	26	Seeding		1,181,190	sf	$0.09	$100,553
		Subtotal Page 2 =>					**$2,909,796**
		Segment 1 Subtotal =>					***$35,842,369***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 11/18/19	**PEER REVIEW / DATE**	**DATE PREPARED** 11/19/19	**PEER REVIEW / DATE**

FEATURE: Canal Enlargement MP 88.2 to 121.5 *Design Max Flow* *2018 Land Surface*	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction		
	WOID:	**ESTIMATE LEVEL:**	Feasibility
	REGION: MP	**UNIT PRICE LEVEL:**	10/1/2019
	FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Final Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 2 - Tule to Deer Creek (New Bypass Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		37,318	lf	$44.00	$1,642,064
	2	Strip/Clear Vegetation at New Embankment Areas		34	ac	$4,335.70	$147,414
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for Truck Hauls		300	dys	$85.13	$25,539
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		290,251	sy	$2.44	$708,091
	5	Excavation to Embankment - Scraper/Dozer (Balance)		300,000	cys	$5.45	$1,636,453
	6	Excavation to Embankment - Short Truck Haul		0	cys	$7.83	$0
	7	Excavation to Embankment - Long Truck Haul		1,000,000	cys	$14.50	$14,495,038
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3.44	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		361,207	sys	$3.92	$1,416,011
	10	Place 3.5" Concrete Liner		361,207	sys	$49.28	$17,800,364
	11	Final Cure for Concrete Liner		361,207	sys	$0.34	$122,996
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$3.41	$0
		Ancillary Facilities					
	13	New Ladders		100	ea	$5,959.00	$595,900
	14	Check Structure - New		1	ea	$4,256,429.24	$4,256,429
	15	Transition to (e) Bridges - 112'		1	ea	$85,128.58	$85,129
	16	Transitions to (e) Turnouts		10	ea	$42,564.29	$425,643
	17	New Turnouts on New Canal		3	ea	$25,538.58	$76,616
	18	Siphon Construction on New Canal		1	ea	$3,830,786.32	$3,830,786
	19	Raise/Modify Existing Turnout Top Deck Actuator		5	ea	$8,512.86	$42,564
	20	Delivery Pools		2	ea	$425,642.92	$851,286
		Bridges					
	21	Demo (e) County or State Bridge		1	ea	$425,642.92	$425,643
	22	Demo (e) Farm Bridge		0	ea	$42,564.29	$0
	23	New County or State Bridges - 90' span (Concrete)		5	ea	$2,301,364.57	$11,506,823
		Subtotal Page 3 =>					**$60,090,788**

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 11/18/19	**PEER REVIEW / DATE**	**DATE PREPARED** 11/19/19	**PEER REVIEW / DATE**

FEATURE:	PROJECT:
Canal Enlargement **MP 88.2 to 121.5** ***Design Max Flow*** ***2018 Land Surface***	**Friant-Kern Canal** **Middle Reach Capacity Correction**
	WOID:
	ESTIMATE LEVEL: **Feasibility**
	REGION: **MP**
	UNIT PRICE LEVEL: **10/1/2019**
	FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Fina Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	24	Bridge Approach Road Construction		6,400	lf	$573.11	$3,667,898
	25	Replace (e) Farm Bridges		1	ea	$212,821.46	$212,821
		O&M Road					
	26	Prep/Compact Subgrade		99,515	sys	$2.94	$292,591
	27	Purchase/Deliver Aggregate Base Course - 4"		22,000	tns	$34.05	$749,132
	28	Place & Compact Aggregate Base - 4"		22,000	tns	$5.11	$112,370
	29	Blue top Aggregate Base		99,515	sys	$1.47	$146,295
		Utilities					
	30	Parallel Overhead Powerline Relocation		4	mi	$595,900.09	$2,085,650
	31	Adjacent Groundwater Well Abandonments		4	ea	$12,769.29	$51,077
	32	Culvert Extensions		5	ea	$12,769.29	$63,846
	33	Pipeline Overcrossing Replacements (8"-12")		1	ea	$59,590.01	$59,590
	34	Impacted Utility Crossings (Attached to Bridges - 4"-24")		4	ea	$85,128.58	$340,514
		Miscellaneous					
	35	Seeding		1,119,540	sf	$0.09	$95,305
		Subtotal Page 4 =>					**$7,877,090**
		Subtotal Segment 2 =>					***$67,967,878***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 11/18/19	**PEER REVIEW / DATE**	**DATE PREPARED** 11/19/19	**PEER REVIEW / DATE**

FEATURE: Canal Enlargement MP 88.2 to 121.5 *Design Max Flow* *2018 Land Surface*	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction
WOID:	**ESTIMATE LEVEL:** Feasibility
REGION: MP	**UNIT PRICE LEVEL:** 10/1/2019
FILE:	https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Final Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 3 - Deer Creek to White River (Enlarge Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		54,698	lf		
	2	Strip/Clear Vegetation at New Embankment Areas		50	ac	$4,336	$216,785
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		500	dys	$128	$63,867
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		425,429	sy	$2	$1,037,868
	5	Excavation to Embankment - Scraper/Dozer (Balance)		600,000	cys	$5	$3,272,905
	6	Excavation to Embankment - Short Truck Haul		0	cys	$8	$0
	7	Excavation to Embankment - Long Truck Haul		1,800,000	cys	$14	$26,091,069
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		530,000	sys	$4	$2,077,717
	10	Place 3.5" Concrete Liner		530,000	sys	$49	$26,118,522
	11	Final Cure for Concrete Liner		530,000	sys	$0	$180,473
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$3	$0
		Ancillary Facilities					
	13	New Ladders		146	ea	$5,959	$870,014
	14	Check Structure - Modify		1	ea	$1,702,572	$1,702,572
	15	Check Structures - Demolish		1	ea	$340,514	$340,514
	16	Check Structure - New		0	ea	$3,405,143	$0
	17	Transition to (e) Bridges - 112'		0	ea	$85,129	$0
	18	Transitions to (e) Turnouts		10	ea	$42,564	$425,643
	19	New Turnouts on New Canal		6	ea	$25,539	$153,231
	20	Siphon Construction on New Canal		7	ea	$3,830,786	$26,815,504
	21	Raise/Modify Existing Turnout Top Deck Actuator		2	ea	$8,513	$17,026
	22	Delivery Pools		6	ea	$425,643	$2,553,858
		Bridges					
	23	Demo (e) County or State Bridge		7	ea	$425,643	$2,979,500
		Subtotal Page 5 =>					**$94,917,068**

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 11/18/19	**PEER REVIEW / DATE**	**DATE PREPARED** 11/19/19	**PEER REVIEW / DATE**

