Appendix B
Evaluation of Alternative Alignments for the Drop 2 Reservoir Canal

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TECHNICAL MEMORANDUM

Date: December 14, 2005

To: Robert Johnson, Regional Director
Bureau of Reclamation, Lower Colorado River Region

From: Russ Reichelt, Bureau of Reclamation – Yuma Area Office
Scott Foster, Bureau of Reclamation – Engineering Services Office, Boulder City

Project: Proposed Drop 2 Reservoir

Subject: Evaluation of Alternative Alignments for the Drop 2 Reservoir Inlet Canal

BACKGROUND

The Bureau of Reclamation (Reclamation) has completed an appraisal level study wherein several alternative lower Colorado River water storage projects were considered and evaluated. Pursuant to the findings and recommendations of this appraisal level study, a storage development strategy was adopted that calls for the development of storage capacity at various locations. The adopted strategy includes development of a new water storage reservoir on a site located adjacent to the All American Canal near Drop 2. This proposed reservoir project is hereinafter referred to as the Drop 2 Reservoir.

The Drop 2 Reservoir will comprise an earthen embankment reservoir. The reservoir will be formed by partially excavating below the existing ground surface elevation. The excavated soils will be used to construct the earthen embankments. The proposed Drop 2 Reservoir project will include the construction of a new Coachella Canal Turnout. Following completion of the construction of the new turnout, the existing Coachella Canal Turnout and connecting section of new lined canal will be modified and thereafter dedicated for use as a diversion and flow control facility for the proposed Drop 2 Reservoir. Water is proposed to be diverted from the All American Canal through the converted Coachella Canal Turnout into a proposed Drop 2 Reservoir Inlet Canal. The turnout is located immediately above Drop 1. An approximately seven mile long concrete lined Inlet Canal will be constructed and used to convey Colorado River water from the turnout to the reservoir.

An operation study to support the preliminary design of the proposed Drop 2 Reservoir is currently underway. A component of this operation study is the evaluation of alternative alignments and facility configurations for the Drop 2 Reservoir Inlet Canal.

STUDY OBJECTIVE

The objective of this supplemental study is to evaluate alternative alignments for the Drop 2 Reservoir Inlet Canal/Pipeline and provide a recommendation on a preferred Drop 2 Reservoir Inlet Canal alignment. This study considers and evaluates various routes and conveyance systems that can be used to meet the Drop 2 Reservoir Inlet Canal

requirements and the respective environmental, implementation, right-of-way acquisition, and cost impacts associated with each alternative.

TECHNICAL TEAM

The various evaluations of this study were undertaken and completed by a technical team comprised of representatives from Reclamation's Lower Colorado Region Engineering Services Office, Yuma Area Office, Technical Service Center in Denver, and Brown and Caldwell. A list of the individuals that formed the technical team is provided in Attachment A.

ALTERNATIVE INLET CANAL ALIGNMENTS CONSIDERED

A total of nine alternative inlet canal alignments were considered and evaluated in this study. All of the inlet canal alignments begin and end at common points. All of the alternative alignments consider the conveyance of water via gravity flow (no pumped systems). For the purpose of this evaluation, the common point of beginning for the various inlet canal alignments is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All American Canal (located within Section 31 T. 16S, R. 20E). Similarly, for the purpose of this evaluation, the common end point for the various inlet canal alignments is the inlet structure to the Proposed Drop 2 Reservoir (located near the northeast corner of the west half of the southeast quarter of Section 32 T. 16S, R. 19E).

Each inlet canal alignment differed in the route selected for the respective conveyance facilities. The different routes represented the most direct routes with due consideration to the following:

- Directness of the route (i.e. avoid bends and turns)
- Perceived acceptability of the alignment to the local community, County of Imperial Planning and Road Departments, State of California Department of Transportation (Caltrans), and BLM.
- Perceived difficulty or ease of construction (constructability)
- Potential environmental impacts, level of mitigation required, and effort required to achieve environmental compliance
- Estimated level of effort for right-of-way (ROW) acquisition and respective cost (i.e. number of acquisitions, total acres, and current public/private ownership of affected lands)
- Utilities relocation and associated costs

The different alternatives that were selected for detailed analysis are listed in Table 1. A graphic presentation of the general location of the alternative alignments is presented in Figure 1. The naming convention for each alternative includes a number and letter, with the number indicating the route or alignment, and the letter indicating an alternative facility configuration. As shown in the table below, some alternatives included more than one facility configuration option. These options each represent a package of different facilities that can be used to achieve the flow conveyance and hydraulic goals of the alternative. More detailed descriptions for each alternative are provided in Attachment B.

Table 1
Drop 2 Reservoir Inlet Canal Alignments Selected for Evaluation

	Description	Alignment Length (feet)	Number of Reaches	Facility Types
1A	Alignment located within County Road ROW proposed to be abandoned	29,240	5	Canal/Box Conduit
1B	Alignment located within County Road ROW proposed to be abandoned	29,240	5	Canal
2A	Portion of alignment located within County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,390	6	Canal/Box Conduit
2B	Portion of alignment located within County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,390	6	Canal
3A	Portion of alignment located on Private lands to be acquired that are located adjacent and parallel to County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,240	5	Canal/Box Conduit
3B	Portion of alignment located on Private lands to be acquired that are located adjacent and parallel to County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,240	5	Canal
4A	Portion of alignment located along 1/2 Section Line of Section 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	33,840	7	Canal/Box Conduit
4B	Portion of alignment located along 1/2 Section Line of Sections 31 and 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	33,840	7	Canal
5A	Portion of alignment circumvents Section 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	36,960	7	Canal
6A	Large portion of alignment located within area between existing AAC and I-8 ROWs	32,040	6	Canal/Pipeline
7A	Most of alignment generally located along 1/2 Section Line of Sections 31, 36, 35, 34, & 33	25,840	4	Canal/Box Conduit
7B	Most of alignment generally located along 1/2 Section Line of Sections 31, 36, 35, 34, & 33	25,840	4	Canal
8A	Portion of alignment located within abandoned Coachella Canal and along 1/2 Section Line of Sections 31 and 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	32,080	7	Canal
9A	Portion of alignment located within abandoned Coachella Canal, portion of alignment circumvents Section 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	37,160	7	Canal

PROPOSED DROP 2 RESERVOIR SITE

ALIGNMENT 9
ALIGNMENT 5
ALIGNMENT 4
ALIGNMENT 8
ALIGNMENT 7
ALIGNMENT 6
ALIGNMENT 3
ALIGNMENT 2
ALIGNMENT 1

MODIFIED TURNOUT STRUCTURE

I-8 FREEWAY
DROP 2 OUTLET CANAL/PIPELINE
ALL AMERICAN CANAL

SAND DUNES
MESA
EAST
CALIFORNIA
BAJA CALIFORNIA NORTE
UNITED STATES
MEXICO

LEGEND

- PARCEL LINE
- ALIGNMENT 1
- ALIGNMENT 2
- ALIGNMENT 3
- ALIGNMENT 4
- ALIGNMENT 5
- ALIGNMENT 6
- ALIGNMENT 7
- ALIGNMENT 8
- ALIGNMENT 9

0 1000 2000
SCALE IN FEET

FIGURE 1
DROP 2 RESERVOIR INLET ALIGNMENT ALTERNATES

PROJECT LOCATION	DATE	PROJECT NUMBER
IMPERIAL COUNTY YUMA, CALIFORNIA	JULY 2005	128051

BROWN AND CALDWELL
OXNARD, CALIFORNIA

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FACILITY SIZING

The different alternative alignments will traverse different types of terrain and different combinations of publicly and privately owned lands. In some cases, the alignments will also cross underneath or be located within public rights of way. To minimize the impacts to the privately owned parcels and to the public rights of way, some of the alignments considered the use of either buried pipelines or box conduits in lieu of open channels (canals). Also, in other cases, the inlet canal alignments were routed around the privately owned parcels to minimize the impacts to these properties and their owners or to minimize the land acquisition cost. The circumventing of the privately owned parcels increased the length of the inlet canal alignment. Because these conditions changed the layout and configuration of the inlet canal system contemplated in the Preliminary Study, it was necessary to evaluate the hydraulic conditions of the subject system with consideration to the different alternative alignments, and the different facility types, sizes and lengths.

System Hydraulic Conditions

The hydraulic analysis for each alternative alignment considered the following:

- Facility design parameters (provided by Reclamation)
- Preliminary reservoir and canal design information as provided in the Preliminary Study of Lower Colorado River Storage Alternatives
- All American Canal operational data provided by the Imperial Irrigation District
- Topographic survey data

The sizing of the conveyance facilities for all of the alternative alignments considers the range of operating water surface elevations in the All American Canal at a point located immediately upstream of Drop 1. This water surface elevation operating range was provided in the Preliminary Study of Lower Colorado River Storage Alternatives and is reported to be between 1157.50 feet and 1163.50 feet.

The terminus of the conveyance facilities for all of the alternative alignments is the inlet structure to the Drop 2 Reservoir. As such, the sizing of the conveyance facilities also considered the planned range of operating water surface elevations of the Drop 2 Reservoir. The planned water surface elevation operating range for the Drop 2 Reservoir was also provided in the Preliminary Study of Lower Colorado River Storage Alternatives and is reported to be between 1135.00 feet and 1155.00 feet.

The anticipated worst case operating condition was used to size all of the facilities. This condition assumes that the water surface elevation in the All American Canal immediately upstream of Drop 1 is at the bottom of its operating range (1157.5 feet) and the water surface elevation of the Drop 2 Reservoir is at the top of its operating range (1155.00 feet).

Given the above noted alternative alignment conditions and hydraulic parameters, hydraulic analyses were conducted for each alternative alignment to determine what combination of facility types and sizes are needed to convey a design flow of 1,800 cubic feet per second (cfs) from the turnout at the All American Canal to the Drop 2 Reservoir Inlet Structure.

Sizing and Design Criteria

Given the above noted alternative alignment conditions and hydraulic parameters, hydraulic analyses were conducted for each alternative alignment to determine what

combination of facility types and sizes are needed to convey a design flow of 1,800 cfs from the turnout at the All American Canal to the Drop 2 Reservoir Inlet Structure. The sizing and design criteria that was used in this analysis is summarized in Attachment C - Sizing and Design Criteria.

Hydraulic Analyses

Hydraulic losses for each facility type were calculated using derivations of Manning's equation and the Energy Equation (Bernoulli's equation). As note above, all of the facilities for each alternative alignment were sized to convey a design flow of 1800 cfs. A spread sheet model was used to calculate the sum of the head losses of the individual conveyance system components and to evaluate the hydraulic profile across the system.

The anticipated worst case operating condition was used to size all of the facilities. This condition assumes that the water surface elevation in the All American Canal immediately upstream of Drop 1 (source) is at the bottom of its operating range (1157.5 feet) and the water surface elevation of the Drop 2 Reservoir is at the top of its operating range (1155.00 feet). The individual facility sizing for each system component was varied to reduce the individual system component headloss accordingly to achieve the target hydraulic gradeline (HGL) of 1155.00 feet at the terminus point of the inlet canal system. This was done independently for each alternative alignment. In most instances, several iterations of this process were needed to arrive at the final sizing for the different system components. More details on the methodology and detailed results for the hydraulic analyses are provided in Attachment D - Hydraulic Analyses Methods and Results.

Facility Configuration and Sizing

The combinations of facility types and sizes that were determined to be needed to convey a design flow of 1,800 cfs under each respective inlet canal alternative alignment are summarized in the following tables. A 400-foot wide ROW was assumed in the absence of design information to include provisions for temporary construction access and associated impacts. (Note: Subsequent design information, available after the analysis, suggests that a 200-ft wide ROW with some wider temporary construction easements will suffice.) The layout and location of the individual alternative alignments and respective reaches are depicted in the figure provided following the detailed description for each respective alignment in Attachment B – Alternative Inlet Canal Alignments and System Configurations.

Alternative No. 1A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=20' / h=15.4'	0.000031
2	Sec 36	within County Road ROW	1,800	5,280	Box Conduit	13' x 13'	N/A
3	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=20' / h=15.4'	0.000031
4	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=20' / h=15.4'	0.000031
5	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=20' / h=15.4'	0.000031
Total	NA	NA	1,800	29,240	NA	NA	NA

Alternative No. 1B

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=17.5' / h=13.5'	0.000062
2	Sec 36	within County Road ROW	1,800	5,280	Canal	b=17.5' / h=13.5'	0.000062
3	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=17.5' / h=13.5'	0.000062
4	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=17.5' / h=13.5'	0.000062
5	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=17.5' / h=13.5'	0.000062
Total	NA	NA	1,800	29,240	NA	NA	NA

Alternative No. 2A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=20' / h=15.4'	0.000031
2	Sec 36	within County Road ROW	1,800	5,280	Box Conduit	13' x 13'	N/A
3	Sec 35	400 foot strip west & parallel to west section line of Section 36	1,800	150	Canal	b=20' / h=15.4'	0.000031
4	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=20' / h=15.4'	0.000031
5	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=20' / h=15.4'	0.000031
6	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=20' / h=15.4'	0.000031
Total	NA	NA	1,800	29,390	NA	NA	NA

Alternative No. 2B

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=17.5' / h=13.5'	0.000062
2	Sec 36	within County Road ROW	1,800	5,280	Canal	b=17.5' / h=13.5'	0.000062
3	Sec 35	400 foot strip west & parallel to west section line of Section 36	1,800	150	Canal	b=17.5' / h=13.5'	0.000062
4	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=17.5' / h=13.5'	0.000062
5	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=17.5' / h=13.5'	0.000062
6	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=17.5' / h=13.5'	0.000062
Total	NA	NA	1,800	29,390	NA	NA	NA

Alternative No. 3A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=20' / h=15.4'	0.000031
2	Sec 36	within County Road ROW	1,800	5,280	Box Conduit	13' x 13'	N/A
3	Sec 32, 33, 34, 35	400 foot strip located north/parallel to the County Road ROW (adjacent to ROW)	1,800	17,160	Canal	b=20' / h=15.4'	0.000031
4	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=20' / h=15.4'	0.000031
5	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=20' / h=15.4'	0.000031
Total	NA	NA	1,800	29,240	NA	NA	NA

Alternative No. 3B

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=17.5' / h=13.5'	0.000062
2	Sec 36	within County Road ROW	1,800	5,280	Canal	b=17.5' / h=13.5'	0.000062
3	Sec 32, 33, 34, 35	400 foot strip located north/parallel to the County Road ROW (adjacent to ROW)	1,800	17,160	Canal	b=17.5' / h=13.5'	0.000062
4	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=17.5' / h=13.5'	0.000062
5	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=17.5' / h=13.5'	0.000062
Total	NA	NA	1,800	29,240	NA	NA	NA

Alternative No. 4A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=19.5' / h=15'	0.000035
2	Sec 31	West 400 feet of SW Sec 31	1,800	2,000	Canal	b=19.5' / h=15'	0.000035
3	E-W on half Sec Ln 36	within County Road ROW	1,800	5,280	Box Conduit	14' x 14'	N/A
4	SE quarter of Sec 35	400 foot strip diagonal (NE to SW) SE quarter Sec 35	1,800	2,600	Canal	b=19.5' / h=15'	0.000035
5	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=19.5' / h=15'	0.000035
6	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=19.5' / h=15'	0.000035
7	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=19.5' / h=15'	0.000035
Total	NA	NA	1,800	33,840	NA	NA	NA

Alternative No. 4B

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=18' / h=13.8'	0.000054
2	Sec 31	West 400 feet of SW Sec 31	1,800	2,000	Canal	b=18' / h=13.8'	0.000054
3	E-W on half Sec Ln 36	within County Road ROW	1,800	5,280	Canal	b=18' / h=13.8'	0.000054
4	SE quarter of Sec 35	400 foot strip diagonal (NE to SW) SE quarter Sec 35	1,800	2,600	Canal	b=18' / h=13.8'	0.000054
5	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=18' / h=13.8'	0.000054
6	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=18' / h=13.8'	0.000054
7	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=18' / h=13.8'	0.000054
Total	NA	NA	1,800	33,840	NA	NA	NA

Alternative No. 5A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,200	Canal	b=18.5' / h=14.2'	0.000046
2	Sec 31	west 400 feet of SW Sec 31	1,800	2,600	Canal	b=18.5' / h=14.2'	0.000046
3	Sec 36	south 400 feet of Sec 25	1,800	5,680	Canal	b=18.5' / h=14.2'	0.000046
4	Sec 35	east 400 feet of Sec 35	1,800	5,280	Canal	b=18.5' / h=14.2'	0.000046
5	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	1,800	17,160	Canal	b=18.5' / h=14.2'	0.000046
6	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,640	Canal	b=18.5' / h=14.2'	0.000046
7	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=18.5' / h=14.2'	0.000046
Total	NA	NA	1,800	36,960	NA	NA	NA

Alternative No. 6A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip north & parallel to dirt road	1,800	3,800	Canal	b=22.5' / h=17.3'	0.000016
2	Sec 31, 6	400 foot strip. Parallel and east of east section line of Section 31	1,800	1,200	Pipeline	D = 13'	N/A
3	Sec 6, 1, 2, 3, 4	400 foot strip. Parallel to All American Canal	1,800	22,800	Canal	b=22.5' / h=17.3'	0.000016
4	Sec 4, 32	400 foot strip. Parallel and east of east section line of Section 33	1,800	1,200	Pipeline	D = 13'	N/A
5	Secs 32	400 foot strip. Parallel and east of east section line of Section 33	1,800	2,640	Canal	b=22.5' / h=17.3'	0.000016
6	Secs , 32	400 foot strip located on south side of east-west ½ section line of Sec 32	1,800	400	Canal	b=22.5' / h=17.3'	0.000016
Total	NA	NA	1,800	32,040	NA	NA	NA

Alternative No. 7A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	west by northwest route from T.O. to NW corner of SW 1/4 of Sec 31	1,800	3,000	Canal	b=17.5' / h=13.5'	0.000062
2	Sec 36	north 400 feet of south 1/2 of Section 36	1,800	5,280	Box Conduit	14' x 14'	N/A
3	Secs 35, 34, 33	north 400 feet of south 1/2 of Secs 35, 34, & 33	1,800	15,840	Canal	b=17.5' / h=13.5'	0.000062
4	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	1,720	Canal	b=17.5' / h=13.5'	0.000062
Total	NA	NA	1,800	25,840	NA	NA	NA

Alternative No. 7B

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	west by northwest route from T.O. to NW corner of SW 1/4 of Sec 31	1,800	3,000	Canal	b=18.5' / h=14.2'	0.000046
2	Sec 36	north 400 feet of south 1/2 of Section 36	1,800	5,280	Canal	b=18.5' / h=14.2'	0.000046
3	Secs 35, 34, 33	north 400 feet of south 1/2 of Secs 35, 34, & 33	1,800	15,840	Canal	b=18.5' / h=14.2'	0.000046
4	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	1,720	Canal	b=18.5' / h=14.2'	0.000046
Total	NA	NA	1,800	25,840	NA	NA	NA