FEATURE:	PROJECT:	
Canal Enlargement	**Friant-Kern Canal**	
MP 88.2 to 121.5	**Middle Reach Capacity Correction**	
	WOID:	**ESTIMATE LEVEL:** Feasibility
Design Max Flow	**REGION:** MP	**UNIT PRICE LEVEL:** 10/1/2019
2018 Land Surface	**FILE:** https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Final Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	24	Demo (e) Farm Bridge		0	ea	$42,564	$0
	25	New County or State Bridges - 90' span		5	ea	$2,301,365	$11,506,823
	26	Bridge Approach Road Construction		4,800	lf	$573	$2,750,923
	27	Replace (e) Farm Bridges		2	ea	$212,821	$425,643
		O&M Road					
	28	Prep/Compact Subgrade		145,860	sys	$2.94	$428,853
	29	Purchase/Deliver Aggregate Base Course - 4"		32,000	tns	$34.05	$1,089,646
	30	Place & Compact Aggregate Base		32,000	tns	$5.11	$163,447
	31	Blue top Aggregate Base		145,860	sys	$1.47	$214,426
		Utilities					
	32	Parallel Overhead Powerline Relocation		3	mi	$595,900	$1,787,700
	33	Adjacent Groundwater Well Abandonments		8	ea	$12,769	$102,154
	34	Culvert Extensions (Each End)		4	ea	$12,769	$51,077
	35	Pipeline Overcrossing Replacements (8"-12")		2	ea	$59,590	$119,180
	36	Impacted Utility Crossings (Attached to Bridges - 4"-24")		7	ea	$85,129	$595,900
		Miscellaneous					
	37	Seeding		1,640,940	sf	$0.09	$139,691
		Subtotal Page 6 =>					**$19,375,464**
		Subtotal Segment 3 =>					***$114,292,531***

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
11/18/19		11/19/19	

FEATURE:	PROJECT:
Canal Enlargement MP 88.2 to 121.5 *Design Max Flow* *2018 Land Surface*	Friant-Kern Canal Middle Reach Capacity Correction WOID: ESTIMATE LEVEL: Feasibility REGION: MP UNIT PRICE LEVEL: 10/1/2019 FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Final Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 4 - White River to Ave 8 Bridge (Enlarge Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		15,727	lf	$0.00	$0
	2	Strip/Clear Vegetation at New Embankment Areas		14	ac	$4,335.70	$60,700
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for Truck Hauls		100.00	dys	$3.44	$344
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		122,321	sy	$2.44	$298,412
	5	Excavation to Embankment - Scraper/Dozer (Balance)		200,000	cys	$5.45	$1,090,968
	6	Excavation to Embankment - Short Truck Haul		0	cys	$7.83	$0
	7	Excavation to Embankment - Long Truck Haul		200,000	cys	$14.50	$2,899,008
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3.44	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		336,000	sys	$3.92	$1,317,194
	10	Place 3.5" Concrete Liner		336,000	sys	$49.28	$16,558,158
	11	Final Cure for Concrete Liner		336,000	sys	$0.34	$114,413
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$3.41	$0
		Ancillary Facilities					
	13	New Ladders		42	ea	$5,959.00	$250,278
	14	Transition to (e) Bridges - 112'		2	ea	$85,128.58	$170,257
	15	Transitions to (e) Turnouts		11	ea	$42,564.29	$468,207
	16	New Turnouts on New Canal		1	ea	$25,538.58	$25,539
	17	Siphon Construction on New Canal		1	ea	$3,830,786.32	$3,830,786
	18	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$8,512.86	$0
	19	Delivery Pools		1	ea	$425,642.92	$425,643
		Bridges					
	20	Demo (e) County or State Bridge		1	ea	$425,642.92	$425,643
		Subtotal Page 7 =>					**$27,935,550**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
11/18/19		11/19/19	

FEATURE:	PROJECT:
Canal Enlargement	**Friant-Kern Canal**
MP 88.2 to 121.5	**Middle Reach Capacity Correction**
	WOID:
	ESTIMATE LEVEL: Feasibility
Design Max Flow	**REGION:** MP
	UNIT PRICE LEVEL: 10/1/2019
2018 Land Surface	**FILE:** https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Fina Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		O&M Road					
	21	Prep/Compact Subgrade		41,938	sys	$2.94	$123,305
	22	Purchase/Deliver Aggregate Base Course - 4"		9,000	tns	$34.05	$306,463
	23	Place & Compact Aggregate Base		9,000	tns	$5.11	$45,969
	24	Blue top Aggregate Base		41,938	sys	$1.47	$61,652
		Utilities					
	25	Parallel Overhead Powerline Relocation		1	mi	$595,900	$595,900
	26	Adjacent Groundwater Well Abandonments		0	ea	$12,769	$0
	27	Culvert Extensions (Each End)		0	ea	$12,769	$0
	28	Pipeline Overcrossing Replacements (8"-12")		2	ea	$59,590	$119,180
	29	Impacted Utility Crossings (Attached to Bridges - 4"-24")		1	ea	$85,129	$85,129
		Miscellaneous					
	30	Seeding		471,810	sf	$0.09	$40,165
		Subtotal Page 8 =>					**$1,377,763**
		Segment 4 Subtotal =>					***$29,313,312***

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
11/18/19		11/19/19	

FEATURE:	PROJECT:
Canal Enlargement MP 88.2 to 121.5 *Design Max Flow* *2018 Land Surface*	Friant-Kern Canal Middle Reach Capacity Correction WOID: ESTIMATE LEVEL: Feasibility REGION: MP UNIT PRICE LEVEL: 10/1/2019 FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Fina Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Construction Allowances					
	1	Contractor Quality Control		1	ls	0.75%	$1,855,621
	2	Flaggers		1,000	hr	$102	$102,154
	3	Rent Traffic Message Boards + Other T.C.s		1,000	dys	$341	$340,514
	4	Cathodic Protection		1	ls	$0.00	$0
	5	Crew / Mgt Per-diems & Travel		1	ls	$0.00	$0
	6	Labor Overtime		1	ls	$0.00	$0
	7	Liquated Damages		1	ls	$0.00	$0
		Mobilization					
	8	Submittals/Procurement/POs/Resource Coordination		3	mo	$42,564	$127,693
	9	Establish Survey Controls		1	ls	$0	$0
	10	Establish Baseline Survey / Alignment / As-builts		1,000	hr	$426	$425,643
	11	Install/Maintain BMPs, SWPPP		1	ls	$595,900	$595,900
	12	Initial Equipment Mobilization		10	ea	$68,103	$681,029
	13	Initial Labor Mobilization		10	ea	$0	$0
	14	Third Party Design Services / Outside Consultants		1	ls	$0	$0
	15	Develop & Maintain Water Supply		1	ls	$297,950	$297,950
	16	Create & Maintain Access / Cofferdams, Crane Pads, etc.		1	ls	$425,643	$425,643
	17	Create & Maintain Access to Borrow or Dump Areas		5	ea	$42,564	$212,821
	18	Clear/Prep Borrow or Dump Areas		5	ea	$34,051	$170,257
	19	Reclaim Borrow Areas		5	ea	$85,129	$425,643
	20	Build New Haul Roads to Facilitate Earthwork Hauling		20.41	mi	$85,129	$1,737,123
	21	Reclaim Temporary Haul Roads		20.41	mi	$34,051	$694,849
		Startup/Commission/Owner Training					
	22	Pre-commissioning		600	hrs	$255	$153,231
	23	Vendor Support		1	ls	$0	$0
	24	Commissioning		600	hrs	$255	$153,231
	25	Training		200	hrs	$170	$34,051
	26	Startup Expendables		1	ls	$42,564	$42,564
		Subtotal Page 9 =>					**$8,475,919**

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 11/18/19	**PEER REVIEW / DATE**	**DATE PREPARED** 11/19/19	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: **Canal Enlargement** **MP 88.2 to 121.5** ***Design Max Flow*** ***2018 Land Surface***	**PROJECT:** **Friant-Kern Canal** **Middle Reach Capacity Correction**
	WOID:
	ESTIMATE LEVEL: **Feasibility**
	REGION: **MP**
	UNIT PRICE LEVEL: **10/1/2019**
	FILE: https://stantec.sharepoint.com/teams/184031016/Shared Documents/4.0 Draft and Fina Reports/Subtask 2.6 Federal Feasibility Report/MRCC/Cost Estimates/CE_Qmax_2018/[FKC__BlueSheets__Canal_Alts_30%_QMAX_OPCC_03-18-19.xlsx]Recommended Plan - Oct 2019

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal from Page 1					**$32,932,573**
		Subtotal from Page 2					**$2,909,796**
		Subtotal from Page 3					**$60,090,788**
		Subtotal from Page 4					**$7,877,090**
		Subtotal from Page 5					**$94,917,068**
		Subtotal from Page 6					**$19,375,464**
		Subtotal from Page 7					**$27,935,550**
		Subtotal from Page 8					**$1,377,763**
		Subtotal from Page 9					**$8,475,919**
		Subtotal with Mobilization, Startup, Commission, & Owner Training					**$255,892,010**
		Contract Cost Allowances (Sum of):	17%	+/-			$43,501,642
		Design Contingencies, 0% (+/-)					
		APS, 0% (+/-). Type of Procurement: Full and Open Request for Proposal					
		CONTRACT COST					**$300,000,000**
		Construction Contingencies	20%	+/-			$60,000,000
		FIELD COST (Unit Price Level October 2019)					**$360,000,000**
		Escalation to Notice to Proceed (NTP) from Unit Price Level not included here. Will be included in the Construction Cost Estimate (CCE)/					
		Project Cost Estimate (PCE) generated by the appropriate responsible office.					
		Non-Contract Costs		**To be determined by the appropriate responsible office.**			
		CONSTRUCTION COST		**To be determined by the appropriate responsible office.**			
		Ref: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02, and 09-03.					

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 11/18/19	**PEER REVIEW / DATE**	**DATE PREPARED** 11/19/19	**PEER REVIEW / DATE**

Friant-Kern Canal
Middle Reach Capacity Correction Project

Alternative 5 – Parallel Canal
Design Maximum Capacity

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET**

FEATURE: Alternative 5 - Parallel Canal, MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal, Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 1 - 5th Ave to Tule					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 10' to 15' at Both Sides)		39,379	lf	$35.36	$1,392,262
	2	Strip/Clear Vegetation at New Embankment Areas		41	ac	$3,484	$141,721
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		200	dys	$102.63	$20,527
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		306,281	sy	$1.96	$600,371
	5	Excavation to Embankment - Scraper/Dozer (Balance)		483,273	cys	$4.38	$2,118,163
	6	Excavation to Spoil Embankment (Scraper/Dozer)		519,898	cys	$3.29	$1,709,017
	7	Excavation to Embank. - Short Truck Haul (Est - Qty under Dev)		50,000	cys	$6.29	$314,567
	8	Excavation to Embank. - Long Truck Haul (Est - Qty under Dev)		50,000	cys	$8.94	$447,245
	9	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$2.76	$0
		Concrete Canal Liner					
	10	Trim/Compact Excavated Areas		384,213	sys	$3.15	$1,210,228
	11	Place 3.5" Concrete Liner		384,213	sys	$39.60	$15,213,513
	12	Final Cure for Concrete Liner		384,213	sys	$0.27	$105,122
	13	Trim/Point/Patch at (e) Liner Joint		78,758	lf	$2.74	$215,484
		Ancillary Facilities					
	14	New Ladders		105	ea	$4,788	$502,745
	15	Check Structure - Modify		0	ea	$1,368,013	$0
	16	Check Structures - Demolish		0	ea	$273,603	$0
	17	Check Structure - New		0	ea	$2,736,025	$0
	18	Transition to (e) Bridges -112'		18	ea	$68,401	$1,231,211
	19	Transitions to (e) Turnouts		0	ea	$34,200	$0
	20	New Turnouts on New Canal		7	ea	$20,520	$143,641
	21	Siphon Construction on New Canal		0	ea	$3,078,028	$0
	22	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$6,840	$0
	23	Delivery Pools		0	ea	$342,003	$0
		Subtotal Page 1 =>					**$25,365,817**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

FEATURE: Alternative 5 - Parallel Canal, MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal, Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	24	Demo (e) County or State Bridge		0	ea	$342,003	$0
	25	Demo (e) Farm Bridge		0	ea	$34,200	$0
	26	New County or State Bridges - 90' span		0	ea	$1,849,141	$0
	27	Replace (e) Farm Bridges		0	ea	$171,002	$0
		O&M Road					
	28	Prep/Compact Subgrade		105,011	sys	$2.36	$248,080
	29	Purchase/Deliver Aggregate Base Course - 4"		23,000	tns	$27.36	$629,286
	30	Place & Compact Aggregate Base		23,000	tns	$4.10	$94,393
	31	Blue top Aggregate Base		105,011	sys	$1.18	$124,040
		Utilities					
	32	Parallel Overhead Powerline Relocation		5	mi	$478,804	$2,154,620
	33	Adjacent Groundwater Well Abandonments		6	ea	$10,260	$61,561
	34	Culvert Extensions		4	ea	$10,260	$41,040
	35	Pipeline Overcrossing Replacements (8"-12")		0	ea	$47,880	$0
	36	Impacted Utility Crossings (Attached to Bridges - 4"-24")		0	ea	$68,401	$0
		Miscellaneous					
	37	Seeding		1,181,370	sf	$0.07	$80,806
		Subtotal Page 2 =>					**$3,433,826**
		Segment 1 Subtotal =>					***$28,799,642***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE:	PROJECT:
Alternative 5 - Parallel Canal	**Friant-Kern Canal**
MP 88.2 to 121.5	**Middle Reach Capacity Correction (MRCC)**
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: MP / **UNIT PRICE LEVEL:** 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 2 - Tule to Deer Creek (New Bypass Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		36,995	lf	$0.00	$0
	2	Strip/Clear Vegetation at New Embankment Areas		102	ac	$3,484	$355,340
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		400	dys	$68.40	$27,360
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		287,739	sy	$1.96	$564,025
	5	Excavation to Embankment - Scraper/Dozer (Balance)		1,853,658	cys	$4.38	$8,124,496
	6	Excavation to Embankment - Short Truck Haul		48,000	cys	$6.29	$301,984
	7	Excavation to Embankment - Long Truck Haul		135,000	cys	$8.94	$1,207,562
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$2.76	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		396,505	sys	$3.15	$1,248,947
	10	Place 3.5" Concrete Liner		396,505	sys	$39.60	$15,700,233
	11	Final Cure for Concrete Liner		396,505	sys	$0.27	$108,485
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$2.74	$0
		Ancillary Facilities					
	13	New Ladders		99	ea	$4,788	$474,016
	14	Check Structure - Modify		0	ea	$1,368,013	$0
	15	Check Structures - Demolish		1	ea	$273,603	$273,603
	16	Check Structure - New		1	ea	$3,420,032	$3,420,032
	17	Transition to (e) Bridges - 112'		1	ea	$68,401	$68,401
	18	Transitions to (e) Turnouts		2	ea	$34,200	$68,401
	19	New Turnouts on New Canal		9	ea	$20,520	$184,682
	20	Siphon Construction on New Canal		6	ea	$3,078,028	$18,468,171
	21	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$6,840	$0
	22	Delivery Pools		2	ea	$342,003	$684,006
		Subtotal Page 3 =>					**$51,279,744**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 4 OF 12