Alternative No. 8A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip with centerline that follows the centerline of abandoned Coachella Canal	1,800	1,000	Canal	b=18' / h=13.8'	0.000054
2	Sec 31	400 foot strip along north side of east-west 1/2 Sec line of Sec 31	1,800	3,000	Canal	b=18' / h=13.8'	0.000054
3	E-W on half Sec Ln 36	within County Road ROW	1,800	5,280	Canal	b=18' / h=13.8'	0.000054
4	SE quarter of Sec 35	400 foot strip diagonal (NE to SW) SE quarter Sec 35	1,800	2,640	Canal	b=18' / h=13.8'	0.000054
5	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	1,800	17,160	Canal	b=18' / h=13.8'	0.000054
6	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,600	Canal	b=18' / h=13.8'	0.000054
7	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=18' / h=13.8'	0.000054
Total	NA	NA	1,800	32,080	NA	NA	NA

Alternative No. 9A

Reach No.	Location	Orientation	Design Flow (cfs)	Length (ft)	Facility Type	Dimensions	Slope
1	Sec 31	400 foot strip with centerline that follows the centerline of abandoned Coachella Canal	1,800	3,800	Canal	b=18.5' / h=14.2'	0.000046
2	Sec 31	south 400 feet of Sec 30	1,800	2,200	Canal	b=18.5' / h=14.2'	0.000046
3	Sec 36	south 400 feet of Sec 25	1,800	5,680	Canal	b=18.5' / h=14.2'	0.000046
4	Sec 35	east 400 feet of Sec 35	1,800	5,280	Canal	b=18.5' / h=14.2'	0.000046
5	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	1,800	17,160	Canal	b=18.5' / h=14.2'	0.000046
6	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	1,800	2,640	Canal	b=18.5' / h=14.2'	0.000046
7	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	1,800	400	Canal	b=18.5' / h=14.2'	0.000046
Total	NA	NA	1,800	37,160	NA	NA	NA

EVALUATION PROCESS AND CRITERIA

Several work tasks were undertaken in the evaluation of each inlet canal alternative alignment. These tasks include the development of reconnaissance-level configuration concepts and generalized plan layouts of the conveyance facilities needed to convey water from All American Canal to the proposed Drop 2 Reservoir. The work tasks also included:

- A visual survey of the alternative alignments by members of the Technical Team to better relate proposed structures to the site conditions and assess potential issues that may affect cost estimating for the facilities,
- A preliminary assessment of land ownership and site acquisition issues and constraints,
- An assessment of site development and construction considerations,

- An assessment of alternative routes and different type of conveyance facilities needed to convey 1,800 cfs from the All American Canal to the Drop 2 Reservoir,
- An assessment of the hydraulic characteristics and operational requirements of each alternative alignment and respective conveyance system,
- A preliminary environmental analysis that considered potential environmental impacts, permitting challenges, and cost of mitigation for potential impacts for each inlet canal alternative,
- An assessment of implementation issues including the development of a preliminary schedule for the implementation of each inlet canal alternative alignment, and
- An assessment of capital costs for each inlet canal alternative alignment.

The Technical Team also developed criteria for use in the comparison and further evaluation of the different inlet canal alternative alignments. This criterion is listed and generally described in the following table:

Table 2
Description and Bases of Evaluation Criteria

Factor		Description	Evaluation Basis
1.	Project Cost	• Estimate of upfront capital expenditure requirements.	• Affordability of project. • Project cost is within estimates of funding that can be secured for project.
2.	Schedule	• Number and type of agencies having jurisdiction or approval authority in development of project. • Timeframe that physical construction can commence.	• Ease of permitting shortest construction start date. • Shortest implementation period (online by Oct. 2008)
3.	Environmental considerations	• Level of potential impacts to protected or listed habitat or species. • Number and type of environmental entities having review or approval authority. • Cost and timing associated with potential mitigation actions.	• Relative ease that environmental compliance can be achieved and lowest compliance and mitigation cost.
4.	Land / ROW Acquisition	• Number and type of different owners and ease/difficulty that lands can be secured for project purpose. • Cost associated with acquiring the lands for project.	• Ease that required right-of-way can be readily acquired for project use.
5.	Engineering Effort	• Level of engineering complexity and timeframe needed for project designs • Minimal impacts to public during construction	• Ease of construction and implementation • Risk associated with construction and future operation

EVALUATION OF ALTERNATIVES

General Alignment Issues

The analysis and comparison of the alternatives focused principally on those factors that can potentially vary between the different alternative alignments. Some general alignment issues that apply to all alternatives are as follows:

- All of the alignments begin at the Coachella Turnout and end at the proposed inlet structure to the Drop 2 Reservoir
- All of the alternatives considered assume that a new Coachella Canal Turnout will be constructed and that the existing Coachella Canal will be modified and ultimately used as a dedicated turnout for the Drop 2 Reservoir
- All of the alternatives consider the same low and high water levels within the All American Canal above Drop 1 and at the proposed Drop 2 Reservoir
- All alternatives designed to convey 1800 cfs
- All alternatives considered assume canal section to have membrane liner with concrete lining

Land and Right-of-Way

A general discussion on the various right-of-way issues that can potentially affect the different alternative alignments follows:

Right-of-Way Width Requirements

For analysis purposes, the alignment widths that were deemed necessary for the construction and future operation of the different conveyance facilities are listed in Table 3.

Table 3
Right-of-Way Width Requirements (feet)

Facility Type	Permanent	Temporary	Total
Canal	400	0	400
Pipeline	200	200	400
Box Conduit	200	200	400

Use of Federal Lands

One of the goals of this evaluation was to evaluate the possibility of locating all or most of the needed conveyance facilities within Federal lands that exist within or in close proximity to the project site. Using Federal lands will facilitate project implementation by reducing the land acquisition, project approval, and environmental compliance effort and associated costs. Federal lands are all lands owned by the United States. Reclamation withdrawn lands are federal lands withdrawn from the public domain for specific Reclamation project purposes.

The Federal lands of interest to the project are included in the following table.

Table 4
Federal Lands of Interest to the Project

Township	Range	Section(s)	Comments
16S	20E	30 and 31	None
16S	19E	25, 26, 27, 28 & 29	None
16S	19E	32, 33, 34 & 35	All; including land under Imperial County right-of-way for Evan Hewes Highway excluding those lands designated as Imperial County Road right-of-way (Evan Hewes Highway)
17S	20E	5 & 6	All; including land under Imperial County right-of-way for Evan Hewes Highway and Interstate 8 excluding those lands designated as Imperial County Road right-of -way (Evan Hewes Highway) and/or State of California Department of Transportation (Caltrans) Interstate Highway No. 8 (I-8) right-of-way
17S	19E	1, 2, 3 & 4	All; including land under Imperial County right-of-way for Evan Hewes Highway and Interstate 8 excluding those lands designated as Imperial County Road right-of-way (Evan Hewes Highway) and/or State of California Department of Transportation (Caltrans) Interstate Highway No. 8 (I-8) right-of-way

Privately Owned Lands Within Section 36

All of the lands within Section 36 (T. 16S, R. 20S) are under private ownership (23 parcels with 12 owners). Therefore, any of the alternative alignments that traverse through any portion of Section 36 will require federal acquisition of the affected lands through an easement or fee.

For this analysis, Reclamation sent letters to the various owners of record of the potentially affected lands. The letters described the proposed project and noted Reclamation's interest in locating a portion of inlet canal alignment within their lands. The letters also asked the owners to note their interest in making the needed land available subject to compensation. The responses varied and included several negative responses.

Table 5 provides a preliminary assessment of the acreage of privately owned lands that would be needed under each alternative.

Table 5
ROW and Land Acquisition Requirements and Costs

Alignment	Reach	Reach Length (feet)	ROW Width (feet)	Traverse Privately Owned Properties	ROW Acreage Within Privately Owned Lands (acres)	Est. Unit Cost	Total Estimate Cost for Row
1A	1	3,800	400	No			
	2	5,280	200	Yes	8.5	$50,000	$424,242
	3	17,160	400	No			
	4	2,600	400	No			
	5	400	400	No			
	Subtotal	29,240	NA	NA	8.5	$50,000	$424,242
1B	1	3,800	400	No			
	2	5,280	400	Yes	32.7	$50,000	$1,636,364
	3	17,160	400	No			
	4	2,600	400	No			
	5	400	400	No			
	Subtotal	29,240	NA	NA	32.7	$50,000	$1,636,364
2A	1	3,800	400	No			
	2	5,280	200	Yes	8.5	$50,000	$424,242
	3	150	400	No			
	4	17,160	400	No			
	5	2,600	400	No			
	6	400	400	No			
	Subtotal	29,390	NA	NA	8.5	$50,000	$424,242
2B	1	3,800	400	No			
	2	5,280	400	Yes	32.7	$50,000	$1,636,364
	2	150	400	No			
	4	17,160	400	No			
	5	2,600	400	No			
	6	400	400	No			
	Subtotal	29,390	NA	NA	32.7	$50,000	$1,636,364
3A	1	3,800	400	No			
	2	5,280	200	Yes	24.2	$50,000	$1,212,121
	3	17,160	400	No			
	4	2,600	400	No			
	5	400	400	No			
	Subtotal	29,240	NA	NA	24.2	$50,000	$1,212,121
3B	1	3,800	400	No			
	2	5,280	400	Yes	48.5	$50,000	$2,424,242
	3	17,160	400	No			
	4	2,600	400	No			
	5	400	400	No			
	Subtotal	29,240	NA	NA	48.5	$50,000	$2,424,242

Table 5 (Continued)
ROW and Land Acquisition Requirements and Costs

Alignment	Reach	Reach Length (feet)	ROW Width (feet)	Traverse Privately Owned Properties	ROW Acreage Within Privately Owned Lands (acres)	Est. Unit Cost	Total Estimate Cost for ROW
4A	1	3,800	400	No			
	2	2,000	400	No			
	3	5,280	400	Yes	48.5	$12,500	$606,061
	4	2,600	400	No			
	5	17,120	400	No			
	6	2,600	400	No			
	7	400	400	No			
	Subtotal	33,840	NA	NA	48.5	$12,500	$606,061
4B	1	3,800	400	No			
	2	2,000	400	No			
	3	5,280	200	Yes	24.2	$12,500	$303,030
	4	2,600	400	No			
	5	17,120	400	No			
	6	2,600	400	No			
	7	400	400	No			
	Subtotal	33,840	NA	NA	24.2	$12,500	$303,030
5A	1	3,200	400	No			
	2	2,600	400	No			
	3	5,680	400	No			
	4	5,280	400	No			
	5	17,160	400	No			
	6	2,640	400	No			
	7	400	400	No			
	Subtotal	39,960	NA	NA	0.0	$0	$0
6	1	3,800	400	No			
	2	1,200	200	No			
	3	22,800	400	No			
	4	1,200	200	No			
	5	2,640	400	No			
	6	400	400	No			
	Subtotal	32,040	NA	NA	0.0	$0	$0
7A	1	3,000	400	No			
	2	5,280	200	Yes	24.2	$12,500	$303,030
	3	15,840	400	No			
	4	1,720	400	No			
	Subtotal	25,840	NA	NA	24.2	$12,500	$303,030
7B	1	3,000	400	No			
	2	5,280	400	Yes	48.5	$12,500	$606,061
	3	15,840	400	No			
	4	1,720	400	No			
	Subtotal	25,840	NA	NA	48.5	$12,500	$606,061

Table 5 (Continued)
ROW and Land Acquisition Requirements and Costs

Alignment	Reach	Reach Length (feet)	ROW Width (feet)	Traverse Privately Owned Properties	ROW Acreage Within Privately Owned Lands (acres)	Est. Unit Cost	Total Estimate Cost for ROW
8A	1	1,000	400	No			
	2	3,000	400	No			
	3	5,280	400	Yes	52.2	$50,000	$2,607,897
	4	2,640	400	No			
	5	17,160	400	No			
	6	2,600	400	No			
	7	400	400	No			
	Subtotal	**32,080**	**NA**	**NA**	52.2	$50,000	$2,607,897
9A	1	3,800	400	No			
	2	2,200	400	No			
	3	5,680	400	No			
	4	5,280	400	No			
	5	17,160	400	No			
	6	2,640	400	No			
	7	400	400	No			
	Subtotal	39,920	NA	NA	0.0	$0	$0

Lands Designated to be Within Flat-Tailed Horned Lizard Management Area

Most of the lands within T. 16S, R. 19E lie within the East Mesa Management Area for the flat-tailed horned lizard (FTHL MA). The North half of Section 36 (privately owned) is within the MA boundary (Strategy 2003). The proposed Drop 2 Reservoir site is outside of the FTHL MA. The flat-tailed horned lizard (FTHL) is not federally listed as endangered or threatened, but is the subject of an interagency planning agreement to manage suitable habitat to improve the status of the species. The actions of the FTHL Interagency Coordinating Committee and the status of the species are of ongoing interest to several environmental organizations that have expressed concern regarding the species' long-term status.

Compensatory mitigation of FTHL impacts is required of federal agencies per the Strategy (2003). Impacts within a MA may receive a higher mitigation ratio (up to 6:1) than those outside a MA (e.g. 1:1). The managing federal agency determines the mitigation requirement for the particular MA, in this case BLM El Centro. Consultation with the FTHL Management Oversight Group and BLM may be required for the alternatives that traverse any of the lands that lie within the FTHL MA.

While the reviews for all the inlet canal alternative alignments will be similar, those that impact the greatest area of the East Mesa MA will require more permitting and mitigation effort than those that minimize or avoid FTHL habitat.

Imperial County Road Right-of-Way (Evan Hewes Highway)

The right-of-way for Imperial County's Evan Hewes Highway transverses Reclamation withdrawn lands between Gordon's Well Road and Brock Ranch Road. Imperial County acquired the right-of-way through a relinquishment from California Department of

Transportation after completion of alternate route Interstate 8. If and when Imperial County ceases to use and maintain the County Road right-of-way for the intended purposes stated, then the land would revert back to the respective property owners. Also, since Imperial County does not own the land that underlies the County Road right-of-way, then Imperial County cannot issue a utility easement to any other entity that may want to locate a utility within this right-of-way, or in the case of this project, a conveyance canal or pipeline. As such, a separate utility easement may be needed from the owners of the privately owned lands that underlie the County Road for project conveyance facilities or respective right-of-way that will cross or overlay the County Road right-of-way.

Interstate Highway No. 8 (I-8) Right-of-Way

Alternative Alignment No. 6 is the only alternative that crosses the I-8 right-of-way. Two crossings of the highway are needed. The proposed conveyance facility under Alternative No. 6 assumes pipeline crossings at each location. Each crossing is composed of three parallel pipe barrels that will be constructed using tunneling methods. Each of the three conveyance pipes will have an inside diameter of 13 feet and a casing pipe with an inside diameter of 15 feet. Both the carrier and casing pipes will be constructed of steel plate.

For this evaluation, local Caltrans representatives were contacted to inquire with respect to Caltrans' requirements for trenchless utility crossings of interstate freeways. Caltrans' representatives noted that the requirements for utilities installed by trenchless methods (tunneling) are specified in the Caltrans Encroachment Permit Manual (Section 623, Tunneling – Rib & Lagging). A copy of Section 623 of the Caltrans Encroachment Permit Manual is provided in Attachment G.

Environmental Issues

A preliminary assessment of the acreage within the FTHL MA that may be impacted by the different alternative alignments and the potential mitigation acreage is presented in Table 6. A preliminary estimate of the cost for the replacement lands and assessment of the environmental compliance effort for each alternative is presented in Table 7. For this analysis, the calculation of required replacement lands considers FTHL MA lands that are severed by the alignment as impacted by the project. A mitigation ratio of six to one (6:1) [e.g. worst case] was assumed. The actual replacement ratio may differ from this and will need to be negotiated with the FTHL Management Oversight Group and BLM.

Table 6
Assessment of Potentially Impacted FTHL MA Lands

Alignment	Reach	Within FTHLMA	Reach Length (feet)	ROW Width (feet)	ROW Acreage Within FTHLMA Lands (acres)	Additional FTHLMA Lands Severed by Alignment (acres)	Total FTHL MA Lands Impacted (acres)
1	1	**Yes**	3,800	400	35		**59**
	2	No	5,280	200	0		
	3	No	17,160	400	0		
	4	**Yes**	2,600	400	24		
	5	No	400	400	0		
	Subtotal	**NA**	**29,240**	**NA**	**59**	**0**	
2	1	**Yes**	3,800	400	35		**216**
	2	No	5,280	200	0		
	3	**Yes**	150	400	0		
	4	**Yes**	17,160	400	157		
	5	**Yes**	2,600	400	24		
	6	No	400	400	0		
	Subtotal	**NA**	**29,390**	**NA**	**216**	**0**	
3	1	**Yes**	3,800	400	35		**216**
	2	No	5,280	200	0		
	3	**Yes**	17,160	400	157		
	4	**Yes**	2,600	400	24		
	5	No	400	400	0		
	Subtotal	**NA**	**29,240**	**NA**	**217**	**0**	
4	1	**Yes**	3,800	400	35		**429**
	2	**Yes**	2,000	400	18		
	3	No	5,280	200	0		
	4	**Yes**	2,600	400	34	160	
	5	**Yes**	17,160	400	158		
	6	**Yes**	2,600	400	24		
	7	No	400	400	0		
	Subtotal	**NA**	**33,840**	**NA**	**269**	**160**	
5	1	**Yes**	3,200	400	35		**363**
	2	**Yes**	2,600	400	46		
	3	**Yes**	5,680	400	52		
	4	**Yes**	5,280	400	48		
	5	**Yes**	17,160	400	158		
	6	**Yes**	2,640	400	24		
	7	No	400	400	0		
	Subtotal	**NA**	**36,960**	**NA**	**363**	**0**	
6	1	**Yes**	3,800	400	35		**35**
	2	No	1,200	200	0		
	3	No	22,800	400	0		
	4	No	1,200	200	0		
	5	No	2,640	400	0		
	6	No	400	400	0		
	Subtotal	**NA**	**32,040**	**NA**	**35**	**0**	

Table 6 (Continued)
Assessment of Potentially Impacted FTHL MA Lands

Alignment	Reach	Within FTHLMA	Reach Length (feet)	ROW Width (feet)	ROW Acreage Within FTHLMA Lands (acres)	Additional FTHLMA Lands Severed by Alignment (acres)	Total FTHL MA Lands Impacted (acres)
7	1	**Yes**	3,000	400	28	172	**1,239**
	2	No	5,280	400	0		
	3	**Yes**	15,840	400	158	882	
	4	No	1,720	400	0		
	Subtotal	**NA**	**25,840**	**NA**	**186**	**1,054**	
8	1	**Yes**	1,000	400	9		**422**
	2	**Yes**	3,000	400	28	180	
	3	**No**	5,280	400	0		
	4	**Yes**	2,640	400	24		
	5	**Yes**	17,160	400	158		
	6	**Yes**	2,600	400	24		
	7	No	400	400	0		
	Subtotal	**NA**	**32,080**	**NA**	**242**	**0**	
9	1	**Yes**	3,800	400	35		**657**
	2	**Yes**	2,200	400	20	320	
	3	**Yes**	5,680	400	52		
	4	**Yes**	5,280	400	48		
	5	**Yes**	17,160	400	158		
	6	**Yes**	2,640	400	24		
	7	No	400	400	0		
	Subtotal	**NA**	**37,160**	**NA**	**337**	**0**	