FEATURE: Alternative 5 - Parallel Canal MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	23	Demo (e) County or State Bridge		6	ea	$342,003	$2,052,019
	24	Demo (e) Farm Bridge		0	ea	$34,200	$0
	25	New County or State Bridges - 90' span		0	ea	$1,849,141	$0
	26	Replace (e) Farm Bridges		0	ea	$171,002	$0
		O&M Road					
	27	Prep/Compact Subgrade		98,653	sys	$2	$233,059
	28	Purchase/Deliver Aggregate Base Course - 4"		21,000	tns	$27	$574,565
	29	Place & Compact Aggregate Base		21,000	tns	$4	$86,185
	30	Blue top Aggregate Base		98,653	sys	$1	$116,530
		Utilities					
	31	Parallel Overhead Powerline Relocation		4	mi	$478,804	$1,675,816
	32	Adjacent Groundwater Well Abandonments		4	ea	$10,260	$41,040
	33	Culvert Extensions		5	ea	$10,260	$51,300
	34	Pipeline Overcrossing Replacements (8"-12")		1	ea	$47,880	$47,880
	35	Impacted Utility Crossings (Attached to Bridges - 4"-24")		4	ea	$68,401	$273,603
		Miscellaneous					
	36	Seeding		1,109,850	sf	$0	$75,914
		Subtotal Page 4 =>					**$5,227,912**
		Segment 2 Subtotal =>					***$56,507,656***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE:	PROJECT:
Alternative 5 - Parallel Canal	**Friant-Kern Canal**
MP 88.2 to 121.5	**Middle Reach Capacity Correction (MRCC)**
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 3 - Deer Creek to White River (New Bypass Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		53,983	lf	$0.00	$0
	2	Strip/Clear Vegetation at New Embankment Areas		149	ac	$3,484	$519,075
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		600	dys	$102.63	$61,580
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		419,868	sy	$1.96	$823,023
	5	Excavation to Embankment - Scraper/Dozer (Balance)		2,493,335	cys	$4.38	$10,928,172
	6	Excavation to Embankment - Short Truck Haul		102,500	cys	$5.90	$604,559
	7	Excavation to Embankment - Long Truck Haul		250,000	cys	$14.11	$3,526,357
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$2.76	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		632,657	sys	$3.15	$1,992,799
	10	Place 3.5" Concrete Liner		632,657	sys	$39.60	$25,051,040
	11	Final Cure for Concrete Liner		632,657	sys	$0.27	$173,097
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$2.74	$0
		Ancillary Facilities					
	13	New Ladders		144	ea	$4,788	$689,478
	14	Check Structure - Modify		0	ea	$1,368,013	$0
	15	Check Structures - Demolish		1	ea	$273,603	$273,603
	16	Check Structure - New		1	ea	$2,736,025	$2,736,025
	17	Transition to (e) Bridges - 112'		1	ea	$68,401	$68,401
	18	Transitions to (e) Turnouts		0	ea	$34,200	$0
	19	New Turnouts on New Canal		8	ea	$20,520	$164,162
	20	Siphon Construction on New Canal		11	ea	$3,078,028	$33,858,313
	21	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$6,840	$0
	22	Delivery Pools		6	ea	$342,003	$2,052,019
		Subtotal Page 5 =>					**$83,521,703**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 6 OF 12

FEATURE: **Alternative 5 - Parallel Canal** **MP 88.2 to 121.5**	**PROJECT:** **Friant-Kern Canal** **Middle Reach Capacity Correction (MRCC)**
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: MP / **UNIT PRICE LEVEL:** 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	23	Demo (e) County or State Bridge		12	ea	$342,003	$4,104,038
	24	Demo (e) Farm Bridge		0	ea	$34,200	$0
	25	New County or State Bridges - 90' span		0	ea	$1,849,141	$0
	26	Replace (e) Farm Bridges		0	ea	$171,002	$0
		O&M Road					
	27	Prep/Compact Subgrade		143,935	sys	$2.36	$340,034
	28	Purchase/Deliver Aggregate Base Course - 4"		31,000	tns	$27.36	$848,168
	29	Place & Compact Aggregate Base		31,000	tns	$4.10	$127,225
	30	Blue top Aggregate Base		143,935	sys	$1.18	$170,017
		Utilities					
	31	Parallel Overhead Powerline Relocation		3	mi	$478,804	$1,436,413
	32	Adjacent Groundwater Well Abandonments		8	ea	$10,260	$82,081
	33	Culvert Extensions (Each End)		4	ea	$10,260	$41,040
	34	Pipeline Overcrossing Replacements (8"-12")		2	ea	$47,880	$95,761
	35	Impacted Utility Crossings (Attached to Bridges - 4"-24")		7	ea	$68,401	$478,804
		Miscellaneous					
	36	Seeding		1,619,490	sf	$0.07	$110,774
		Subtotal Page 6 =>					**$7,834,357**
		Segment 3 Subtotal =>					***$91,356,060***