Table 7
Preliminary Assessment of FTHL Land Replacement Costs

ROW ALT	Brief Description	ROW Acreage Within FTHL MA (acres)	Additional FTHL MA Lands Severed by Alignment (acres)	Total FTHL MA Lands Impacted (acres)	FTHL Acreage Required for Mitigation (@ 6% ratio)	Mitigation Land Acquisition Cost @ BLM Cost ($200/acre)	Mitigation Land Acquisition Cost at Market Value	NEPA Cost	Cultural Resources	Recreation Impact
1. A.	Uses Co. ROW	59	0	59	353	$81,102	$352,617	Least	Mitigatable	Low
1. B.	Uses Co. ROW	59	0	59	353	$81,102	$352,617	Least	Mitigatable	Low
2. A.	N. of Section Line	216	0	216	1298	$298,556	$1,298,072	Low	Low	Low
2. B.	N. of Section Line	216	0	216	1298	$298,556	$1,298,072	Low	Low	Low
3. A.	Minor Pvt. Take	216	0	216	1298	$298,556	$1,298,072	Low	Low	Low
3. B.	Minor Pvt. Take	216	0	216	1298	$298,556	$1,298,072	Low	Low	Low
4. A.	Diagonal canal in Sect. 35	363	160	523	3137	$721,604	$3,137,410	Medium	Medium	Medium
4. B.	Diagonal canal in Sect. 35	363	160	523	3137	$721,604	$3,137,410	Medium	Medium	Medium
5. A.	avoids pvt sect. 36	35	0	35	209	$48,154	$209,366	Low	Medium	High
6. A.	S. of I-8	35	0	35	209	$48,154	$209,366	Low	Low	Low
7. A.	@1/2 sec. line	185	1,055	1240	7440	$1,711,200	$7,440,000	High: EIS	Medium-High	High
7. B.	@1/2 sec. line	185	1,055	1240	7440	$1,711,200	$7,440,000	High: EIS	Medium-High	High
8.A.	Coachella to ½ sect. 36	242	180	422	2535	$582,945	$1,267,273	High	Medium	Low-Medium
9.A.	Coachella to N. sect. 36	337	320	657	3943	$906,922	$1,971,570	High	Medium	Medium

Engineering and Construction

The alternatives under consideration generally include two types of conveyance facilities, canals and pipelines. The size, materials used for construction, and site conditions determine the level of complexity for each. Relatively speaking, a canal is much simpler to design and construct than a pipeline; and small, unlined canals are less complex than large concrete lined canals. For pipelines, one that is built in flat undeveloped land is less complex than a pipeline that is built in right-of-ways with paved roads, with extensive existing utilities, traffic, and/or narrow right-of-ways. Also, pipelines that are constructed using open trench methods are much easier to design and construct than pipes that are constructed using tunneling or bore and jack methods. Lastly, a small diameter pipeline is much simpler to design and construct than a large diameter pipeline.

Table 8 presents a general assessment of the level of complexity anticipated for each reach and each respective overall alternative alignment.

Table 8
Assessment of Construction Complexity

Alternative Alignment	Reach / Facility Type / Complexity Level							Overall Complexity
	1	2	3	4	5	6	7	
1A	Canal	Box Conduit	Canal	Canal	Canal	Not Applicable	Not Applicable	Medium-High
	Low	Medium-High	Low-Medium	Low-Medium	Low			
1B	Canal	Canal	Canal	Canal	Canal	Not Applicable	Not Applicable	High
	Low	High	Low-Medium	Low-Medium	Low			
2A	Canal	Box Conduit	Canal	Canal	Canal	Canal	Not Applicable	Medium-High
	Low	Medium-High	Low	Low	Low	Low		
2B	Canal	Canal	Canal	Canal	Canal	Canal	Not Applicable	High
	Low	High	Low	Low	Low	Low		
3A	Canal	One Barrel	Canal	Canal	Canal	Not Applicable	Not Applicable	High
	Low	High	Low	Low	Low			
3B	Canal	Canal	Canal	Canal	Canal	Not Applicable	Not Applicable	High
	Low	High	Low	Low	Low			
4A	Canal	Canal	One Barrel	Canal	Canal	Canal	Canal	Low-Medium
	Low	Low	Medium	Low	Low	Low	Low	
4B	Canal	Canal	Canal	Canal	Canal	Canal	Canal	Low
	Low	Low	Low	Low	Low	Low	Low	
5A	Canal	Canal	Canal	Canal	Canal	Canal	Canal	Low
	Low	Low	Low	Low	Low	Low	Low	
6A	Canal	Tunnel Pipe	Canal	Tunnel Pipe	Canal	Canal	Not Applicable	High
	Low	High	Low	High	Low	Low		
7A	Canal	One Barrel	Canal	Canal	Not Applicable	Not Applicable	Not Applicable	Low-Medium
	Low	Medium	Low	Low				
7B	Canal	Canal	Canal	Canal	Not Applicable	Not Applicable	Not Applicable	Low
	Low	Low	Low	Low				
8A	Canal	Canal	Canal	Canal	Canal	Canal	Canal	Low
	Low	Low	Low	Low	Low	Low	Low	
9A	Canal	Canal	Canal	Canal	Canal	Canal	Canal	Low
	Low	Low	Low	Low	Low	Low	Low	

Capital Cost

Estimates of the capital costs were developed for each alternative alignment. The following provides an overview of the process and assumptions used to develop these estimates.

Quantity Estimates

The inlet canal quantities were based on takeoffs from the alignment layouts which were overlaid on USGS 7.5 minute quadrangle maps. Canal earthwork quantities were calculated based on the proposed inlet canal alignment. Quantities consisted of excavation, canal embankment, and 3.5 inch thick unreinforced concrete lining with a 60 mil HDPE geomembrane underlayment.

The earth excavation and fill quantities for the inlet canal were developed using a canal earthwork modeling spread sheet. For each alignment alternative the following information was collected at 5,000 foot intervals and input into the spreadsheet:

- Canal size
- Canal invert elevation
- Existing ground surface elevation

Given this information, the required cut and fill areas were calculated at each 5,000 foot station. The cut and fill areas were then averaged between adjacent stations and multiplied by the distance between the stations to estimate cut and fill volume required for each 5,000 foot segment.

Unit concrete lining and geomembrane texture quantities were calculated for each alignment alternative based on proposed canal geometry and size information. Unit quantities were then multiplied by the length of each alignment alternative to estimate the total quantity of concrete lining and geomembrane material required for each alignment.

Pipelines and Conduits

The length or quantity of pipeline and concrete box conduit materials were derived from the alignment layouts. For the pipelines, the diameter and estimated cover were used to estimate the required pipe wall thickness or pipe class needed. This information was then used to solicit information on pipe cost from different local pipe manufacturers. For the concrete box conduits, a preliminary design was prepared for each conduit. This was then used to estimate the quantities of concrete and steel reinforcement needed. This information was used to estimate the per lineal foot cost of the materials, forming, and placement of the concrete box conduit.

For both the pipeline and the box conduits, estimates of the required trench excavating backfill and compaction were also calculated for each size facility in order to develop estimates of the respective installation costs. In situations where the facility construction required the removal and replacement of existing manmade features, such as pavement or utilities, the associated costs were also estimated and included in the construction costs for the respective alternative.

Unit Price Estimates

The unit prices were developed from previous Reclamation construction projects with similar work. These unit prices were indexed up to current prices to factor inflation related increases. The Bureau of Reclamation cost estimating manual, which includes curves for pricing earthwork for dams and canals, and concrete lining, was also used. The RSMeans cost estimating handbook was also utilized. The cost of geomembrane and gravel surfacing was obtained by contacting suppliers and obtaining quotes.

Cost Estimate Markups

The cost estimates include 5 percent mobilization, 15 percent unlisted items, and a 20 percent contingency allowance. The mobilization percent estimates the cost for the contractor to mobilize equipment to the site and setup of an onsite office. The unlisted items allowance provides for the cost of items not estimated in detail. The purpose for the contingency allowance is to pay contractors for overruns on quantities, changed site conditions, and orders for changes.

The cost estimate includes non-contract costs. These costs include pre-construction activities such as design data collection, site investigations, land acquisition, pre-construction administrative costs, construction management costs, design costs, and environmental compliance costs including land acquisition for mitigation. The estimate for the pre-construction and construction management activities was assumed to be equal to 20 percent of the contract costs.

The right-of-way and land acquisition cost estimates were based on the estimated acreage that would be impacted for each respective alternative alignment. An assessment was made with respect to the condition of the affected privately owned lands; i.e., they were classified as undeveloped or developed lands. For each category of land, a unit (per acre) cost factor was developed and applied to estimate the potential cost associated with acquiring the needed right-of-way. For undeveloped lands, a unit cost of $12,500 per acre was applied. For the developed lands, an average unit cost of $50,000 per acre was applied. These unit costs were obtained from Reclamation. For each alternative, the cost for the privately owned developed and undeveloped lands was added to estimate the total cost of acquiring the needed right-of-way within the privately owned lands.

The assumption was made that there would be no costs associated with acquiring right-of-way within Federal lands, County owned rights-of-way, or rights-of-way owned by Caltrans.

A similar approach was used for the Environmental Mitigation costs. The lands that would be impacted were estimated, i.e., number of acres. This calculated acreage was then multiplied by a factor of 6 (replacement ratio) to estimate the total number of acres that would need to be acquired as replacement lands. To this latter amount, we then applied a $500 per acre cost factor to calculate the total cost of the replacement lands needed for each respective alternative.

A 25 percent contingency allowance markup was applied to the noncontract cost estimate. This contingency allowance is intended to provide an allowance for unforeseen conditions or costs that were not anticipated at this appraisal level of the study.

Intended Use and Limitations of Cost Estimates

The cost estimates were developed and are presented in this report for the sole purpose of comparing costs of the different Inlet Canal alternative alignments. These cost estimates are not recommended to be used for budgeting or construction purposes. During the feasibility phase of the project, more accurate costs will be developed for the preferred alternative. The feasibility assessment and cost estimates that are expected to be prepared at that time will likely include design data not currently available.

A summary and comparison of the Capital Cost Estimate for each alternative is presented in the following table. The detailed estimate worksheets are provided in Attachment E.

Table 9
Preliminary Estimate of Most Probable Capital Costs

	Alternative Alignment	1A	1B	2A	2B	3A	3B	4A	4B	5A	6A	7A	7B	8A	9A
	Total Length (feet)	29,240	29,240	29,390	29,390	29,240	29,240	33,840	33,840	36,960	32,040	25,840	25,840	32,080	37,160
	Number of Reaches	5	5	6	6	5	5	7	7	7	6	4	4	7	7
Cost Factor	Facility Types	Canal / Box Conduit	Canal	Canal / Box Conduit	Canal	Canal / Box Conduit	Canal	Canal / Box Conduit	Canal	Canal	Canal / Pipeline	Canal / Box Conduit	Canal	Canal	Canal
Contract Costs	Estimate Basis	1A	1B	2A	2B	3A	3B	4A	4B	5A	6A	7A	7B	8A	9A
Construction of Conveyance Facility	Estimated	$47,277,729	$10,834,973	$47,183,010	$11,327,479	$47,120,769	$10,808,348	$50,792,315	$13,110,177	$15,118,357	$53,110,194	$46,135,747	$10,113,464	$12,535.000	14,820,117
Mobilization	5.00%	$2,363,886	$541,749	$2,359,151	$566,374	$2,356,038	$540,417	$2,539,616	$655,509	$755,918	$2,655,510	$2,306,787	$505,673	$626,774	$741,006
Allowance for Unlisted Items	15.00%	$7,091,659	$1,625,246	$7,077,452	$1,699,122	$7,068,115	$1,621,252	$7,618,847	$1,966,527	$2,267,754	$7,966,529	$6,920,362	$1,517,020	$1,880,322	$2,223,018
Contingency Allowance	25.00%	$11,819,432	$2,708,743	$11,795,753	$2,831,870	$11,780,192	$2,702,087	$12,698,079	$3,277,544	$3,779,589	$13,277,549	$11,533,937	$2,528,366	$3,133,870	$3,705,029
Subtotal	NA	$68,552,707	$15,710,711	$68,415,365	$16,424,845	$68,325,115	$15,672,105	$73,648,857	$19,009,757	$21,921,618	$77,009,781	$66,896,833	$14,664,523	$18,176,446	$21,489,170
Noncontract Costs															
Design, C.M., Administration, etc.	20.00%	$ 13,710,541	$ 3,142,142	$ 13,683,073	$ 3,284,969	$ 13,665,023	$ 3,134,421	$ 14,729,771	$ 3,801,951	$ 4,384,324	$ 15,401,956	$ 13,379,367	$ 2,932,905	$ 3,635,289	$ 4,297,834
ROW and Land Acquisition	Estimated	$424,242	$16,336,364	$424,242	$16,336,364	$1,212,121	$2,424,242	$606,061	$303,030	$0	$0	$303,030	$606,061	$2,607,897	$0
Environmental Mitigation	Estimated	$176,309	$176,309	$649,036	$649,036	$649,036	$649,036	$1,205,344	$1,205,344	$1,088,705	$104,683	$3,720,000	$3,720,000	$1,267,273	$1,971,570
Contingency Allowance	25.00%	$150,138	$4,128,168	$268,320	$4,246,350	$465,289	$768,320	$452,851	$377,094	$272,176	$26,171	$1,005,758	$1,081,515	$968,793	$492,893
Subtotal	NA	$14,461,230	$23,782,983	$15,024,670	$24,516,719	$15,991,469	$6,976,018	$16,994,028	$5,687,419	$5,745,205	$15,532,810	$18,408,154	$8,340,481	$8,479,252	$6,762,296
Total Capital Cost Estimate		$83,013,937	$39,493,694	$83,440,035	$40,941,563	$84,316,584	$22,648,123	$90,642,884	$24,697,175	$27,666,822	$92,542,591	$85,304,987	$23,005,004	$26,655,698	$28,251,466

Schedule

The variable factors among the different alternatives that have the potential to affect the implementation schedule include:

- Right-of-Way Aquisition
- Environmental Compliance

The alternative alignments have similar facilities and therefore the construction schedules for the different alternatives are assumed will be similar.

The acquisition of lands or right-of-way from private owners have the potential to require more time if the land acquisition is done under an action such as Reclamation's use of eminent domain. Under such a case, the time required for a compensation settlement can range between 12 to 36 months. However, there are methods through which Reclamation can take possession of the needed land in a much shorter time period with the provision that it enter into a dispute resolution and compensation settlement process with the affected owners. As such, while land and right-of-way acquisition has the potential to affect the project implementation schedule, there are methods available to Reclamation that it can use to manage the process and to minimize any impacts to the project schedule. Thus, land and right-of-way acquisition is not expected to significantly affect the project implementation schedule.

Generally, the greater the impact to FTHL habitat and MA, the longer and more complex will be the environmental clearance process. It was felt that at some un-quantified threshold of FTHL impact, the project may be considered a "significant environmental impact" and would require an EIS. Thus, alternatives which impacted lesser amounts of FTHL habitat were considered to have a shorter schedule. A subjective evaluation of the potential schedule impacts was made by Reclamation staff versed in NEPA and the permitting codes.

Table 10
Range of FTHL MA Impacts and Compliance Requirements

Acreage Impacted Within FTHL MA (acre)	Estimated Impact Level	Required Compliance Document	Compliance Timeframe
None	Low	Environmental Assessment	< One Year
Less than 66 acres	Medium	Environmental Assessment plus Mitigation	Approximately 12 to 18 months
More than 66 acres	High	Environmental Impact Statement plus mitigation	> 2 years

COMPARISON OF ALTERNATIVES

Table 11 presents the evaluation criteria developed by the Technical Team and Table 12 presents the scoring of the alternatives based on this evaluation criteria. As shown on Table 12, each alternative is given a score between one to five. A value of five is given to the condition that is considered most favorable to the project or project development. By multiplying the raw score by the assigned weight value for each respective criterion, we obtain the weighted score. The sum of the five weighted scores (five different criteria) for each alternative provides an indicator of the relative superiority of the alternatives. The alternatives with the highest score are considered to be superior to those with lower scores.

Table 11
Evaluation Criteria and Bases for Scoring

Criteria		Scoring Basis 1	to	5	Weight
1	Total Project Cost	Most Expensive	to	Least Expensive	30
2	Schedule	Cannot Meet Oct. 2006 Target Date	to	Minimal Risk of Meeting Schedule	25
3	Environmental Considerations	EIS	to	Categorical Exclusion	15
4	Land/ROW Acquisition	High Impact/Condemnation	to	Straightforward	15
5	Engineering Effort	Many Challenges/Risks	to	Straightforward	15
Total					**100**

Table 12
Scoring of Reservoir Alternatives

Criteria		Scoring Basis 1	to	5	Weight	Alt. 1A Score	Alt. 1A Weighted Score	Alt. 1B Score	Alt. 1B Weighted Score	Alt. 2A Score	Alt. 2A Weighted Score	Alt. 2B Score	Alt. 2B Weighted Score	Alt. 3A Score	Alt. 3A Weighted Score	Alt. 3B Score	Alt. 3B Weighted Score	Alt.4A Score	Alt.4A Weighted Score	Alt. 4B Score	Alt. 4B Weighted Score
1	Total Project Cost	Most Expensive	to	Least Expensive	30	2	60	4	120	2	60	4	120	2	60	4	120	1	30	4	120
2	Engineering Effort	Many Challenges /Risks	to	Straightforward	15	2	30	3	45	2	30	3	45	2	30	3	45	3	45	5	75
3	Environmental Considerations	EIS	to	Clear EA	15	4	60	4	60	4	60	4	60	4	60	4	60	3	45	3	45
4	Land Acquisition	High Impact/Condemnation	to	Straightforward	15	2	30	1	15	2	30	1	15	2	30	1	15	2	30	2	30
5	Schedule	Can't Meet Oct. 2006	to	Minimal Risk of Meeting Schedule	25	3	75	2	50	3	75	2	50	3	75	2	50	3	75	2	50
Total					100	N/A	255	N/A	290	N/A	255	N/A	290	N/A	255	N/A	290	N/A	225	N/A	320

Table 12
Scoring of Reservoir Alternatives

Criteria		Scoring Basis 1	to	5	Weight	Alt. 5A Score	Alt. 5A Weighted Score	Alt. 6A Score	Alt. 6A Weighted Score	Alt. 7A Score	Alt. 7A Weighted Score	Alt. 7B Score	Alt. 7B Weighted Score	Alt. 8A Score	Alt. 8A Weighted Score	Alt. 9A Score	Alt. 9A Weighted Score
1	Total Project Cost	Most Expensive	to	Least Expensive	30	4	120	3	90	2	60	5	150	4	120	3	90
2	Engineering Effort	Many Challenges /Risks	to	Straightforward	15	3	45	1	15	3	45	5	75	5	75	4	60
3	Environmental Considerations	EIS	to	Clear EA	15	3	45	4	60	1	15	1	15	3	45	2	30
4	Land Acquisition	High Impact/Condemnation	to	Straightforward	15	5	75	4	60	2	30	1	15	2	30	5	75
5	Schedule	Can't Meet Oct. 2006	to	Minimal Risk of Meeting Schedule	25	4	100	3	75	1	25	1	25	3	75	2	50
Total					100	N/A	385	N/A	300	N/A	175	N/A	280	N/A	345	N/A	305

CONCLUSIONS

Table 13 presents the ranking of the alternatives based on the sum of the weighted scores calculated for each alternative. For this analysis, a higher score is considered to be superior in terms of ranking. As shown on this table, Alternative Alignment 5A appears to be the preferred alternative based on the evaluation criteria used for the evaluation.