QUANTITIES		**PRICES**	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE: Alternative 5 - Parallel Canal MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 4 - White River to Garces Hwy (New Bypass Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		34,592	lf	$0.00	$0
	2	Strip/Clear Vegetation at New Embankment Areas		95	ac	$3,484	$330,954
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		400	dys	$2.76	$1,106
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		269,049	sy	$1.96	$527,389
	5	Excavation to Embankment - Scraper/Dozer (Balance)		179,853	cys	$4.38	$788,289
	6	Excavation to Spoil Embankment (Scraper/Dozer)		1,319,983	cys	$3.29	$4,339,068
	7	Excavation to Embank. - Short Truck Haul (Estimate - Qty under Dev)		100,000	cys	$5.90	$589,813
	8	Excavation to Embank. - Long Truck Haul (Estimate - Qty under Dev)		250,000	cys	$14.11	$3,526,357
	9	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$2.76	$0
		Concrete Canal Liner					
	10	Trim/Compact Excavated Areas		366,827	sys	$3.15	$1,155,464
	11	Place 3.5" Concrete Liner		366,827	sys	$39.60	$14,525,087
	12	Final Cure for Concrete Liner		366,827	sys	$0.27	$100,365
	13	Trim/Point/Patch at (e) Liner Joint		0	lf	$2.74	$0
		Ancillary Facilities					
	14	New Ladders		92	ea	$4,788	$440,500
	15	Check Structure - Modify		0	ea	$1,368,013	$0
	16	Check Structures - Demolish		0	ea	$273,603	$0
	17	Check Structure - New		0	ea	$2,736,025	$0
	18	Transition to (e) Bridges - 112'		1	ea	$68,401	$68,401
	19	Transitions to (e) Turnouts		0	ea	$34,200	$0
	20	New Turnouts on New Canal		6	ea	$20,520	$123,121
	21	Siphon Construction on New Canal		8	ea	$3,078,028	$24,624,228
	22	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$6,840	$0
	23	Delivery Pools		6	ea	$342,003	$2,052,019
		Subtotal Page 7 =>					**$53,192,162**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

FEATURE: Alternative 5 - Parallel Canal MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	24	Demo (e) County or State Bridge		8	ea	$342,003	$2,736,025
	25	Demo (e) Farm Bridge		0	ea	$34,200	$0
	26	New County or State Bridges - 90' span		0	ea	$1,849,141	$0
	27	Replace (e) Farm Bridges		0	ea	$171,002	$0
		O&M Road					
	28	Prep/Compact Subgrade		92,245	sys	$2	$217,921
	29	Purchase/Deliver Aggregate Base Course - 4"		20,000	tns	$27	$547,205
	30	Place & Compact Aggregate Base		20,000	tns	$4	$82,081
	31	Blue top Aggregate Base		92,245	sys	$1	$108,961
		Utilities					
	32	Parallel Overhead Powerline Relocation		3	mi	$478,804	$1,197,011
	33	Adjacent Groundwater Well Abandonments		4	ea	$10,260	$41,040
	34	Culvert Extensions (Each End)		0	ea	$10,260	$0
	35	Pipeline Overcrossing Replacements (8"-12")		4	ea	$47,880	$191,522
	36	Impacted Utility Crossings (Attached to Bridges - 4"-24")		3	ea	$68,401	$205,202
		Miscellaneous					
	37	Seeding		1,037,760	sf	$0	$70,983
		Subtotal Page 8 =>					**$5,397,951**
		Segment 4 Subtotal =>					***$58,590,113***

QUANTITIES		**PRICES**	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE: Alternative 5 - Parallel Canal, MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal, Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 5 - Garces Hwy to Woollomes (Widen Existing Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 10-15' at Both Sides)		10,763	lf	$35	$380,531
	2	Strip/Clear Vegetation at New Embankment Areas		11	ac	$3,484	$38,735
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		0	dys	$21	$0
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		83,712	sy	$2	$164,092
	5	Excavation to Embankment - Scraper/Dozer (Balance)		36,899	cys	$4	$161,726
	6	Excavation to Spoil Embankment (Scraper/Dozer)		132,437	cys	$3	$435,349
	7	Excavation to Embankment - Short Truck Haul (Estimate - Qty under Dev)		10,000	cys	$6	$62,913
	8	Excavation to Embankment - Long Truck Haul (Estimate - Qty under Dev)		5,000	cys	$9	$44,725
	9	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3	$0
		Concrete Canal Liner					
	10	Trim/Compact Excavated Areas		0	sys	$3	$0
	11	Place 3.5" Concrete Liner		0	sys	$40	$0
	12	Final Cure for Concrete Liner		0	sys	$0	$0
	13	Trim/Point/Patch at (e) Liner Joint		0	lf	$3	$0
		Ancillary Facilities					
	14	New Ladders		0	ea	$4,788	$0
	15	Check Structure - Modify		0	ea	$1,368,013	$0
	16	Check Structures - Demolish		0	ea	$273,603	$0
	17	Check Structure - New		0	ea	$2,736,025	$0
	18	Transition to (e) Bridges - 112'		0	ea	$68,401	$0
	19	Transitions to (e) Turnouts		0	ea	$34,200	$0
	20	New Turnouts on New Canal		3	ea	$20,520	$61,561
	21	Siphon Construction on New Canal		0	ea	$3,078,028	$0
	22	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$6,840	$0
	23	Delivery Pools		0	ea	$342,003	$0
		Subtotal Page 9 =>					**$1,349,632**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET**