Table 13
Ranking Based on Scoring

Rank	Alternative	Weighted Score
1	5A	385
2	8A	345
3	4B	320
4	9A	305
5	6A	300
6	1B	290
6	2B	290
6	3B	290
7	7B	280
8	1A	255
8	2A	255
8	3A	255
9	4A	225
10	7A	175

As noted in Table 13, Alternative Alignment No. 5A received the highest weighted score for the evaluation criteria used in this evaluation. As such, Alternative 5A is considered to be the preferred alternative.

RECOMMENDATIONS

Pursuant to the findings of this Inlet Canal Alignment Study, the technical team recommends that Alternative 5A be advanced for additional consideration and analysis in the feasibility evaluation of the Drop 2 Reservoir project. Coincident with the feasibility study, it is also recommended that the appropriate land acquisition and environmental compliance studies be undertaken. This will include the required consultation and negotiations with the FTHL Management Oversight Group, BLM and other jurisdictional and permitting agencies.

Attachment A

Technical Team Members

TECHNICAL TEAM MEMBERS

The following individuals were members of the technical team for this study, undertook and completed the various evaluations of the study, and contributed towards the preparation of this technical memorandum.

Member	Agency/Firm
Bob Adams	Reclamation - Lower Colorado River Region, Yuma Area Office
Nicholas Boswell	Brown and Caldwell
Thayer Broili	Reclamation - Lower Colorado River Region, Yuma Area Office
Jackie Carrera	Reclamation - Lower Colorado River Region, Yuma Area Office
Ron Curiel	Reclamation - Lower Colorado River Region, Yuma Area Office
Jack Delp	Consultant to Lower Colorado River Regional Engineer
Anthony Dubin	Brown and Caldwell
John English	Reclamation - Lower Colorado River Region, Yuma Area Office
Cindy Flores	Reclamation - Lower Colorado River Region, Yuma Area Office
Scott Foster	Reclamation - Lower Colorado River Region, Engineering Services Offices
Peggy Haren	Reclamation - Lower Colorado River Region, Yuma Area Office
Cindy Hoeft	Reclamation - Lower Colorado River Region, Yuma Area Office
James Keith	Reclamation - Technical Service Center, Denver
Al Kiene	Reclamation - Technical Service Center, Denver
Bruce Moore	Reclamation - Lower Colorado River Region, Engineering Services Offices
Russell Reichelt	Reclamation - Lower Colorado River Region, Yuma Area Office
Rick Strahan	Reclamation - Lower Colorado River Region, Yuma Area Office
Rex Wahl	Reclamation - Lower Colorado River Region, Yuma Area Office
Ruben Zubia	Brown and Caldwell

Attachment B

Detailed Description of Alternative Inlet Canal Alignments

DETAILED DESCRIPTIONS OF ALTERNATIVE INLET CANAL ALIGNMENTS

This attachment provides detailed descriptions of the alternative alignments considered in this analysis. A total of nine (9) different inlet canal alignments were considered and evaluated in this study. All of the inlet canal alignments begin and end at common points. All of the alternative alignments consider the conveyance of water via gravity flow (no pumped systems). For the purpose of this evaluation, the common point of beginning for the various inlet canal alignments is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 20E). Similarly, for the purpose of this evaluation, the common end point for the various inlet canal alignments is the inlet structure to the Drop 2 Reservoir (located near the northeast corner of the west half of the southeast quarter of Section 32 T. 16S, R. 19E).

The naming convention for each alternative includes a number and letter, with the number indicating the route or alignment, and the letter indicating an alternative facility configuration. As shown in Table B-1, some alternative alignments included more than one facility configuration option. These options each represent a package of different facilities that can be used to achieve the flow conveyance and hydraulic goals of the alternative. The detailed description for each alternative follows.

ALTERNATIVE ALIGNMENT NO. 1

ALIGNMENT DESCRIPTION

Alternative Alignment No. 1 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. A large portion of this alignment will be located within the existing County Road (Evan Hewes Highway) Right-of-Way (ROW). This alternative assumes that the County will relinquish to Reclamation (Federal Government) the portions of the County Road ROW that lay within Sections 32, 33, 34, 35, 36, 4, 3, 2, 1, and 6. The alignment for this alternative will comprise five reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the inlet canal alignment proceeds in a southwest direction and approximately 3,800 feet to the west section line of Section 31. The ROW width required for this initial reach is 400 feet. This ROW will be generally be located north and parallel to the unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site. The terminus for this reach is located near the intersection of the unpaved access road and the west section line of Section 31. Reach 1 of this alternative alignment is located entirely within Reclamation Withdrawn land and Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is the intersection of the County Road (Evan Hewes Highway) and the east section line of Section 36. From this point, the centerline of the inlet canal will transition towards, merge with, and follow in a westerly direction, the centerline of the existing County Road. The alignment for this reach will terminate at the intersection of the southerly extension of the west section line of Section 36 with the centerline of the County Road. The length of Reach 2 is 5,280 feet.

Table B-1
Drop 2 Reservoir Inlet Canal Alignments Selected for Evaluation

	Description	Alignment Length (feet)	Number of Reaches	Facility Types
1A	Alignment located within County Road ROW proposed to be abandoned	29,240	5	Canal/Box Conduit
1B	Alignment located within County Road ROW proposed to be abandoned	29,240	5	Canal
2A	Portion of alignment located within County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,390	6	Canal/Box Conduit
2B	Portion of alignment located within County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,390	6	Canal
3A	Portion of alignment located on Private lands to be acquired that are located adjacent and parallel to County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,240	5	Canal/Box Conduit
3B	Portion of alignment located on Private lands to be acquired that are located adjacent and parallel to County Road ROW and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	29,240	5	Canal
4A	Portion of alignment located along 1/2 Section Line of Section 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	33,840	7	Canal/Box Conduit
4B	Portion of alignment located along 1/2 Section Line of Sections 31 and 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	33,840	7	Canal
5A	Portion of alignment circumvents Section 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	36,960	7	Canal
6A	Large portion of alignment located within area between existing AAC and I-8 ROWs	32,040	6	Canal/Pipeline
7A	Most of alignment generally located along 1/2 Section Line of Sections 31, 36, 35, 34, & 33	25,840	4	Canal/Box Conduit
7B	Most of alignment generally located along 1/2 Section Line of Sections 31, 36, 35, 34, & 33	25,840	4	Canal
8A	Portion of alignment located within abandoned Coachella Canal and along 1/2 Section Line of Sections31 and 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	32,080	7	Canal
9A	Portion of alignment located within abandoned Coachella Canal, portion of alignment circumvents Section 36 and remainder on Federal Withdrawn Lands located adjacent and parallel to County Road ROW	37,160	7	Canal

The width of the paved portion of the County Road is approximately 40 feet. The existing right-of-way of the County Road varies between 60 feet to 100 feet within the proximity of Reach 2.

Two alternative facility types are proposed for this reach, a canal and a buried box conduit. The ROW width required for these facilities are 400 feet and 100 feet, respectively. An additional 50 to 100 feet wide temporary construction easement may be required for the construction of the box conduit option. The additional width of ROW, beyond the existing County Road ROW that varies from 60 feet to 100, will need to be acquired from the owners of the affected privately owned lands within Section 36. In addition, temporary access roads will need to be made available to provide access to the affected privately owned parcels within Section 36 during construction (independent of which facility type is constructed). For the box conduit option, Reclamation would need to secure an encroachment permit from Imperial County to construct the box conduit within County Road ROW. For the canal option, Imperial County would need to relinquish the County Road ROW to Reclamation (Federal Government). In the event that a canal is constructed, permanent access will need to be provided to the privately owned parcels that currently front the County Road within Section 36. This may require that Reclamation construct a new paved roadway on the north side and parallel to the new inlet canal ROW. In this case, an additional 60 foot to 80 foot strip of land would need to be acquired for the new roadway. Reclamation will need to confer with Imperial County with respect to who would own and maintain this new access road and respective ROW.

Reach 3

Reach 3 of the inlet canal ROW alignment will mostly be located within the existing County Road ROW. The starting point for Reach 3 is the intersection of the southerly extension of the west section line of Section 36 with the centerline of the County Road. From this point of beginning, the centerline of the inlet canal ROW will coincide with the centerline of the County Road ROW as the ROW proceeds west towards the Drop 2 Reservoir site. The terminus of Reach 3 inlet canal ROW alignment is the southerly extension of the west line of the east half of the southeast quarter of Section 32. The length of the Reach 3 inlet canal ROW is approximately 17,160 feet and the width is 400 feet.

Within the proximity of Reach 3, the County Road ROW lies partially within T. 15 S. and partially within T. 17 S. (i.e. in Sections 32, 33, 34, 35, 1, 2, 3, and 4). The existing County Road ROW widens from 150 feet in width to 400 feet in width, as it extends west from the east section line of Section 35. The County Road ROW is 400 feet in width within most of this reach.

This alternative assumes that the County will relinquish to Reclamation (Federal Government) the portions of the County Road ROW that lay within this reach. Also, additional ROW will need to be acquired within Section 35 where the existing County Road ROW is less than 400 feet.

Lastly, overhead electric lines parallel both sides of the existing paved portion of the County Road. One or both of these overhead eclectic lines may need to be relocated. The assumption is that these lines will be relocated to an area still within the proposed Reach 3 ROW and therefore, no additional lands will be needed. This assumption and other requirements that may be imposed by the owners of these overhead electric lines will need to be verified.

Reach 4

Reach 4 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 4 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 4 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 5

The centerline of the Reach 5 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 5 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 5 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 5 will be located entirely on Reclamation Withdrawn lands and within Section 32.

A layout of the alignment of the proposed inlet canal under Alternative No. 1 is provided in Plate B-1.

PRELIMINARY DESCRIPTION OF FACILITIES:

Two option(s) will be considered for Alternative Alignment No. 1. Each option will occupy the same general alignment noted above but will comprise different types of facilities. Table B-2 notes the facility types considered in each option.

Table B-2
Summary of Alternative No. 1 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Option A Facility Type	Option B Facility Type	General Description
1	3,800	Sec 31	400 foot strip north & parallel to dirt road	Canal	Canal	Portions of the Alignment ROW within Section 36 (Reach 2) are within County ROW and on private property. Temporary and/or permanent ROW may need to be acquired from the property owners of Section 36. The centerline of the ROW alignment for Reach 3 parallels the County Road ROW. Portions of Alignment ROW for Reach 3 are within Sections 32, 33, 34, 35, 4, 3, 2, 1. Portions of the ROW required for these sections lie within Federally Withdrawn Lands. The remaining area will need to be relinquished to the Reclamation (Federal Government) from the County of Imperial. The ROW required for Reaches 1, 4 and 5 are within Federally Withdrawn Lands
2	5,280	Sec 36	within County Road ROW	Box Conduit	Canal	
3	17,160	Sec 32, 33, 34, 35, 1, 2, 3, 4	400 foot strip parallel to the County Road ROW Centerline	Canal	Canal	
4	2,600	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	Canal	
5	400	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	Canal	

Alternative No. 1A

Reach No.	Length (ft)	Facility Type	Dimsnsions	Slope
1	3,800	Canal	b=20' / h=15.4'	0.000031
2	5,280	Box Conduit	13' x 13'	N/A
3	17,160	Canal	b=20' / h=15.4'	0.000031
4	2,600	Canal	b=20' / h=15.4'	0.000031
5	400	Canal	b=20' / h=15.4'	0.000031
Total	29,240	NA	NA	NA

Alternative No. 1B

Reach No.	Length (ft)	Facility Type	Dimsnsions	Slope
1	3,800	Canal	b=17.5' / h=13.5'	0.000062
2	5,280	Canal	b=17.5' / h=13.5'	0.000062
3	17,160	Canal	b=17.5' / h=13.5'	0.000062
4	2,600	Canal	b=17.5' / h=13.5'	0.000062
5	400	Canal	b=17.5' / h=13.5'	0.000062
Total	29,240	NA	NA	NA

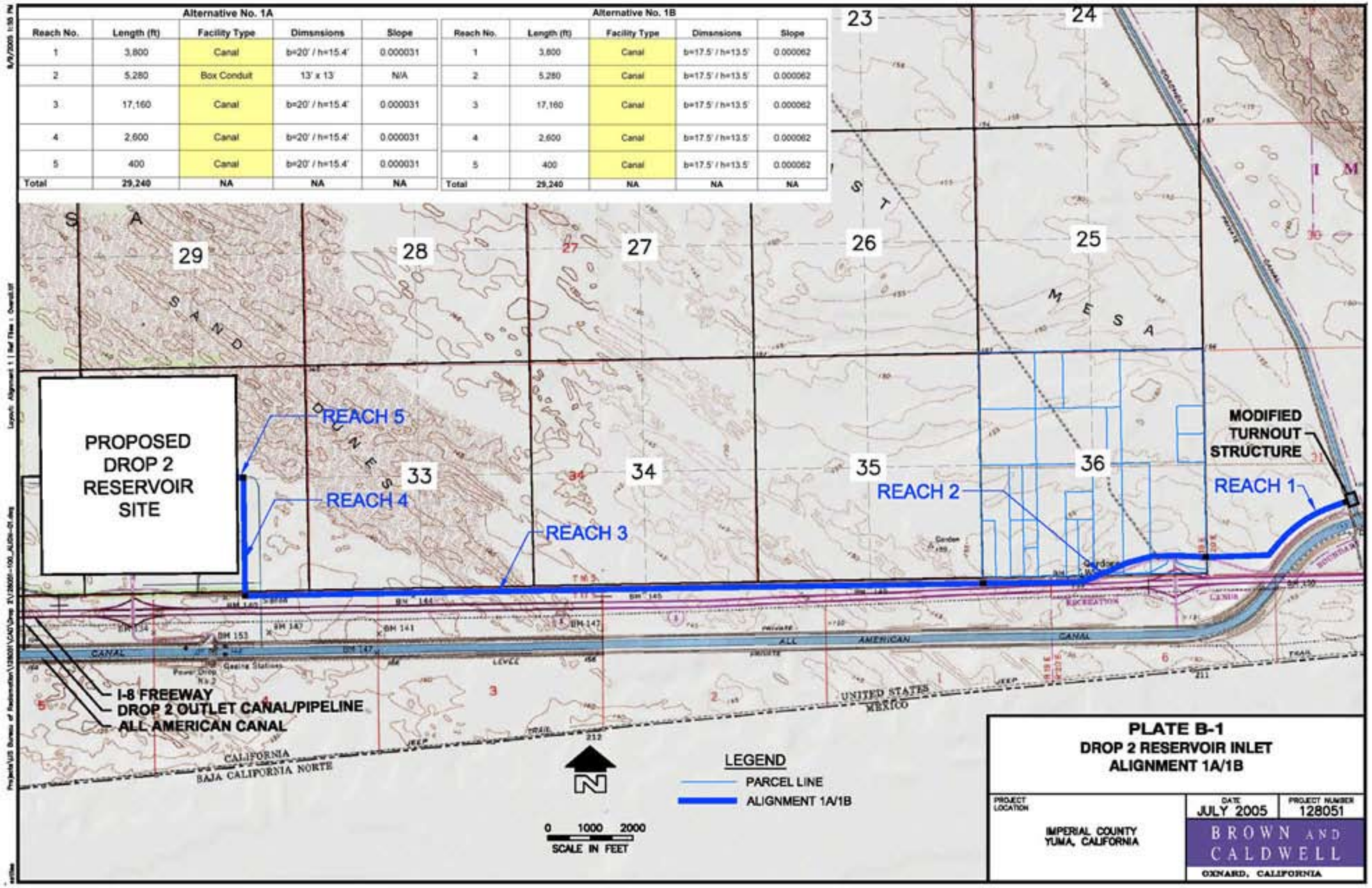


PLATE B-1
DROP 2 RESERVOIR INLET ALIGNMENT 1A/1B

PROJECT LOCATION: IMPERIAL COUNTY YUMA, CALIFORNIA

DATE: JULY 2005

PROJECT NUMBER: 128051

BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 2

ALIGNMENT DESCRIPTION

Alternative Alignment No. 2 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. A portion of this alignment will be located within the existing County Road (Evan Hewes Highway) right-of-way (ROW) and the remainder on land located north and immediately adjacent to the County Road ROW. This alternative assumes that Imperial County will relinquish to Reclamation (Federal Government) the portion of the County Road ROW that lies within Sections 36, 1, and 6. The alignment for this alternative will comprise six reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the inlet canal alignment proceeds in a southwest direction and approximately 3,800 feet to the west section line of Section 31. The right-of-way width required for this initial reach is 400 feet. This right-of-way will generally be located north and parallel to the unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site. The terminus for this reach is located near the intersection of the unpaved access road with the west section line of Section 31. Reach 1 of this alternative inlet canal alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is the intersection of the County Road (Evan Hewes Highway) and the east section line of Section 36. From this point, the centerline of the inlet canal will transition towards, merge with, and follow in a westerly direction, the centerline of the existing County Road. The alignment for this reach will terminate at the intersection of the southerly extension of the west section line of Section 36 with the centerline of the County Road. The length of Reach 2 is 5,280 feet.

The width of the paved portion of the County Road is approximately 40 feet. The existing right-of-way of the County Road varies between 60 feet to 100 feet within the proximity of Reach 2.

Two alternative facility types are proposed for this reach, a canal and a buried box conduit. The ROW width required for these facilities are 400 feet and 100 feet, respectively. An additional 50 to 100 feet wide temporary construction easement may be required for the construction of the box conduit option. The additional width of ROW, beyond the existing County Road ROW that varies from 60 feet to 100, will need to be acquired from the owners of the affected privately owned lands within Section 36. In addition, temporary access roads will need to be made available to provide access to the affected privately owned parcels within Section 36 during construction (independent of which facility type is constructed). For the box conduit option, Reclamation would need to secure an encroachment permit from Imperial County to construct the box conduit within County Road ROW. For the canal option, Imperial County would need to relinquish the County Road ROW to Reclamation (Federal Government). In the event that a canal is

constructed, permanent access will need to be provided to the privately owned parcels that currently front the County Road within Section 36. This may require that Reclamation construct a new paved roadway on the north side and parallel to the new inlet canal ROW. In this case, an additional 60 foot to 80 foot strip of land would need to be acquired for the new roadway. Reclamation will need to confer with Imperial County with respect to who would own and maintain this new access road and respective ROW.

Reach 3

Reach 3 of the inlet canal ROW will be located to the west of and parallel to the west section line of Section 36. This segment will transition the centerline if the inlet canal ROW from the centerline of the roadway to the area north of the paved roadway. The centerline of the Reach 3 inlet canal ROW will extend north approximately 150 feet from the end of Reach 2 inlet canal ROW and will be located 100 feet west of the west section line of Section 36. Reach 3 of the inlet canal ROW will begin in Section 1 and terminates in Section 35. The width of the ROW required for Reach 3 is 400 feet.

Reach 4

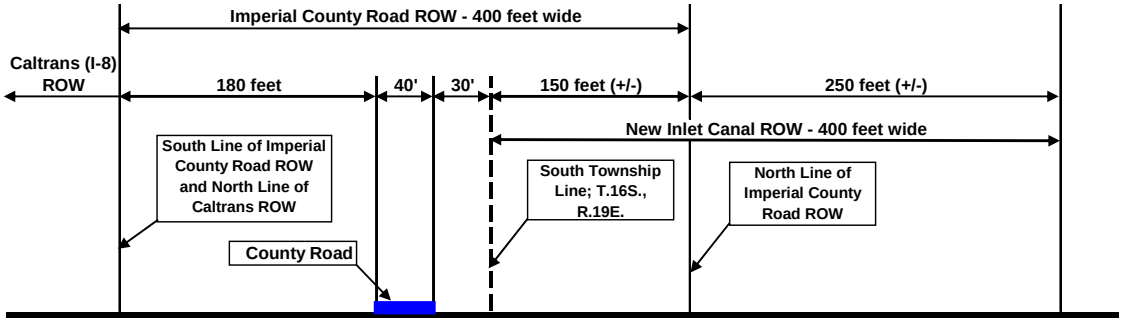
Reach 4 of the inlet canal ROW will be situated on the north side and generally parallel the County Road. Reach 4 is located within Sections 32, 33, 34 and 35 which are within T. 16 S., R. 19 E. However, the centerline of the existing 40 foot wide paved roadway is located approximately 40 feet south of the township line and within T. 17 S., R. 19 E. Also, from documents provided by Imperial County that show the portion of the ROW that the State of California (Caltrans) relinquished to Imperial County for the County Road (old highway), it appears that the northernmost 150 feet of the 400 foot wide County Road ROW is located within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E. and the remainder 250 feet of width is located within Sections 1, 2, 3 ad 4 of T. 17 S., R. 19 E.

The length of the Reach 4 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. This would comprise the south 400 feet of Sections 33, 34 and 35 and the south 400 feet of the west half of the southeast quarter of Section 32 (T. 16 S., R. 19 E). Approximately 150 feet of the 400 foot wide inlet canal ROW will comprise a portion of the 400 foot wide ROW that the State of California (Caltrans) relinquished to Imperial County. This will require that Imperial County relinquish the northernmost 150 feet of their 400 foot wide ROW to the federal Government (Reclamation). An additional 50 foot wide strip of land will be required to provide the required 400 foot ROW for this reach of the inlet canal. The length of the Reach 4 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. Reach 4 is located entirely within Sections 32, 33, 34 and 35 of T. 16 S., R. 19E.

Reach 5

Reach 5 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 5 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 5 is located entirely within Section 32, T. 16 S., R. 19 E.

Figure B-1
Proposed Reach 4 ROW – Alignment Cross Section at East Section Line of Section 34



Reach 6

The centerline of the Reach 6 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 6 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 6 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 6 will be located entirely on Reclamation Withdrawn lands and within Section 32.

A layout of the alignment of the proposed inlet canal under Alternative No. 2 is provided in Plate B-2.

Preliminary Description of Facilities:

Two option(s) will be considered for Alternative Alignment No. 2. Each option will occupy the same general alignment noted above but will comprise different types of facilities. Table B-3 notes the facility types considered in each option.

Table B-3
Summary of Alternative No. 2 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Option A Facility Type	Option B Facility Type	General Description
1	3,800	Sec 31	400 foot strip north & parallel to dirt road	Canal	Canal	Portions of Alignment ROW within Section 36 are within County ROW and on private property. Temporary and/or permanent ROW may need to be acquired from the property owners of Section 36. 400 feet of ROW will be needed in Sections 32, 33, 34, 35 and 31. Portions of the ROW required for these sections lie within Federally Withdrawn Lands. The remaining area will need to be relinquished to the Reclamation (Federal Government) from the County of Imperial.
2	5,280	Sec 36	within County Road ROW	Box Conduit	Canal	
3	150	Sec 35	400 foot strip west & parallel to west section line of Section 36	Canal	Canal	
4	17,160	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent)	Canal	Canal	
5	2,600	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	Canal	
6	400	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	Canal	

Alternative No. 2A

Reach No.	Length (ft)	Facility Type	Dimensions	Slope
1	3,800	Canal	b=20' / h=15.4'	0.000031
2	5,280	Box Conduit	13' x 13'	N/A
3	150	Canal	b=20' / h=15.4'	0.000031
4	17,160	Canal	b=20' / h=15.4'	0.000031
5	2,600	Canal	b=20' / h=15.4'	0.000031
6	400	Canal	b=20' / h=15.4'	0.000031
Total	29,390	NA	NA	NA

Alternative No. 2B

Reach No.	Length (ft)	Facility Type	Dimensions	Slope
1	3,800	Canal	b=17.5' / h=13.5'	0.000062
2	5,280	Canal	b=17.5' / h=13.5'	0.000062
3	150	Canal	b=17.5' / h=13.5'	0.000062
4	17,160	Canal	b=17.5' / h=13.5'	0.000062
5	2,600	Canal	b=17.5' / h=13.5'	0.000062
6	400	Canal	b=17.5' / h=13.5'	0.000062
Total	29,390	NA	NA	NA

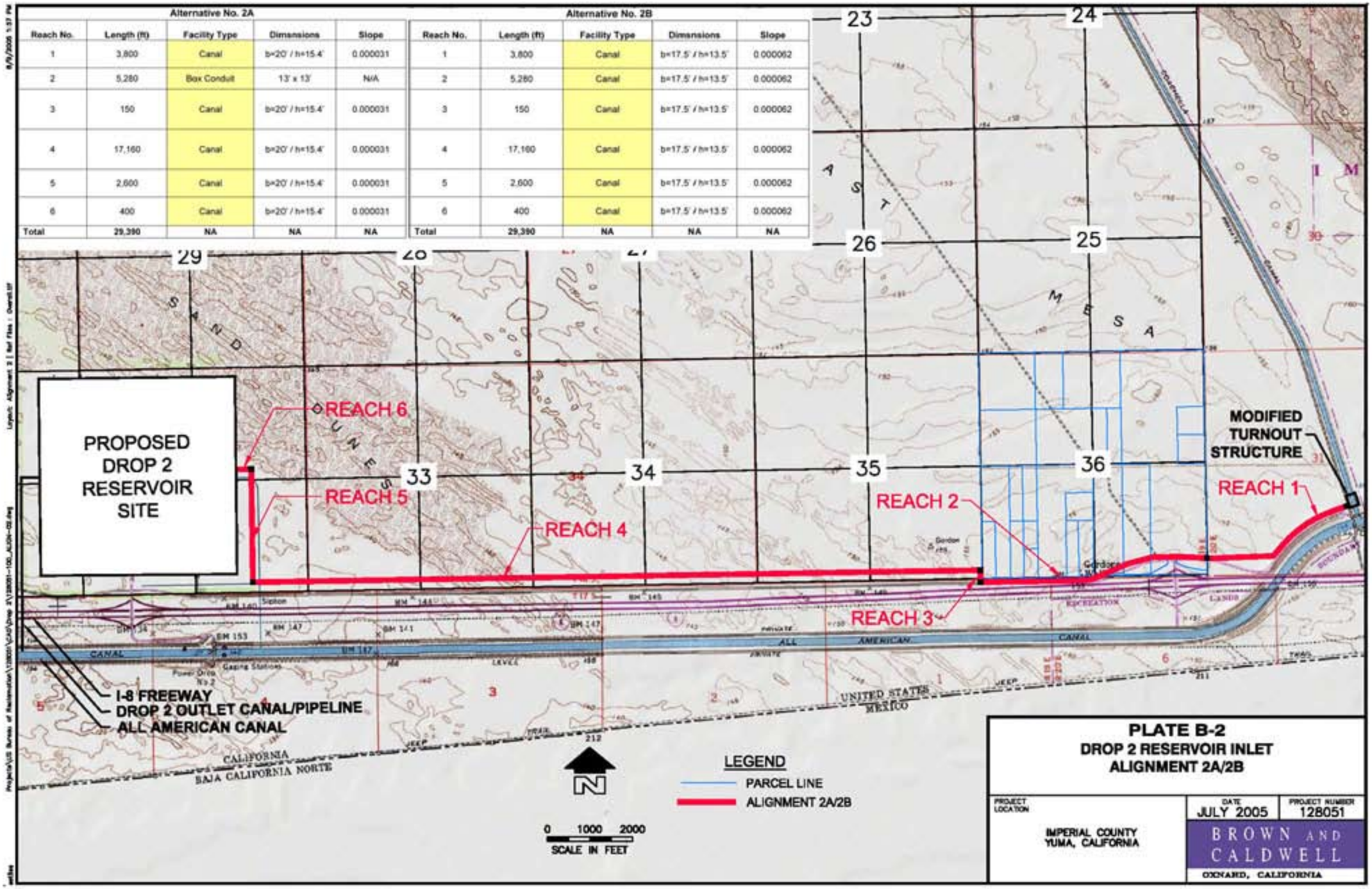


PLATE B-2
DROP 2 RESERVOIR INLET ALIGNMENT 2A/2B

PROJECT LOCATION	DATE	PROJECT NUMBER
IMPERIAL COUNTY YUMA, CALIFORNIA	JULY 2005	128051

BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 3

ALIGNMENT DESCRIPTION

Alternative Alignment No. 3 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. A large portion of the centerline of the inlet canal ROW will lay to the north and parallel to the centerline of the County Road. Portions of the ROW will cross private property and Reclamation Withdrawn lands. This alternative alignment assumes that the County will relinquish to Reclamation (Federal Government) the portions of the County Road ROW that lies within Sections 32, 33, 34, 35, and 36. The alignment for this alternative will comprise five reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the inlet canal alignment proceeds in a southwest direction and approximately 3,800 feet to the west section line of Section 31. The right-of-way width required for this initial reach is 400 feet. This right-of-way will generally be located north and parallel to the unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site. The terminus for this reach is located near the intersection of the unpaved access road and the west section line of Section 31. Reach 1 of this alternative alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is the intersection of the County Road and the east section line of Section 36. From this point, the centerline of the inlet canal will parallel the centerline of the existing County Road on an approximately 150 foot offset to the north of the County Road centerline. The limits of Reach 2 are from the east section line of Section 36 to the west section line of Section 36. The ROW width required for Reach 2 is 400 feet. The approximate length of Reach 2 is 5,280 feet. The ROW will cross privately owned lands and will require the removal or relocation of all structures and above ground facilities that may exist within this proposed ROW. Construction of this inlet canal reach within this proposed ROW will require the purchase of a 400 foot wide strip of land or a permanent easement from the owners of the privately owned lands that front the County Road within Section 36. If a canal is constructed, access will need to be provided to the various parcels that front the County Road within Section 36. This may require the construction of several canal crossings.

Reach 3

Reach 3 of the inlet canal ROW will be situated on the north side and generally parallel to the County Road. Reach 3 is located within Sections 32, 33, 34 and 35 which are within T. 16 S., R. 19 E. However, the centerline of the existing 40 foot wide paved roadway is located approximately 40 feet south of the township line and within T. 17 S., R. 19 E. Also, from documents provided by Imperial County that show the portion of the ROW that the State of California (Caltrans) relinquished to Imperial County for the County Road (old highway), it appears that the northernmost 150 feet of the 400 foot wide County Road

ROW is located within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E. and the remainder 250 feet of width is located within Sections 1, 2, 3 ad 4 of T. 17 S., R. 19 E.

The length of the Reach 3 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. This would comprise the south 400 feet of Sections 33, 34 and 35 and the south 400 feet of the west half of the southeast quarter of Section 32 (T. 16 S., R. 19 E). Approximately 150 feet of the 400 foot wide inlet canal ROW will comprise a portion of the 400 foot wide ROW that the State of California (Caltrans) relinquished to Imperial County. This will require that Imperial County relinquish the northernmost 150 feet of their 400 foot wide ROW to the federal Government (Reclamation). An additional 50 foot wide strip of land will be required to provide the required 400 foot ROW for this reach of the inlet canal. The length of the Reach 3 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. Reach 3 is located entirely within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E.

Reach 4

Reach 4 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 4 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 4 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 5

The centerline of the Reach 5 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 5 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 5 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 5 will be located entirely on Reclamation Withdrawn lands and within Section 32.

A layout of the alignment of the proposed inlet canal under Alternative No. 3 is provided in Plate B-3.

PRELIMINARY DESCRIPTION OF FACILITIES:

Two option(s) will be considered for Alternative Alignment No. 3. Each option will occupy the same general alignment noted above but will comprise different types of facilities. Table B-4 notes the facility types considered in each option.

Table B-4
Summary of Alternative No. 3 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Option A Facility Type	Option B Facility Type	General Description
1	3,800	Sec 31	400 foot strip north & parallel to dirt road	Canal	Canal	All of alignment located to the north side (an outside) the County Road ROW. Assume that any and all structures and above ground facilities within portion of ROW that exists within Section 36 will need to be relocated.
2	5,280	Sec 36	400 foot strip located north/parallel to County Road ROW (adjacent)	One Barrel	Canal	
3	17,160	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	Canal	Canal	
4	2,600	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	Canal	
5	400	E-W on 1/2 Sec Line of Sec 32	along east-west 1/2 Sec line of Sec 32	Canal	Canal	

Alternative No. 3A

Reach No.	Length (ft)	Facility Type	Dimsnsions	Slope
1	3,800	Canal	b=20' / h=15.4'	0.000031
2	5,280	Box Conduit	13' x 13'	N/A
3	17,160	Canal	b=20' / h=15.4'	0.000031
4	2,600	Canal	b=20' / h=15.4'	0.000031
5	400	Canal	b=20' / h=15.4'	0.000031
Total	29,240	NA	NA	NA

Alternative No. 3B

Reach No.	Length (ft)	Facility Type	Dimsnsions	Slope
1	3,800	Canal	b=17.5' / h=13.5'	0.000062
2	5,280	Canal	b=17.5' / h=13.5'	0.000062
3	17,160	Canal	b=17.5' / h=13.5'	0.000062
4	2,600	Canal	b=17.5' / h=13.5'	0.000062
5	400	Canal	b=17.5' / h=13.5'	0.000062
Total	29,240	NA	NA	NA

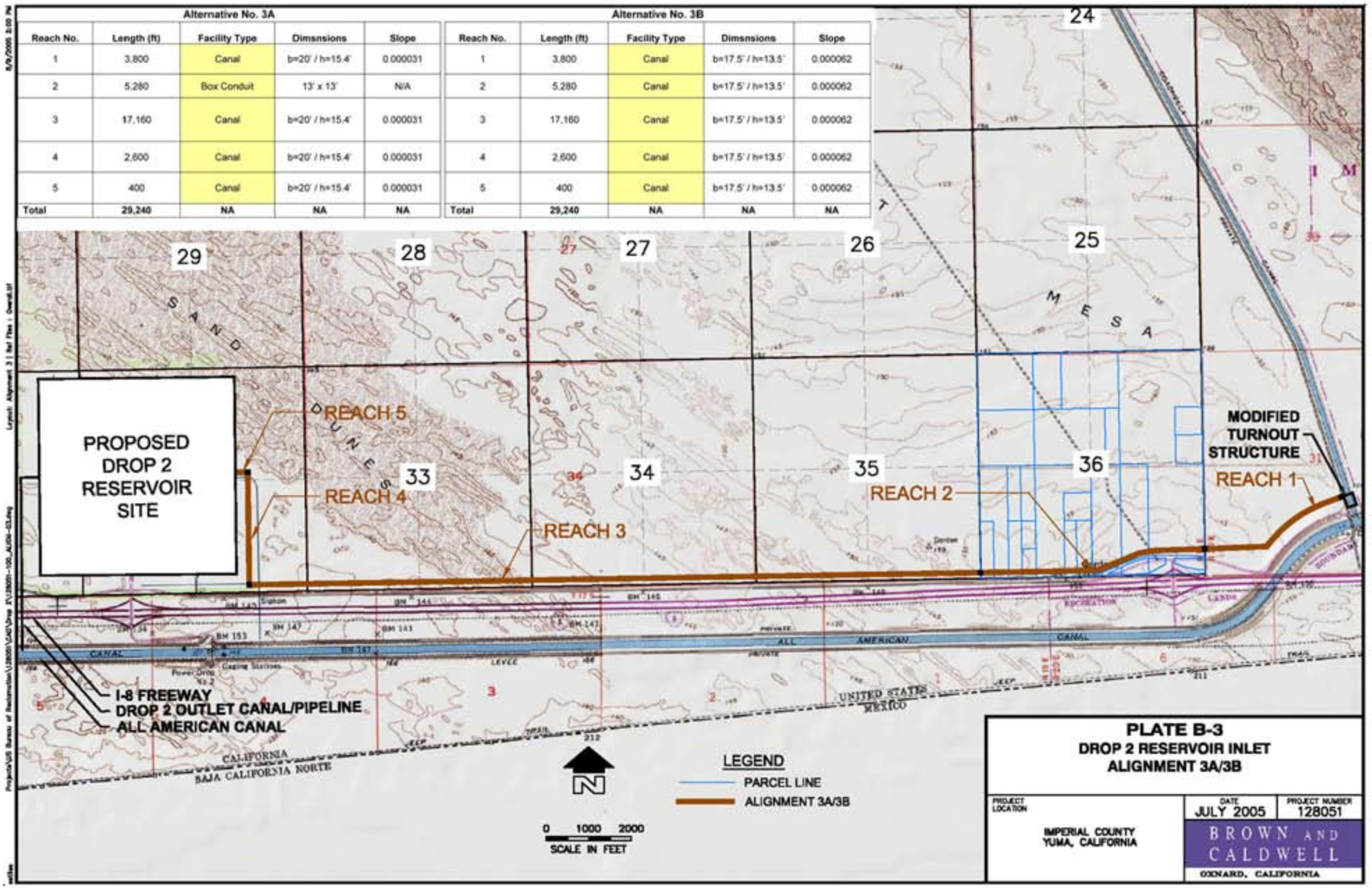


PLATE B-3
DROP 2 RESERVOIR INLET ALIGNMENT 3A/3B

PROJECT LOCATION
IMPERIAL COUNTY
YUMA, CALIFORNIA

DATE
JULY 2005

PROJECT NUMBER
128051

BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 4

ALIGNMENT DESCRIPTION

Alternative Alignment No. 4 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. This alignment strives to avoid impacts to the developed lands within Section 36 by circumventing the south half of Section 36. The alignment drops back down towards the County Road and then proceeds in a westerly direction. The inlet canal right-of-way (ROW) for the portion that parallels the County Road (within Sections 32, 33, 34 and 35) is situated on the north side and immediately adjacent to the County Road ROW. The alignment for this alternative will comprise seven reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the inlet canal alignment proceeds in a southwest direction and approximately 3,800 feet to the west section line of Section 31. The right-of-way width required for this initial reach is 400 feet. This right-of-way will be generally be located north and parallel to the unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site. The terminus for this reach is located near the intersection of the unpaved access road and the west section line of Section 31. Reach 1 of this alternative alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is located near the intersection of unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site with the west section line of Section 31. From this point the alignment turns north, and will comprise the west 400 feet of the southwest quarter of Section 31. The limits of this reach will be from the terminus point of Reach 1 to north line of the southwest quarter of Section 31. The length of Reach 2 inlet canal ROW is approximately 2,000 feet and the width is 400 feet. Reach 2 is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 3

The ROW for Reach 3 of the inlet canal ROW will comprise the north 400 feet of the south half of Section 36. This ROW will traverse some 7 privately owned parcels. The length of the Reach 3 inlet canal ROW is approximately 5,280 feet and the width is 400 feet. Reach 3 is located entirely within Section 36, T. 16 S., R. 19 E.