FEATURE: Alternative 5 - Parallel Canal, MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal, Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	24	Demo (e) County or State Bridge		0	ea	$342,003	$0
	25	Demo (e) Farm Bridge		0	ea	$34,200	$0
	26	New County or State Bridges - 90' span		0	ea	$1,849,141	$0
	27	Replace (e) Farm Bridges		0	ea	$171,002	$0
		O&M Road					
	28	Prep/Compact Subgrade		28,701	sys	$2.36	$67,804
	29	Purchase/Deliver Aggregate Base Course - 4"		7,000	tns	$27.36	$191,522
	30	Place & Compact Aggregate Base		7,000	tns	$4.10	$28,728
	31	Blue top Aggregate Base		28,701	sys	$1.18	$33,902
		Utilities					
	32	Parallel Overhead Powerline Relocation		1	mi	$478,804	$239,402
	33	Adjacent Groundwater Well Abandonments		1	ea	$10,260	$10,260
	34	Culvert Extensions		0	ea	$10,260	$0
	35	Pipeline Overcrossing Replacements (8"-12")		0	ea	$47,880	$0
	36	Impacted Utility Crossings (Attached to Bridges - 4"-24")		0	ea	$68,401	$0
		Miscellaneous					
	37	Seeding		322,890	sf	$0.07	$22,086
		Subtotal Page 10 =>					**$593,704**
		Segment 5 Subtotal =>					***$1,943,335***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE: Alternative 5 - Parallel Canal, MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal, Middle Reach Capacity Correction (MRCC)		
	WOID:	**ESTIMATE LEVEL:**	Appraisal
	REGION: MP	**UNIT PRICE LEVEL:**	3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Construction Allowances					
	1	Contractor Quality Control		1	ls	0.75%	$1,778,976
	2	Flaggers		1,000	hr	$82.08	$82,081
	3	Rent Traffic Message Boards + Other T.C.s		1,000	dys	$273.60	$273,603
	4	Cathodic Protection		1	ls	$0.00	$0
	5	Crew / Mgt Per-diems & Travel		1	ls	$0.00	$0
	6	Labor Overtime		1	ls	$0.00	$0
	7	Liquated Damages		1	ls	$0.00	$0
		Mobilization					
	8	Submittals/Procurement/POs/Resource Coordination		3	mo	$34,200	$102,601
	9	Establish Survey Controls		1	ls	$0.00	$0
	10	Establish Baseline Survey / Alignment / As-builts		1,000	hr	$342.00	$342,003
	11	Install/Maintain BMPs, SWPPP		1	ls	$478,804	$478,804
	12	Initial Equipment Mobilization		20	lds	$2,736	$54,721
	13	Initial Labor Mobilization		1	ls	$0.00	$0
	14	Third Party Design Services / Outside Consultants		1	ls	$0.00	$0
	15	Develop & Maintain Water Supply		1	ls	$239,402	$239,402
	16	Create & Maintain Access / Cofferdams, Crane Pads, etc.		1	ls	$342,003	$342,003
	17	Create & Maintain Access to Borrow or Dump Areas		0	ea	$34,200	$0
	18	Clear/Prep Borrow or Dump Areas		0	ea	$27,360	$0
	19	Reclaim Borrow Areas		0	ea	$68,401	$0
	20	Build New Haul Roads to Facilitate Earthwork Hauling		0	mi	$68,401	$0
	21	Reclaim Temporary Haul Roads		0	mi	$27,360	$0
		Startup/Commission/Owner Training					
	22	Pre-commissioning		600	hrs	$205.20	$123,121
	23	Vendor Support		1	ls	$0.00	$0
	24	Commissioning		600	hrs	$205.20	$123,121
	25	Training		200	hrs	$136.80	$27,360
	26	Startup Expendables		1	ls	$34,200	$34,200
		Subtotal Page 11 =>					**$4,001,997**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

FEATURE:			**PROJECT:**			
Alternative 5 - Parallel Canal			**Friant-Kern Canal**			
MP 88.2 to 121.5			**Middle Reach Capacity Correction (MRCC)**			
			WOID:		**ESTIMATE LEVEL:**	**Appraisal**
			REGION:	**MP**	**UNIT PRICE LEVEL:**	**3/1/2019**
			FILE:	C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal from Page 1					**$25,365,817**
		Subtotal from Page 2					**$3,433,826**
		Subtotal from Page 3					**$51,279,744**
		Subtotal from Page 4					**$5,227,912**
		Subtotal from Page 5					**$83,521,703**
		Subtotal from Page 6					**$7,834,357**
		Subtotal from Page 7					**$53,192,162**
		Subtotal from Page 8					**$5,397,951**
		Subtotal from Page 9					**$1,349,632**
		Subtotal from Page 10					**$593,704**
		Subtotal from Page 11					**$4,001,997**
		Subtotal with Mobilization, Startup, Commission, & Owner Training					**$241,198,803**
		Contract Cost Allowances (Sum of):	17%	+/-			$41,003,796
		Design Contingencies, 0% (+/-)					
		APS, 0% (+/-). Type of Procurement: Full and Open Request for Proposal					
		CONTRACT COST					**$280,000,000**
		Construction Contingencies	20%	+/-			$56,000,000
		FIELD COST (Unit Price Level March 2019)					**$340,000,000**
		Escalation to Notice to Proceed (NTP) from Unit Price Level not included here. Will be included in the Construction Cost Estimate (CCE)/					
		Project Cost Estimate (PCE) generated by the appropriate responsible office.					
		Non-Contract Costs		**To be determined by the appropriate responsible office.**			
		CONSTRUCTION COST		**To be determined by the appropriate responsible office.**			
		Ref: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02, and 09-03.					

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

Friant-Kern Canal
Middle Reach Capacity Correction Project

Alternative 1 – Enlarge Existing Canal
Historical Capacity

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:	PROJECT:
Alternative 1 - Enlarge Existing Canal **MP 88.2 to 121.5**	**Friant-Kern Canal** **Middle Reach Capacity Correction (MRCC)**
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	**Segment 1 - 5th Ave to Tule**		1	ls	$0.00	$0
		Subtotal Page 1 =>					**$0**
		Segment 1 Subtotal =>					***$0***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE:	**PROJECT:**
Alternative 1 - Enlarge Existing Canal	**Friant-Kern Canal**
MP 88.2 to 121.5	**Middle Reach Capacity Correction (MRCC)**
	WOID:
	ESTIMATE LEVEL: **Appraisal**
	REGION: **MP**
	UNIT PRICE LEVEL: **3/1/2019**
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 2 - Tule to Deer Creek (Enlarge Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		37,318	lf	$41.42	$1,545,564
	2	Strip/Clear Vegetation at New Embankment Areas		34	ac	$4,082	$138,798
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		200	dys	$80.14	$16,028
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		290,251	sy	$2.29	$665,252
	5	Excavation to Embankment - Scraper/Dozer (Balance)		110,242	cys	$5.13	$565,423
	6	Excavation to Embankment - Short Truck Haul		0	cys	$7.37	$0
	7	Excavation to Embankment - Long Truck Haul		737,894	cys	$13.64	$10,064,674
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3.24	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		146,123	sys	$3.69	$538,670
	10	Place 3.5" Concrete Liner		146,123	sys	$46.38	$6,777,871
	11	Final Cure for Concrete Liner		146,123	sys	$0.32	$46,841
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$3.21	$0
		Ancillary Facilities					
	13	New Ladders		100	ea	$5,610	$560,976
	14	Check Structure - Modify		0	ea	$1,602,788	$0
	15	Check Structures - Demolish		0	ea	$320,558	$0
	16	Check Structure - New		1	ea	$4,006,971	$4,006,971
	17	Transition to (e) Bridges - 112'		1	ea	$80,139	$80,139
	18	Transitions to (e) Turnouts		10	ea	$40,070	$400,697
	19	New Turnouts on New Canal		3	ea	$24,042	$72,125
	20	Siphon Construction on New Canal		1	ea	$3,606,274	$3,606,274
	21	Raise/Modify Existing Turnout Top Deck Actuator		5	ea	$8,014	$40,070
	22	Delivery Pools		2	ea	$400,697	$801,394
		Subtotal Page 2 =>					**$29,927,767**