Reach 4

The ROW for Reach 4 of the inlet canal ROW will comprise the east 400 feet of the southwest quarter of Section 35. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 4 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 4 is located entirely within Section 35, T. 16 S., R. 19 E.

Reach 5

Reach 5 of the inlet canal ROW will be situated on the north side and generally parallel to the County Road. Reach 5 is located within Sections 32, 33, 34 and 35 which are within T. 16 S., R. 19 E. However, the centerline of the existing 40 foot wide paved roadway is located approximately 40 feet south of the township line and within T. 17 S., R. 19 E. Also, from documents provided by Imperial County that show the portion of the ROW that the State of California (Caltrans) relinquished to Imperial County for the County Road (old highway), it appears that the northernmost 150 feet of the 400 foot wide County Road ROW is located within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E. and the remainder 250 feet of width is located within Sections 1, 2, 3 ad 4 of T. 17 S., R. 19 E.

The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. This would comprise the south 400 feet of Sections 33, 34 and 35 and the south 400 feet of the west half of the southeast quarter of Section 32 (T. 16 S., R. 19 E). Approximately 150 feet of the 400 foot wide inlet canal ROW will comprise a portion of the 400 foot wide ROW that the State of California (Caltrans) relinquished to Imperial County. This will require that Imperial County relinquish the northernmost 150 feet of their 400 foot wide ROW to the federal Government (Reclamation). An additional 50 foot wide strip of land will be required to provide the required 400 foot ROW for this reach of the inlet canal. The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. Reach 5 is located entirely within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E.

Reach 6

Reach 6 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 6 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 6 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 7

The centerline of the Reach 7 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 7 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 7 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 7 will be located entirely on Reclamation Withdrawn lands and within Section 32.

A layout of the alignment of the proposed inlet canal under Alternative No. 4 is provided in Plate B-4.

PRELIMINARY DESCRIPTION OF FACILITIES:

Two option(s) will be considered for Alternative Alignment No. 4. Each option will occupy the same general alignment noted above but will comprise different types of facilities. Table B-5 notes the facility types considered in each option.

Table B-5
Summary of Alternative No. 4 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Option A Facility Type	Option B Facility Type	General Description
1	3,800	Sec 31	400 foot strip north & parallel to dirt road	Canal	Canal	Portion of ROW located within Section 36 crosses Section 36 along the east-west half section line. This portion of the ROW occupies the north 400 feet of the south half of Section 36. The portion of the ROW within Sections 35, 34,33, and 32 would be located to the north side (an outside) the County Road ROW.
2	2,000	Sec 31	west 400 feet of SW 1/4 of Section 31	Canal	Canal	
3	5,280	E-W on 1/2 Sec Ln 36	north 400 feet of south 1/2 of Section 36	One Barrel	Canal	
4	2,600	Sec 35	east 400 feet of SE 1/4 of Sec 35	Canal	Canal	
5	17,160	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	Canal	Canal	
6	2,600	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	Canal	
7	400	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	Canal	

Alternative No. 4A

Reach No.	Length (ft)	Facility Type	Dimensions	Slope
1	3,800	Canal	b=19.5' / h=15'	0.000035
2	2,000	Canal	b=19.5' / h=15'	0.000035
3	5,280	Box Conduit	14' x 14'	N/A
4	2,640	Canal	b=19.5' / h=15'	0.000035
5	17,160	Canal	b=19.5' / h=15'	0.000035
6	2,600	Canal	b=19.5' / h=15'	0.000035
7	400	Canal	b=19.5' / h=15'	0.000035
Total	33,880	NA	NA	NA

Alternative No. 4B

Reach No.	Length (ft)	Facility Type	Dimensions	Slope
1	3,800	Canal	b=18' / h=13.8'	0.000054
2	2,000	Canal	b=18' / h=13.8'	0.000054
3	5,280	Canal	b=18' / h=13.8'	0.000054
4	2,640	Canal	b=18' / h=13.8'	0.000054
5	17,160	Canal	b=18' / h=13.8'	0.000054
6	2,600	Canal	b=18' / h=13.8'	0.000054
7	400	Canal	b=18' / h=13.8'	0.000054
Total	33,880	NA	NA	NA

PROPOSED DROP 2 RESERVOIR SITE

REACH 7

REACH 6

REACH 5

REACH 4

REACH 3

REACH 2

REACH 1

MODIFIED TURNOUT STRUCTURE

I-8 FREEWAY

DROP 2 OUTLET CANAL/PIPELINE

ALL AMERICAN CANAL

SAND DUNES

EAST MESA

CALIFORNIA

BAJA CALIFORNIA NORTE

UNITED STATES

MEXICO

LEGEND

PARCEL LINE

ALIGNMENT 4A/4B

0 1000 2000

SCALE IN FEET

PLATE B-4

DROP 2 RESERVOIR INLET ALIGNMENT 4A/4B

PROJECT LOCATION: IMPERIAL COUNTY YUMA, CALIFORNIA

DATE: JULY 2005

PROJECT NUMBER: 128051

BROWN AND CALDWELL

OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 5

ALIGNMENT DESCRIPTION

Alternative Alignment No. 5 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. This alignment strives to avoid impacts to the developed lands within Section 36 by circumventing all of Section 36. The alignment drops back down towards the County Road and then proceeds in a westerly direction. The inlet canal right-of-way (ROW) for the portion that parallels the County Road (within Sections 32, 33, 34 and 35) is situated on the north side and immediately adjacent to the County Road ROW. The alignment for this alternative will comprise seven reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the inlet canal alignment proceeds in a southwest direction and approximately 3,200 feet to the west section line of Section 31. The right-of-way width required for this initial reach is 400 feet. This right-of-way will be generally be located north and parallel to the unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site. The terminus for this reach is located near the intersection of the unpaved access road and the west section line of Section 31. Reach 1 of this alternative alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is located near the intersection of unpaved access road that extends from the intersection of Gordon's Well Road and County Road (Evan Hewes Highway) to the Drop 1 site with the west section line of Section 31. From this point the alignment turns north, and will comprise the west 400 feet of Section 31. The limits of this reach will be from the terminus point of Reach 1 to the north section line of Section 31. The length of Reach 2 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 2 is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 3

The ROW for Reach 3 of the inlet canal ROW will comprise the south 400 feet of Section 25 and two 400 feet by 400 feet parcels, one of which will be located in the southwest corner of Section 30 and the other in the southeast corner of Section 26. The Reach 3 ROW will be located entirely within Reclamation Withdrawn lands. The length of the Reach 3 inlet canal ROW is approximately 5,680 feet and the width is 400 feet. Reach 3 is mostly located within Section 25, T. 16 S., R. 19 E. One 400 foot by 400 foot parcel will be located within Section 30, T. 16 S., R. 20 E. and a similar size parcel will be located within Section 26, T. 16 S., R. 19 E.

Reach 4

The ROW for Reach 4 of the inlet canal ROW will comprise the east 400 feet of Section 35. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 4 inlet canal ROW is approximately 5,280 feet and the width is 400 feet. Reach 4 is located entirely within Section 35, T. 16 S., R. 19 E.

Reach 5

Reach 5 of the inlet canal ROW will be situated on the north side and generally parallel to the County Road. Reach 5 is located within Sections 32, 33, 34 and 35 which are within T. 16 S., R. 19 E. However, the centerline of the existing 40 foot wide paved roadway is located approximately 40 feet south of the township line and within T. 17 S., R. 19 E. Also, from documents provided by Imperial County that show the portion of the ROW that the State of California (Caltrans) relinquished to Imperial County for the County Road (old highway), it appears that the northernmost 150 feet of the 400 foot wide County Road ROW is located within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E. and the remainder 250 feet of width is located within Sections 1, 2, 3 ad 4 of T. 17 S., R. 19 E.

The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. This would comprise the south 400 feet of Sections 33, 34 and 35 and the south 400 feet of the west half of the southeast quarter of Section 32 (T. 16 S., R. 19 E). Approximately 150 feet of the 400 foot wide inlet canal ROW will comprise a portion of the 400 foot wide ROW that the State of California (Caltrans) relinquished to Imperial County. This will require that Imperial County relinquish the northernmost 150 feet of their 400 foot wide ROW to the federal Government (Reclamation). An additional 50 foot wide strip of land will be required to provide the required 400 foot ROW for this reach of the inlet canal. The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. Reach 5 is located entirely within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E.

Reach 6

Reach 6 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 6 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 6 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 7

The centerline of the Reach 7 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 7 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 7 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 7 will be located entirely on Reclamation Withdrawn lands and within Section 32.

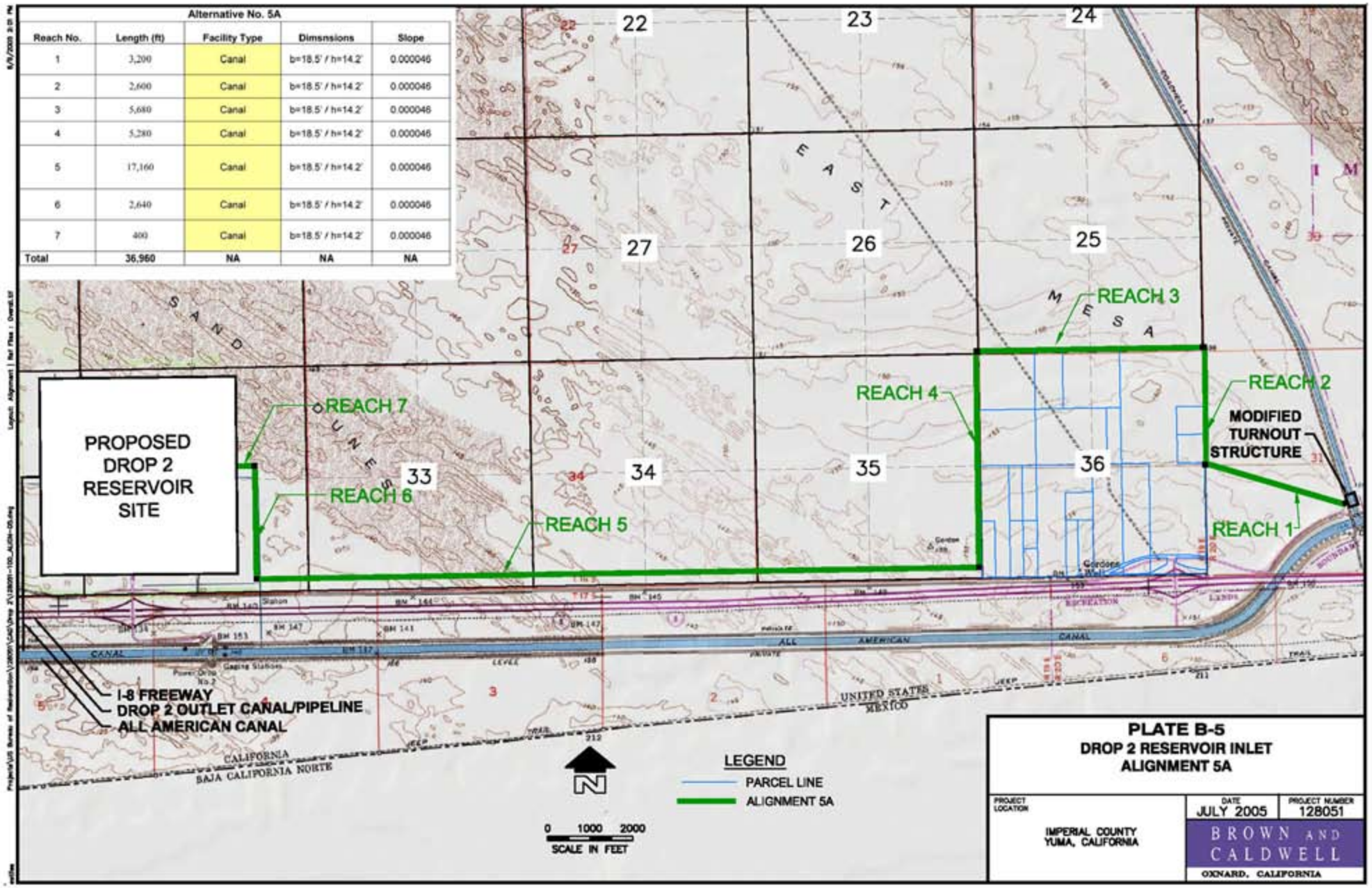
A layout of the alignment of the proposed inlet canal under Alternative No. 5 is provided in Plate B-5.

PRELIMINARY DESCRIPTION OF FACILITIES:

Only one option will be considered for Alternative Alignment No. 5. This alternative considers a canal for the entire length of the conveyance facility. Table B-6 provides a summary of this alternative.

Table B-6
Summary of Alternative No. 5 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Facility Type	General Description
1	3,200	Sec 31	400 foot strip estending northwest from the turnout	Canal	Section 36 is completely circumvented. ROW is located along the outside east, north, and west perimeter lines of Section 36. The portion of the ROW within Sections 35, 34,33, and 32 would be located to the north side (an outside) the County Road ROW.
2	2,600	Sec 31	west 400 feet of NW Sec 31	Canal	
3	5,680	Sec 25	south 400 feet of Sec 25	Canal	
4	5,280	Sec 35	east 400 feet of Sec 35	Canal	
5	17,160	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	Canal	
6	2,640	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	
7	400	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	


Alternative No. 5A
Reach No. | Length (ft) | Facility Type | Dimsnsions | Slope
1 | 3,200 | Canal | b=18.5' / h=14.2' | 0.000046
2 | 2,600 | Canal | b=18.5' / h=14.2' | 0.000046
3 | 5,680 | Canal | b=18.5' / h=14.2' | 0.000046
4 | 5,280 | Canal | b=18.5' / h=14.2' | 0.000046
5 | 17,160 | Canal | b=18.5' / h=14.2' | 0.000046
6 | 2,640 | Canal | b=18.5' / h=14.2' | 0.000046
7 | 400 | Canal | b=18.5' / h=14.2' | 0.000046
Total | 36,960 | NA | NA | NA
PROPOSED DROP 2 RESERVOIR SITE
REACH 1
REACH 2
MODIFIED TURNOUT STRUCTURE
REACH 3
REACH 4
REACH 5
REACH 6
REACH 7
I-8 FREEWAY
DROP 2 OUTLET CANAL/PIPELINE
ALL AMERICAN CANAL
LEGEND
PARCEL LINE
ALIGNMENT 5A
0 1000 2000
SCALE IN FEET
PLATE B-5
DROP 2 RESERVOIR INLET
ALIGNMENT 5A
PROJECT LOCATION
IMPERIAL COUNTY
YUMA, CALIFORNIA
DATE
JULY 2005
PROJECT NUMBER
128051
BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 6

ALIGNMENT DESCRIPTION

Alternative Alignment No. 6 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. The entire ROW for this alternative alignment will be located within Reclamation Withdrawn lands. The alignment strives to avoid impacts to the developed lands within Section 36, environmentally sensitive lands, and to the County Roadway by locating a large portion of the alignment on the south side of I-8, generally between and parallel to the All-American Canal and I-8. This will require two crossings of the County Road and I-8. This alternative alignment will comprise six reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 20E). From this starting point, the inlet canal ROW alignment proceeds in a southwest direction and approximately 3,800 feet to the County Road (Evan Hewes Highway). The ROW width required for this initial reach is 400 feet. This ROW will be generally located north and parallel to the unpaved access road that extends from the intersection of Gordon's Well Road and the County Road to the Drop 1 site. The terminus for this reach is located near the intersection of the east section line of Section 36 and the County Road.

Reach 2

The starting point for Reach 2 is near the intersection of the County Road (Evan Hewes Highway) and the west section line of Section 31 (located within Section 31 T. 16S, R. 20E). The ROW will comprise a 400 foot wide strip that extends south from this starting point and lies adjacent and east of a southerly extension of the west section line of Section 31. The length of the Reach 2 inlet canal ROW is approximately 1,200 feet. Reach 2 begins in Section 31 and terminates within Section 2.

The Reach 2 inlet canal ROW will cross the County Road and I-8 ROWs. The County Road crossing will comprise a pipe or bridge crossing. The crossing of the I-8 ROW will require a tunnel (pipeline) beneath all or most of the I-8 ROW. An encroachment permit will be required from the County for the County Road crossing. An encroachment permit will be required from the State of California (Caltrans) for the I-8 crossing. The remainder of the ROW lands outside the County and I-8 ROWs are Reclamation Withdrawn lands.

Reach 3

Reach 3 of the inlet canal ROW alignment will be located within the stretch of land that lies between the All-American Canal and I-8. The starting point for this reach is the southerly extension of the west section line of Section 36 and the terminus point is the southerly extension of the west line of the west half of the southeast quarter of Section 32. The starting point is also located approximately 800 feet south of the north section line of Section 6. From this point of beginning, the ROW centerline for the inlet canal alignment extends west approximately 22,800 feet, within the area bound by the All-American Canal on the south and I-8 freeway on the north. The centerline of this inlet canal is situated south and on an offset of approximately 250feet from the south ROW line of I-8. The

ROW is located within Sections 6, 1, 2, and 3 of T. 17 S., R19, E. The terminus point of the centerline of the Reach 3 inlet canal ROW is located approximately 800 feet south of the north section line of Section 4 and approximately 2,400 feet east of the west section line of Section 4. The ROW width required for Reach 3 is 400 feet. The entire ROW for Reach 3 lies within Reclamation Withdrawn Lands.

Reach 4

Reach 4 of the inlet canal ROW alignment will comprise a 1,200 foot long by 400 foot wide strip that extends north from the terminus point of Reach 3. The 400 foot wide ROW will lay adjacent to and west of the southerly extension of the west line of the west half of the southeast quarter of Section 32. The Reach 4 point of beginning is also is generally located approximately 800 feet south of the north section line of Section 4 and 2,400 feet east of the west section line of Section 4. The terminus point is on the north section line of Section 4.

The Reach 4 inlet canal ROW will cross the I-8 and County Road ROWs. The crossing of the I-8 ROW will require a tunnel (pipeline) beneath all or most of the I-8 ROW. The County Road crossing will comprise a pipe or bridge crossing. An encroachment permit will be required from the State of California (Caltrans) for the I-8 crossing. An encroachment permit will be required from the County for the County Road crossing. The remainder of the ROW lands outside the County and I-8 ROWs are Reclamation Withdrawn lands. All of Reach 4 of the inlet canal ROW alignment is located within Section 4, T. 17 S., R. 19 E.

Reach 5

Reach 5 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 5 inlet canal ROW is approximately 2,640 feet and the width is 400 feet. Reach 5 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 6

The centerline of the Reach 6 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 6 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 6 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 6 will be located entirely on Reclamation Withdrawn lands and within Section 32, T. 16 S., R. 19 E.

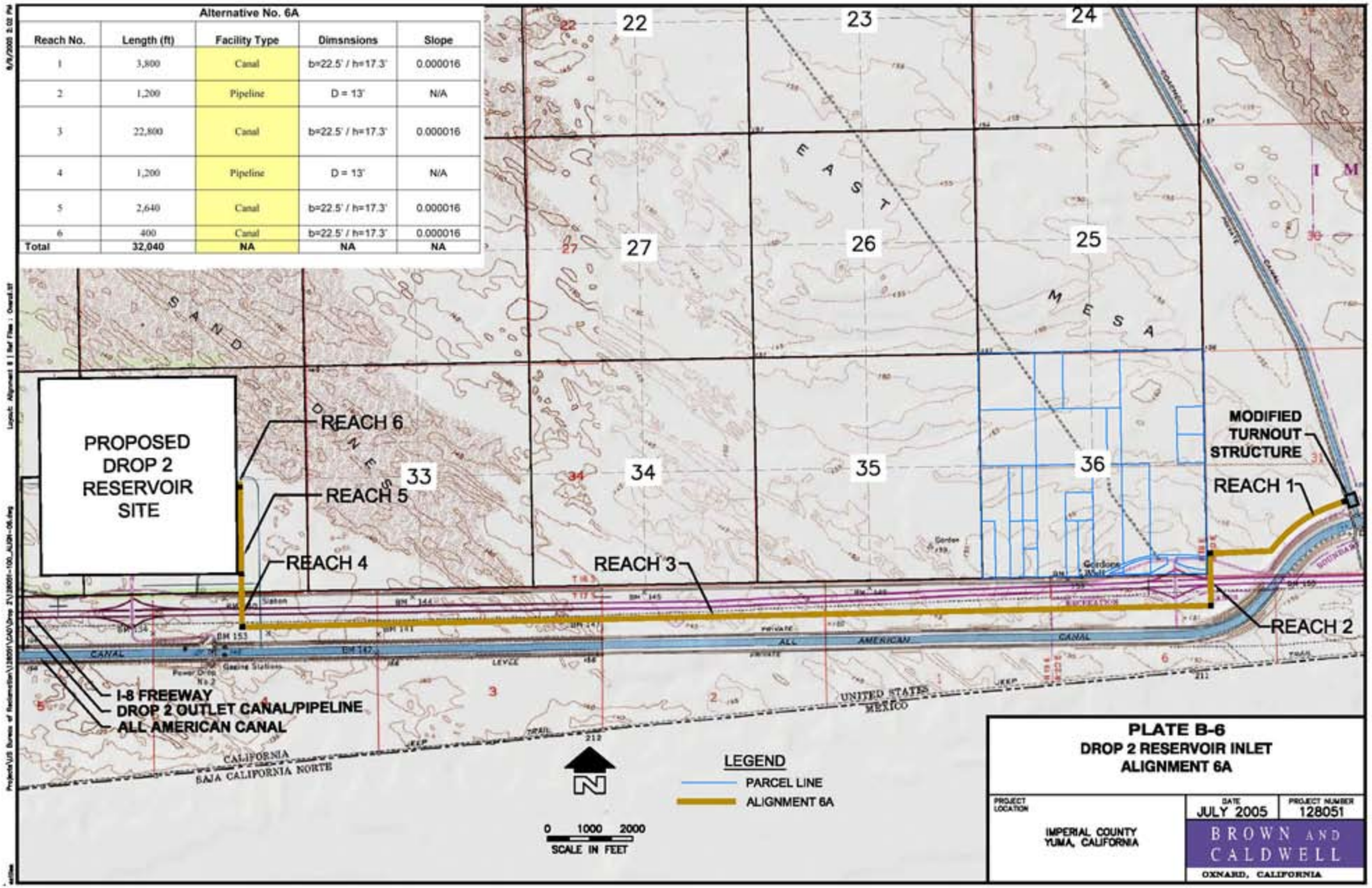
A layout of the alignment of the proposed inlet canal under Alternative No. 6 is provided in Plate B-6.

PRELIMINARY DESCRIPTION OF FACILITIES:

Only one option will be considered for Alternative Alignment No. 6. This alternative consists primarily of a canal. The exception are proposed large diameter pipes that will be used to achieve the two crossings of I-8 (Reaches 2 and 4). Table B-7 provides a summary of this alternative.

Table B-7
Summary of Alternative No. 6 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Facility Type	General Description
1	3,800	Sec 31	400 foot strip north & parallel to dirt road	Canal	A 400 foot wide right of way is required for Alternative 6. The ROW will lie entirely within Reclamation Withdrawn Land. The ROW for the alignment will cross County Road and the I-8 freeway in two places.
2	1,200	Sec 31, 6	400 foot strip. Parallel and east of east section line of Section 31	Pipeline	
3	22,800	Sec 6, 1, 2, 3, 4	400 foot strip. Parallel to All-American Canal	Canal	
4	1,200	Sec 4, 32	400 foot strip. Parallel and east of east section line of Section 33	Pipeline	
5	2,640	Secs 32	400 foot strip. Parallel and east of east section line of Section 33	Canal	
6	400	Secs , 32	400 foot strip located on south side of east-west ½ section line of Sec 32	Canal	


Alternative No. 6A
Reach No. | Length (ft) | Facility Type | Dimsnsions | Slope
1 | 3,800 | Canal | b=22.5' / h=17.3' | 0.000016
2 | 1,200 | Pipeline | D = 13' | N/A
3 | 22,800 | Canal | b=22.5' / h=17.3' | 0.000016
4 | 1,200 | Pipeline | D = 13' | N/A
5 | 2,640 | Canal | b=22.5' / h=17.3' | 0.000016
6 | 400 | Canal | b=22.5' / h=17.3' | 0.000016
Total | 32,040 | NA | NA | NA
PROPOSED DROP 2 RESERVOIR SITE
REACH 6
REACH 5
REACH 4
REACH 3
REACH 2
REACH 1
MODIFIED TURNOUT STRUCTURE
I-8 FREEWAY
DROP 2 OUTLET CANAL/PIPELINE
ALL AMERICAN CANAL
SAND DUNES
EAST MESA
LEGEND
PARCEL LINE
ALIGNMENT 6A
0 1000 2000
SCALE IN FEET
PLATE B-6
DROP 2 RESERVOIR INLET
ALIGNMENT 6A
PROJECT LOCATION
IMPERIAL COUNTY
YUMA, CALIFORNIA
DATE
JULY 2005
PROJECT NUMBER
128051
BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 7

ALIGNMENT DESCRIPTION

Alternative Alignment No. 7 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. This alignment strives to avoid impacts to the developed lands within Section 36 by generally following the alignment of a previously abandoned canal. The alignment is located parallel and on an approximately ½ mile offset to and north of the County Road. This ROW alignment generally follows the half section lines of Section 36, 35, 34, and 33. The alignment for this alternative will comprise four reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the inlet canal alignment proceeds in a west by northwest direction and approximately 3,000 feet to a point that coincides with the northwest corner of the southwest quarter of Section 31. The right-of-way width required for this initial reach is 400 feet. Reach 1 of this alternative alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The ROW for Reach 2 of the inlet canal ROW will comprise the north 400 feet of the south half of Section 36. The limits of this ROW will be the east and west section lines of Section 36. This ROW will traverse some 7 privately owned parcels. The length of the Reach 2 inlet canal ROW is approximately 5,280 feet and the width is 400 feet. Reach 2 is located entirely within Section 36, T. 16 S., R. 19 E.

Reach 3

The ROW for Reach 3 of the inlet canal ROW will comprise the north 400 feet of the south half of Sections 35, 34 and 33. The limits of this ROW are the east section line of Section 35 and the west section line of Section 33. This ROW will traverse some three sections of land that are within the Flat Tailed Horned Lizard Management Area. The length of the Reach 3 inlet canal ROW is approximately 15,840 feet and the width is 400 feet. Reach 3 will be located within Sections 35, 34 and 33 of T. 16 S., R. 19 E.

Reach 4

The centerline of the Reach 4 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 4 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 4 of the inlet canal ROW is approximately 1,720 feet and the width is 400 feet. Reach 4 will be located entirely on Reclamation Withdrawn lands and within Section 32.

A layout of the alignment of the proposed inlet canal under Alternative No. 7 is provided in Plate B-7.

PRELIMINARY DESCRIPTION OF FACILITIES:

Two option(s) will be considered for Alternative Alignment No. 7. Each option will occupy the same general alignment noted above but will comprise different types of facilities. Table B-8 notes the facility types considered in each option.

Table A-8
Summary of Alternative No. 7 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Option A Facility Type	Option B Facility Type	General Description
1	3,000	Sec 31	west by northwest route from T.O. to NW corner of SW 1/4 of Sec 31	Canal	Canal	All of alignment located along 1/2 section lines of Sections 36, 35, 34, 33, & 32.
2	5,280	Sec 36	north 400 feet of south 1/2 of Section 36	One Barrel	Canal	
3	15,840	Secs 35, 34, 33	north 400 feet of south 1/2 of Secs 35, 34, & 33	Canal	Canal	
4	1,720	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	Canal	

Alternative No. 7B

Reach No.	Length (ft)	Facility Type	Dimsnsions	Slope
1	3,000	Canal	b=17.5' / h=13.5'	0.000046
2	5,280	Canal	14' x 14'	0.000046
3	17,160	Canal	b=17.5' / h=13.5'	0.000046
4	400	Canal	b=17.5' / h=13.5'	0.000046
Total	25,840	NA	NA	NA

Alternative No. 7A

Reach No.	Length (ft)	Facility Type	Dimsnsions	Slope
1	3,000	Canal	b=18.5' / h=14.2'	0.000062
2	5,280	Box Conduit	b=18.5' / h=14.2'	N/A
3	17,160	Canal	b=18.5' / h=14.2'	0.000062
4	400	Canal	b=18.5' / h=14.2'	0.000062
Total	25,840	NA	NA	NA

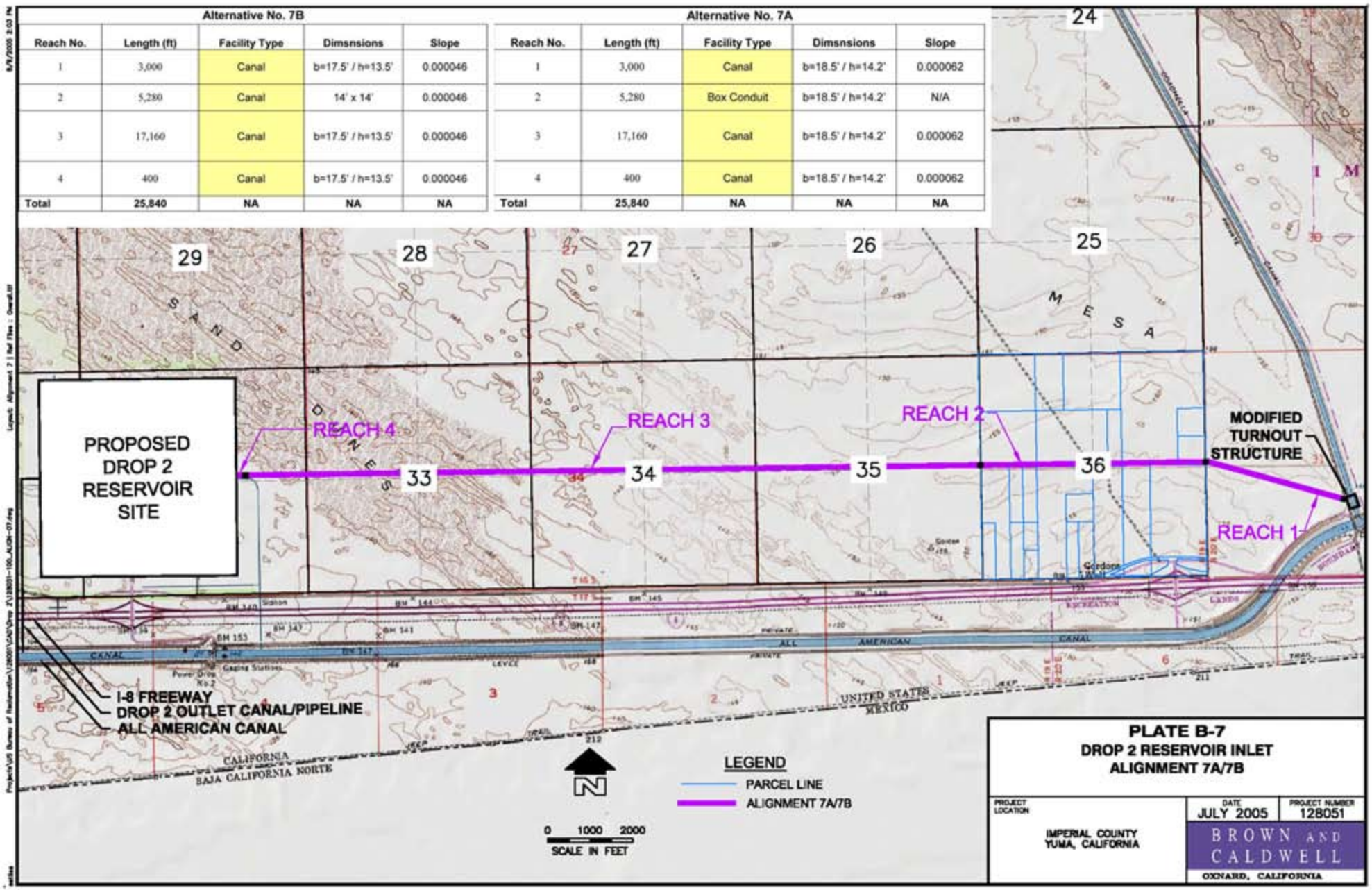


PLATE B-7
DROP 2 RESERVOIR INLET
ALIGNMENT 7A/7B

PROJECT LOCATION
IMPERIAL COUNTY
YUMA, CALIFORNIA

DATE
JULY 2005

PROJECT NUMBER
128051

BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 8

ALIGNMENT DESCRIPTION

Alternative Alignment No. 8 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. This alignment strives to avoid impacts to the developed lands within Section 36 by circumventing the south half of Section 36. The alignment drops back down towards the County Road and then proceeds in a westerly direction. The inlet canal right-of-way (ROW) for the portion that parallels the County Road (within Sections 32, 33, 34 and 35) is situated on the north side and immediately adjacent to the County Road ROW. The alignment for this alternative will comprise seven reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the centerline of the inlet canal alignment proceeds northwest and follows the centerline of the old (unlined) Coachella Canal approximately 1,000 feet. The terminus for this reach is located near the intersection of the old (unlined) Coachella Canal and the east-west half section line of Section 31. The right-of-way width required for this initial reach is 400 feet. Reach 1 of this alternative alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is located near the intersection of the old (unlined) Coachella Canal and the half section line of Section 31. From this point the alignment travels west, and comprises the south 400 feet of the northwest quarter of Section 31. The limits of this reach will be from the terminus point of Reach 1 to west section line of Section 36. The length of Reach 2 inlet canal ROW is approximately 3,000 feet and the width is 400 feet. Reach 2 is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 3

The ROW for Reach 3 of the inlet canal ROW will comprise the north 400 feet of the south half of Section 36. This ROW will traverse some 7 privately owned parcels. The length of the Reach 3 inlet canal ROW is approximately 5,280 feet and the width is 400 feet. Reach 3 is located entirely within Section 36, T. 16 S., R. 19 E.

Reach 4

The ROW for Reach 4 of the inlet canal ROW will comprise the east 400 feet of the southwest quarter of Section 35. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 4 inlet canal ROW is approximately 2,640 feet and the width is 400 feet. Reach 4 is located entirely within Section 35, T. 16 S., R. 19 E.

Reach 5

Reach 5 of the inlet canal ROW will be situated on the north side and generally parallel to the County Road. Reach 5 is located within Sections 32, 33, 34 and 35 which are within

T. 16 S., R. 19 E. However, the centerline of the existing 40 foot wide paved roadway is located approximately 40 feet south of the township line and within T. 17 S., R. 19 E. Also, from documents provided by Imperial County that show the portion of the ROW that the State of California (Caltrans) relinquished to Imperial County for the County Road (old highway), it appears that the northernmost 150 feet of the 400 foot wide County Road ROW is located within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E. and the remainder 250 feet of width is located within Sections 1, 2, 3 ad 4 of T. 17 S., R. 19 E.

The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. This would comprise the south 400 feet of Sections 33, 34 and 35 and the south 400 feet of the west half of the southeast quarter of Section 32 (T. 16 S., R. 19 E). Approximately 150 feet of the 400 foot wide inlet canal ROW will comprise a portion of the 400 foot wide ROW that the State of California (Caltrans) relinquished to Imperial County. This will require that Imperial County relinquish the northernmost 150 feet of their 400 foot wide ROW to the federal Government (Reclamation). An additional 50 foot wide strip of land will be required to provide the required 400 foot ROW for this reach of the inlet canal. The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. Reach 5 is located entirely within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E.

Reach 6

Reach 6 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 6 inlet canal ROW is approximately 2,600 feet and the width is 400 feet. Reach 6 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 7

The centerline of the Reach 7 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 7 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 7 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 7 will be located entirely on Reclamation Withdrawn lands and within Section 32.

A layout of the alignment of the proposed inlet canal under Alternative No. 8 is provided in Plate B-8.

PRELIMINARY DESCRIPTION OF FACILITIES:

Two option(s) will be considered for Alternative Alignment No. 8. Each option will occupy the same general alignment noted above but will comprise different types of facilities. Table B-9 notes the facility types considered in each alternative.