QUANTITIES		**PRICES**	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Alternative 1 - Enlarge Existing Canal MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	23	Demo (e) County or State Bridge		1	ea	$400,697.09	$400,697
	24	Demo (e) Farm Bridge		0	ea	$40,069.71	$0
	25	New County or State Bridges - 90' span		4	ea	$2,166,487.43	$8,665,950
	26	Replace (e) Farm Bridges		1	ea	$200,348.55	$200,349
		O&M Road					
	27	Prep/Compact Subgrade		99,515	sys	$2.77	$275,938
	28	Purchase/Deliver Aggregate Base Course - 4"		22,000	tns	$32.06	$705,227
	29	Place & Compact Aggregate Base		22,000	tns	$4.81	$105,784
	30	Blue top Aggregate Base		99,515	sys	$1.38	$137,171
		Utilities					
	31	Parallel Overhead Powerline Relocation		4	mi	$560,975.93	$1,963,416
	32	Adjacent Groundwater Well Abandonments		4	ea	$12,020.91	$48,084
	33	Culvert Extensions		5	ea	$12,020.91	$60,105
	34	Pipeline Overcrossing Replacements (8"-12")		1	ea	$56,097.59	$56,098
	35	Impacted Utility Crossings (Attached to Bridges - 4"-24")		4	ea	$80,139.42	$320,558
		Miscellaneous					
	36	Seeding		1,119,540	sf	$0.08	$89,719
		Subtotal Page 3 =>					**$13,029,094**
		Segment 2 Subtotal =>					***$42,956,860***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

FEATURE: Alternative 1 - Enlarge Existing Canal, MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal, Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 3 - Deer Creek to White River (Enlarge Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		54,698	lf	$0	$0
	2	Strip/Clear Vegetation at New Embankment Areas		50	ac	$4,082	$204,115
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		500	dys	$120.21	$60,105
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		425,429	sy	$2.29	$975,078
	5	Excavation to Embankment - Scraper/Dozer (Balance)		325,113	cys	$5.13	$1,667,479
	6	Excavation to Embankment - Short Truck Haul		0	cys	$7.37	$0
	7	Excavation to Embankment - Long Truck Haul		1,784,261	cys	$13.64	$24,336,836
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3.24	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		307,553	sys	$3.69	$1,133,767
	10	Place 3.5" Concrete Liner		307,553	sys	$46.38	$14,265,752
	11	Final Cure for Concrete Liner		307,553	sys	$0.32	$98,588
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$3.21	$0
		Ancillary Facilities					
	13	New Ladders		146	ea	$5,610	$819,025
	14	Check Structure - Modify		1	ea	$1,602,788	$1,602,788
	15	Check Structures - Demolish		1	ea	$320,558	$320,558
	16	Check Structure - New		0	ea	$3,205,577	$0
	17	Transition to (e) Bridges - 112'		0	ea	$80,139	$0
	18	Transitions to (e) Turnouts		10	ea	$40,070	$400,697
	19	New Turnouts on New Canal		6	ea	$24,042	$144,251
	20	Siphon Construction on New Canal		7	ea	$3,606,274	$25,243,917
	21	Raise/Modify Existing Turnout Top Deck Actuator		2	ea	$8,014	$16,028
	22	Delivery Pools		6	ea	$400,697	$2,404,183
		Subtotal Page 4 =>					**$73,693,168**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

ESTIMATE WORKSHEET

FEATURE:	**PROJECT:**
Alternative 1 - Enlarge Existing Canal	**Friant-Kern Canal**
MP 88.2 to 121.5	**Middle Reach Capacity Correction (MRCC)**
	WOID:
	ESTIMATE LEVEL: **Appraisal**
	REGION: **MP**
	UNIT PRICE LEVEL: **3/1/2019**
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	23	Demo (e) County or State Bridge		7	ea	$400,697	$2,804,880
	24	Demo (e) Farm Bridge		0	ea	$40,070	$0
	25	New County or State Bridges - 90' span		3	ea	$2,166,487	$6,499,462
	26	Replace (e) Farm Bridges		2	ea	$200,349	$400,697
		O&M Road					
	27	Prep/Compact Subgrade		145,860	sys	$2.77	$404,444
	28	Purchase/Deliver Aggregate Base Course - 4"		32,000	tns	$32.06	$1,025,785
	29	Place & Compact Aggregate Base		32,000	tns	$4.81	$153,868
	30	Blue top Aggregate Base		145,860	sys	$1.38	$201,053
		Utilities					
	31	Parallel Overhead Powerline Relocation		3	mi	$560,976	$1,682,928
	32	Adjacent Groundwater Well Abandonments		8	ea	$12,021	$96,167
	33	Culvert Extensions (Each End)		4	ea	$12,021	$48,084
	34	Pipeline Overcrossing Replacements (8"-12")		2	ea	$56,098	$112,195
	35	Impacted Utility Crossings (Attached to Bridges - 4"-24")		7	ea	$80,139	$560,976
		Miscellaneous					
	36	Seeding		1,640,940	sf	$0.08	$131,504
		Subtotal Page 5 =>					**$14,122,042**
		Segment 3 Subtotal =>					***$87,815,210***

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

FEATURE:		**PROJECT:**	
Alternative 1 - Enlarge Existing Canal		**Friant-Kern Canal**	
MP 88.2 to 121.5		**Middle Reach Capacity Correction (MRCC)**	
		WOID:	**ESTIMATE LEVEL:** Appraisal
		REGION: MP	**UNIT PRICE LEVEL:** 3/1/2019
		FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Segment 4 - White River to Ave 8 Bridge (Enlarge Canal)					
		Removals					
	1	Score/Remove (e) Concrete Liner (Top 7' - Both Sides)		15,727	lf	$0.00	$0
	2	Strip/Clear Vegetation at New Embankment Areas		14	ac	$4,082	$57,152
		Maintenance of Temporary Works					
	3	Maintain Haul Roads & Dust Controls for All Earthworks		0	dys	$3.21	$0
		Excavation to Embankment or Waste					
	4	Disk/Pre-Wet Excavation Areas		122,321	sy	$2.29	$280,358
	5	Excavation to Embankment - Scraper/Dozer (Balance)		111,032	cys	$5.13	$569,475
	6	Excavation to Embank. - Short Truck Haul (Estimate - Qty under Dev)		0	cys		
	7	Excavation to Embank. - Long Truck Haul (Estimate - Qty under Dev)		107,709	cys	$13.64	$1,469,122
	8	Spread/Shape/Compact Waste Matls at Dump or Stockpile Site		0	cys	$3.24	$0
		Concrete Canal Liner					
	9	Trim/Compact Excavated Areas		69,142	sys	$3.69	$254,886
	10	Place 3.5" Concrete Liner		69,142	sys	$46.38	$3,207,131
	11	Final Cure for Concrete Liner		69,142	sys	$0.32	$22,164
	12	Trim/Point/Patch at (e) Liner Joint		0	lf	$3.21	$0
		Ancillary Facilities					
	13	New Ladders		42	ea	$5,610	$235,610
	14	Check Structure - Modify		0	ea	$1,602,788	$0
	15	Check Structures - Demolish		0	ea	$320,558	$0
	16	Check Structure - New		0	ea	$3,205,577	$0
	17	Transition to (e) Bridges - 112'		2	ea	$80,139	$160,279
	18	Transitions to (e) Turnouts		11	ea	$40,070	$440,767
	19	New Turnouts on New Canal		1	ea	$24,042	$24,042
	20	Siphon Construction on New Canal		1	ea	$3,606,274	$3,606,274
	21	Raise/Modify Existing Turnout Top Deck Actuator		0	ea	$8,014	$0
	22	Delivery Pools		1	ea	$400,697	$400,697
		Subtotal Page 6 =>					**$10,727,955**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET**

FEATURE: Alternative 1 - Enlarge Existing Canal MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Bridges					
	24	Demo (e) County or State Bridge		1	ea	$400,697	$400,697
	25	Demo (e) Farm Bridge		0	ea	$40,070	$0
	26	New County or State Bridges - 90' span		0	ea	$2,166,487	$0
	27	Replace (e) Farm Bridges		0	ea	$200,349	$0
		O&M Road					
	28	Prep/Compact Subgrade		41,938	sys	$3	$116,287
	29	Purchase/Deliver Aggregate Base Course - 4"		9,000	tns	$32	$288,502
	30	Place & Compact Aggregate Base		9,000	tns	$5	$43,275
	31	Blue top Aggregate Base		41,938	sys	$1	$57,807
		Utilities					
	32	Parallel Overhead Powerline Relocation		1	mi	$560,976	$560,976
	33	Adjacent Groundwater Well Abandonments		0	ea	$12,021	$0
	34	Culvert Extensions (Each End)		0	ea	$12,021	$0
	35	Pipeline Overcrossing Replacements (8"-12")		2	ea	$56,098	$112,195
	36	Impacted Utility Crossings (Attached to Bridges - 4"-24")		1	ea	$80,139	$80,139
		Miscellaneous					
	37	Seeding		471,810	sf	$0	$37,811
		Subtotal Page 7 =>					**$1,697,689**
		Segment 4 Subtotal =>					***$12,425,645***

QUANTITIES		PRICES	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:

Alternative 1 - Enlarge Existing Canal
MP 88.2 to 121.5

PROJECT:

Friant-Kern Canal
Middle Reach Capacity Correction (MRCC)

WOID:

ESTIMATE LEVEL: **Appraisal**

REGION: **MP**

UNIT PRICE LEVEL: **3/1/2019**

FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Construction Allowances					
	1	Contractor Quality Control		1	ls	0.75%	$1,073,983
	2	Flaggers		1,000	hr	$96.17	$96,167
	3	Rent Traffic Message Boards + Other T.C.s		1,000	dys	$320.56	$320,558
	4	Cathodic Protection		1	ls	$0.00	$0
	5	Crew / Mgt Per-diems & Travel		1	ls	$0.00	$0
	6	Labor Overtime		1	ls	$0.00	$0
	7	Liquated Damages		1	ls	$0.00	$0
		Mobilization					
	8	Submittals/Procurement/POs/Resource Coordination		3	mo	$40,070	$120,209
	9	Establish Survey Controls		1	ls	$0.00	$0
	10	Establish Baseline Survey / Alignment / As-builts		1,000	hr	$400.70	$400,697
	11	Install/Maintain BMPs, SWPPP		1	ls	$560,976	$560,976
	12	Initial Equipment Mobilization		20	lds	$3,206	$64,112
	13	Initial Labor Mobilization		1	ls	$0.00	$0
	14	Third Party Design Services / Outside Consultants		1	ls	$0.00	$0
	15	Develop & Maintain Water Supply		1	ls	$280,488	$280,488
	16	Create & Maintain Access / Cofferdams, Crane Pads, etc.		1	ls	$400,697	$400,697
	17	Create & Maintain Access to Borrow or Dump Areas		0	ea	$40,070	$0
	18	Clear/Prep Borrow or Dump Areas		0	ea	$32,056	$0
	19	Reclaim Borrow Areas		5	ea	$80,139	$400,697
	20	Build New Haul Roads to Facilitate Earthwork Hauling		20.41	mi	$80,139	$1,635,646
	21	Reclaim Temporary Haul Roads		20.41	mi	$32,056	$654,258
		Startup/Commission/Owner Training					
	22	Pre-commissioning		600	hrs	$240.42	$144,251
	23	Vendor Support		1	ls	$0.00	$0
	24	Commissioning		600	hrs	$240.42	$144,251
	25	Training		200	hrs	$160.28	$32,056
	26	Startup Expendables		1	ls	$40,070	$40,070
		Subtotal Page 8 =>					**$6,369,115**

QUANTITIES		PRICES	
BY	**CHECKED**	**BY**	**CHECKED**
M. Carpenter, J. Loucks		J. Loucks, E. Hersh	M. Carpenter, E. Perez
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**
04/02/19		04/08/19	

FEATURE: Alternative 1 - Enlarge Existing Canal MP 88.2 to 121.5	**PROJECT:** Friant-Kern Canal Middle Reach Capacity Correction (MRCC)
	WOID:
	ESTIMATE LEVEL: Appraisal
	REGION: MP
	UNIT PRICE LEVEL: 3/1/2019
	FILE: C:\Users\ehersh\Desktop\FR AD1\[FKC_FR1AD__BlueSheets__2019_0415r.xlsx]ALT 5

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal from Page 1					**$0**
		Subtotal from Page 2					**$29,927,767**
		Subtotal from Page 3					**$13,029,094**
		Subtotal from Page 4					**$73,693,168**
		Subtotal from Page 5					**$14,122,042**
		Subtotal from Page 6					**$10,727,955**
		Subtotal from Page 7					**$1,697,689**
		Subtotal from Page 8					**$6,369,115**
		Subtotal with Mobilization, Startup, Commission, & Owner Training					**$149,566,830**
		Contract Cost Allowances (Sum of):	17%	+/-			$25,426,361
		Design Contingencies, 0% (+/-)					
		APS, 0% (+/-). Type of Procurement: Full and Open Request for Proposal					
		CONTRACT COST					**$175,000,000**
		Construction Contingencies	20%	+/-			$35,000,000
		FIELD COST (Unit Price Level March 2019)					**$210,000,000**
		Escalation to Notice to Proceed (NTP) from Unit Price Level not included here. Will be included in the Construction Cost Estimate (CCE)/					
		Project Cost Estimate (PCE) generated by the appropriate responsible office.					
		Non-Contract Costs		**To be determined by the appropriate responsible office.**			
		CONSTRUCTION COST		**To be determined by the appropriate responsible office.**			
		Ref: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02, and 09-03.					

QUANTITIES		**PRICES**	
BY M. Carpenter, J. Loucks	**CHECKED**	**BY** J. Loucks, E. Hersh	**CHECKED** M. Carpenter, E. Perez
DATE PREPARED 04/02/19	**PEER REVIEW / DATE**	**DATE PREPARED** 04/08/19	**PEER REVIEW / DATE**