Table B-9
Summary of Alternative No. 8 Alignment and Options

Reach No.	Length (ft)	Location	Orientation	Facility Type	General Description
1	1,000	Sec 31	400 foot strip with centerline that follows the centerline of abandoned Coachella Canal	Canal	Portion of ROW located within section 31 follows centerline of old unlined Coachella Canal. Portion of ROW located within section 31 also follows east-west ½ section line of Section 31. Portion of ROW located within Section 36 crosses Section 36 along the east-west half section line. This portion of the ROW occupies the north 400 feet of the south half of Section 36. The portion of the ROW within Sections 35, 34,33, and 32 would be located to the north side (an outside) the County Road ROW.
2	3,000	Sec 31	400 foot strip along south side of east-west 1/2 Sec line of Sec 31	Canal	
3	5,280	E-W on 1/2 Sec Ln 36	north 400 feet of south 1/2 of Section 36	Canal	
4	2,640	Sec 35	east 400 feet of SE 1/4 of Sec 35	Canal	
5	17,160	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	Canal	
6	2,600	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	
7	400	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	

Alternative No. 8A				
Reach No.	Length (ft)	Facility Type	Dimensions	Slope
1	1,000	Canal	b=18.5' / h=14.2'	0.000046
2	3,000	Canal	b=18.5' / h=14.2'	0.000046
3	5,640	Canal	b=18.5' / h=14.2'	0.000046
4	2,640	Canal	b=18.5' / h=14.2'	0.000046
5	17,160	Canal	b=18.5' / h=14.2'	0.000046
6	2,600	Canal	b=18.5' / h=14.2'	0.000046
7	400	Canal	b=18.5' / h=14.2'	0.000046
Total	32,080	NA	NA	NA

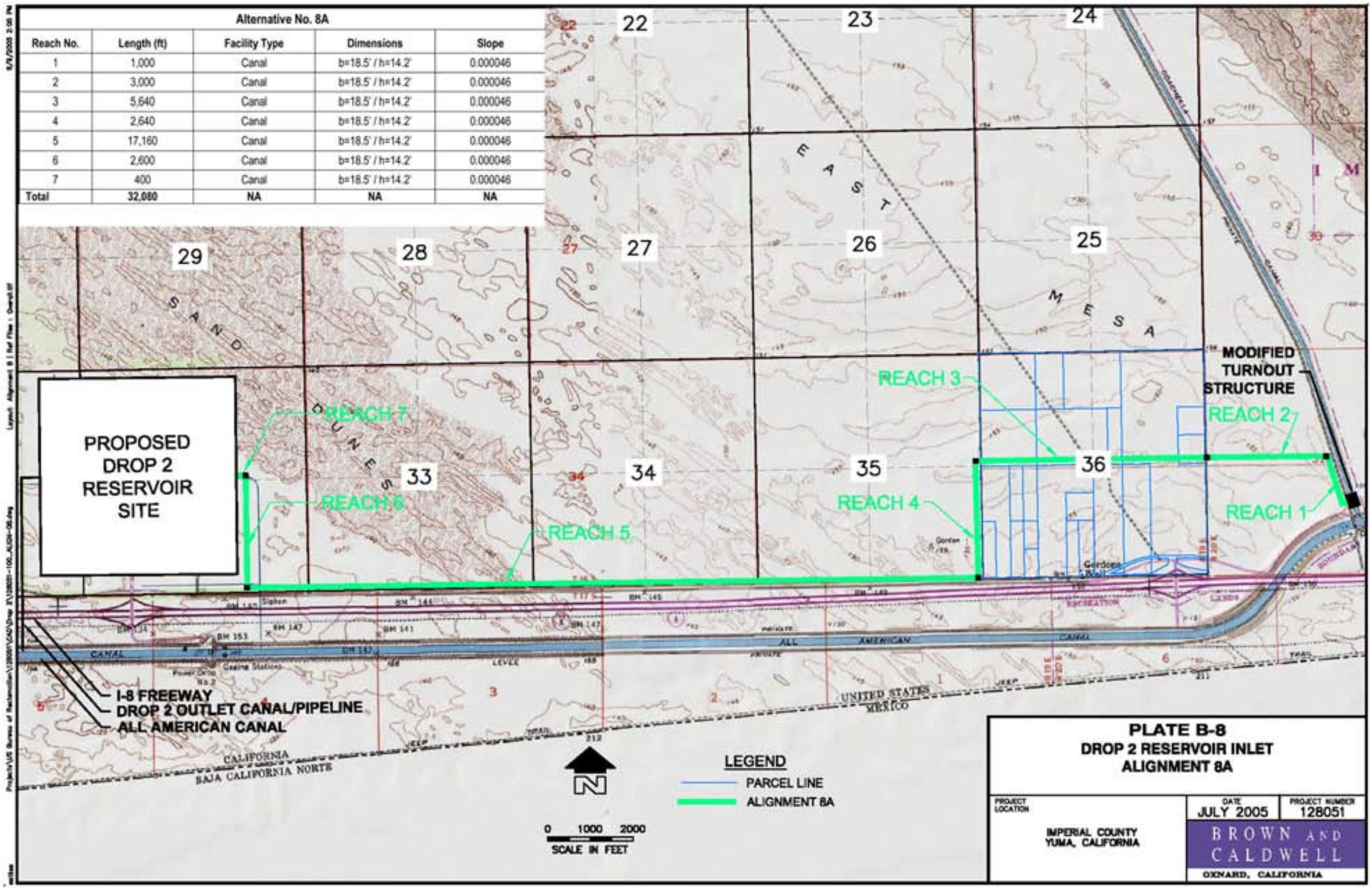


PLATE B-8
DROP 2 RESERVOIR INLET ALIGNMENT 8A

PROJECT LOCATION	DATE	PROJECT NUMBER
IMPERIAL COUNTY YUMA, CALIFORNIA	JULY 2005	128051

BROWN AND CALDWELL
OXNARD, CALIFORNIA

ALTERNATIVE ALIGNMENT NO. 9

ALIGNMENT DESCRIPTION

Alternative Alignment No. 9 extends from the proposed Drop 2 Reservoir Inlet Canal Turnout to the Drop 2 Reservoir. This alignment strives to avoid impacts to the developed lands within Section 36 by circumventing all of Section 36. The alignment drops back down towards the County Road and then proceeds in a westerly direction. The inlet canal right-of-way (ROW) for the portion that parallels the County Road (within Sections 32, 33, 34 and 35) is situated on the north side and immediately adjacent to the County Road ROW. The alignment for this alternative will comprise seven reaches which are described as follows:

Reach 1

The starting point for this alternative and Reach 1 is located on the alignment of the old (unlined) Coachella Canal and is situated some 300 feet north of the turnout and All-American Canal (located within Section 31 T. 16S, R. 19E). From this starting point, the centerline of the inlet canal alignment proceeds northwest and follows the centerline of the old (unlined) Coachella Canal approximately 3,800 feet. The terminus for this reach is located near the intersection of the old (unlined) Coachella Canal and the south section line of Section 30 T. 16 S., R. 20 E. The right-of-way width required for this initial reach is 400 feet. Reach 1 of this alternative alignment is located entirely within Section 31, T. 16 S., R. 20 E.

Reach 2

The starting point for Reach 2 is located near the intersection of the old (unlined) Coachella Canal and the south section line of Section 30 T. 16 S., R. 20 E. From this point the alignment travels west, and will comprise the south 400 feet of Section 30 T. 16 S., R. 20 E. The limits of this reach will be from the terminus point of Reach 1 to east section line of Section 25. The length of Reach 2 inlet canal ROW is approximately 2,200 feet and the width is 400 feet. Reach 2 is located entirely within Section 30, T. 16 S., R. 20 E.

Reach 3

The ROW for Reach 3 of the inlet canal ROW will comprise the south 400 feet of Section 25 and two 400 feet by 400 feet parcels, one of which will be located in the southwest corner of Section 30 and the other in the southeast corner of Section 26. The Reach 3 ROW will be located entirely within Reclamation Withdrawn lands. The length of the Reach 3 inlet canal ROW is approximately 5,680 feet and the width is 400 feet. Reach 3 is mostly located within Section 25, T. 16 S., R. 19 E. One 400 foot by 400 foot parcel will be located within Section 30, T. 16 S., R. 20 E. and a similar size parcel will be located within Section 26, T. 16 S., R. 19 E.

Reach 4

The ROW for Reach 4 of the inlet canal ROW will comprise the east 400 feet of Section 35. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 4 inlet canal ROW is approximately 5,280 feet and the width is 400 feet. Reach 4 is located entirely within Section 35, T. 16 S., R. 19 E.

Reach 5

Reach 5 of the inlet canal ROW will be situated on the north side and generally parallel to the County Road. Reach 5 is located within Sections 32, 33, 34 and 35 which are within T. 16 S., R. 19 E. However, the centerline of the existing 40 foot wide paved roadway is located approximately 40 feet south of the township line and within T. 17 S., R. 19 E. Also, from documents provided by Imperial County that show the portion of the ROW that the State of California (Caltrans) relinquished to Imperial County for the County Road (old highway), it appears that the northernmost 150 feet of the 400 foot wide County Road ROW is located within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E. and the remainder 250 feet of width is located within Sections 1, 2, 3 ad 4 of T. 17 S., R. 19 E.

The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. This would comprise the south 400 feet of Sections 33, 34 and 35 and the south 400 feet of the west half of the southeast quarter of Section 32 (T. 16 S., R. 19 E). Approximately 150 feet of the 400 foot wide inlet canal ROW will comprise a portion of the 400 foot wide ROW that the State of California (Caltrans) relinquished to Imperial County. This will require that Imperial County relinquish the northernmost 150 feet of their 400 foot wide ROW to the federal Government (Reclamation). An additional 50 foot wide strip of land will be required to provide the required 400 foot ROW for this reach of the inlet canal. The length of the Reach 5 inlet canal ROW is approximately 17,160 feet and the width is 400 feet. Reach 5 is located entirely within Sections 32, 33, 34 and 35 of T. 16 S., R. 19 E.

Reach 6

Reach 6 of the inlet canal ROW will comprise the east 400 feet of the west half of the southeast quarter of Section 32. This ROW will be entirely within Reclamation Withdrawn lands. The length of the Reach 6 inlet canal ROW is approximately 2,640 feet and the width is 400 feet. Reach 6 is located entirely within Section 32, T. 16 S., R. 19 E.

Reach 7

The centerline of the Reach 7 inlet canal ROW alignment will follow the north quarter section line of the southeast quarter of Section 32. The limits of Reach 7 are the northeast corner of the west half of the southeast quarter of Section 32 and the inlet structure to the Drop 2 Reservoir. The length of Reach 7 of the inlet canal ROW is approximately 400 feet and the width is 400 feet. Reach 7 will be located entirely on Reclamation Withdrawn lands and within Section 32.

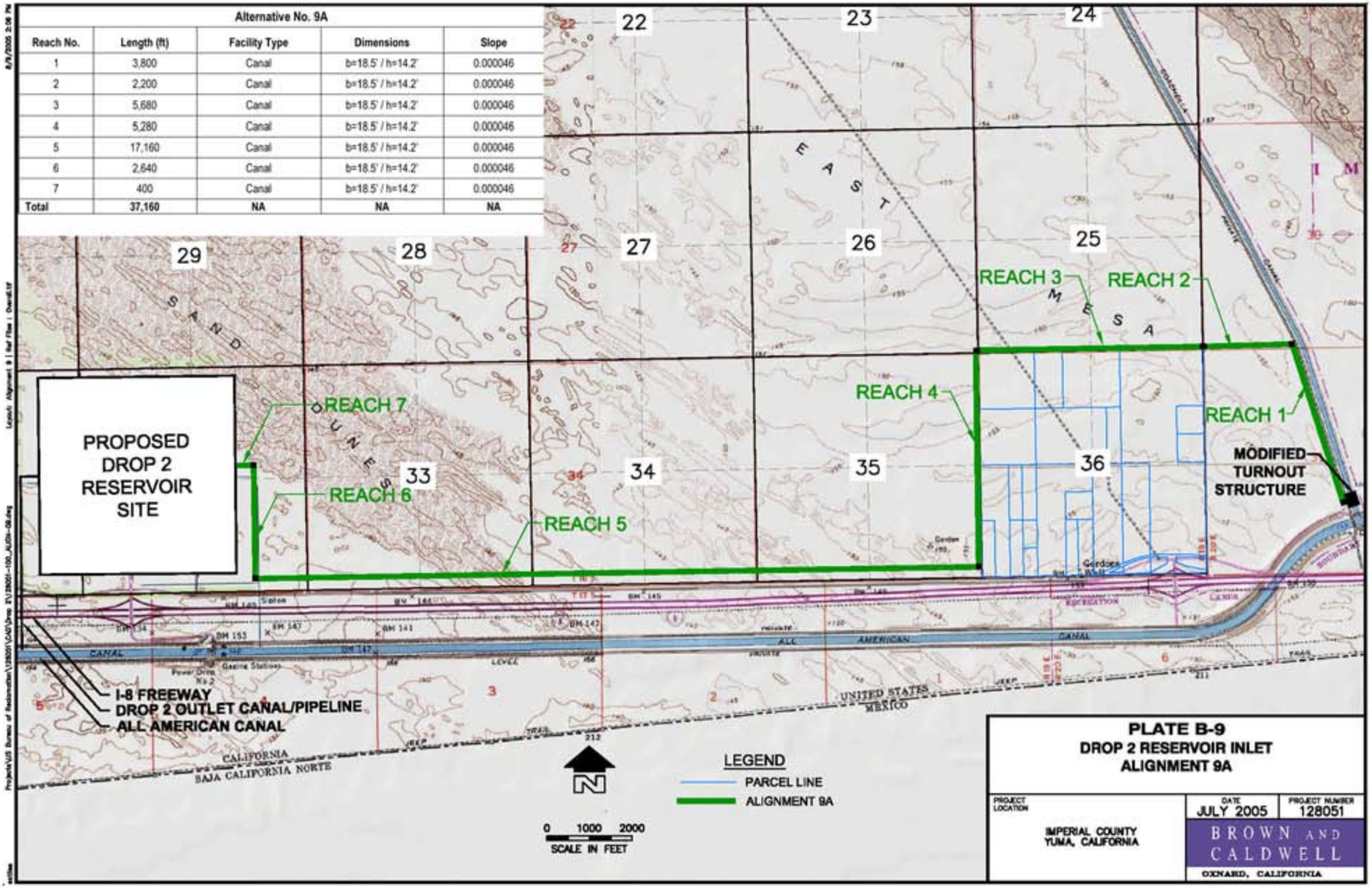
A layout of the alignment of the proposed inlet canal under Alternative No. 9 is provided in Plate B-9.

PRELIMINARY DESCRIPTION OF FACILITIES:

Only one option will be considered for Alternative Alignment No. 9. The alternative considers a canal for the entire conveyance faculty. Table B-10 provides a summary of the different reaches for this alternative.

Table B-10
Summary of Alternative No. 9 Alignment

Reach No.	Length (ft)	Location	Orientation	Facility Type	General Description
1	3,800	Sec 31	400 foot strip with centerline that follows the centerline of abandoned Coachella Canal	Canal	Portion of ROW located within section 31 follows centerline of old unlined Coachella Canal. Portion of ROW located within section 30 follows the south section line of Sec 30. Section 36 is completely circumvented. ROW is located along the outside east, north, and west perimeter lines of Section 36. The portion of the ROW within Sections 35, 34,33, and 32 would be located to the north side (an outside) the County Road ROW.
2	2,200	Sec 31	400 foot strip north and parallel to the south section line of Sec 30	Canal	
3	5,680	Sec 36	south 400 feet of Sec 25	Canal	
4	5,280	Sec 35	east 400 feet of Sec 35	Canal	
5	17,160	Secs 35, 34, 33, 32	400 foot strip located north/parallel to County Road ROW (adjacent to ROW)	Canal	
6	2,640	N-S w/in Sec 32	east 400 feet of west 1/2 of SE1/4 of Sec 32	Canal	
7	400	E-W on 1/2 Sec Ln of 32	along east-west 1/2 Sec line of Sec 32	Canal	


Alternative No. 9A
Reach No. | Length (ft) | Facility Type | Dimensions | Slope
1 | 3,800 | Canal | b=18.5' / h=14.2' | 0.000046
2 | 2,200 | Canal | b=18.5' / h=14.2' | 0.000046
3 | 5,680 | Canal | b=18.5' / h=14.2' | 0.000046
4 | 5,280 | Canal | b=18.5' / h=14.2' | 0.000046
5 | 17,160 | Canal | b=18.5' / h=14.2' | 0.000046
6 | 2,640 | Canal | b=18.5' / h=14.2' | 0.000046
7 | 400 | Canal | b=18.5' / h=14.2' | 0.000046
Total | 37,160 | NA | NA | NA
PROPOSED DROP 2 RESERVOIR SITE
REACH 1
REACH 2
REACH 3
REACH 4
REACH 5
REACH 6
REACH 7
MODIFIED TURNOUT STRUCTURE
I-8 FREEWAY
DROP 2 OUTLET CANAL/PIPELINE
ALL AMERICAN CANAL
LEGEND
PARCEL LINE
ALIGNMENT 9A
0 1000 2000
SCALE IN FEET
PLATE B-9
DROP 2 RESERVOIR INLET
ALIGNMENT 9A
PROJECT LOCATION
IMPERIAL COUNTY
YUMA, CALIFORNIA
DATE
JULY 2005
PROJECT NUMBER
128051
BROWN AND CALDWELL
OXNARD, CALIFORNIA

Attachment C

Design Criteria Considered in Conveyance Facility Sizing

SIZING AND DESIGN CRITERIA

Listed below is design criteria used in the sizing and configuration of the different conveyance systems and facilities considered in the different inlet canal alternative alignments.

Canal Design

1. Design flow (Q) = 1,800 cfs
2. Maximum design velocity = 4 fps
3. Manning's friction coefficient ("n") = 0.015
4. Minimum canal side slopes = 2H:1V
5. Minimum canal bottom width (b) = 14.1*logQ-32.9
6. Minimum ratio of canal bottom width to water depth (b/H) = 1.3
7. Total canal freeboard (HB) = 2.02*logQ - 2.5

   Where: The total freeboard is the difference between the top of the bank height and normal water surface elevation. The normal water surface is the top of water surface elevation at design flow.
8. Canal concrete lining height above normal water surface level (HL) = 1.15*logQ - 1.85
9. Minimum canal concrete lining thickness (t) = 3.5 inches

   Note: This thickness assumes the concrete lining will be underplayed with a 60 mil HDPE lining
10. O&M roads will be constructed on both sides of the canal. Minimum road width is 20 feet and will include 6 inch gravel surfacing.
11. For excavations, minimum cut slope = 2H:1V

Steel Pipe Design

1. Design flow (Q) = 1,800 cfs
2. Design velocity = 5 to 10 fps
3. Manning's friction coefficient ("n") = 0.013
4. For pipe systems, use "B" class pipe, unless otherwise specified
5. Minimum pipe cover is 5 feet with 90 percent compacted backfill where pipe crosses or parallels a road
6. Use liner plate or pipe jacking with where pipe crosses roadways. Extend liner plate or pipe jacking minimum 13 feet beyond right of way limits. Minimum cover is 5 feet.
7. Use "A" class pipe and 3-ft of cover where pipe transverses farmer's fields/desert terrain.
8. Minimum trench width (WP) = (1/12)*(1.167*ID+36)

   Where: ID = inside pipe diameter
12. For excavations, minimum cut slope = 2H:1V

Box Conduit Design

1. Design flow (Q) = 1,800 cfs
2. Design velocity = 5 to 10 fps
3. Manning's friction coefficient ("n") = 0.013
4. For excavations, minimum cut slope = 2H:1V

Attachment D

Hydraulic Analysis Methods and Results

HYDRAULIC ANALYSIS

Methodology

Hydraulic losses for each facility type were calculated using derivations of Manning's equation and the Energy Equation (Bernoulli's equation). The facilities were sized to convey a design flow of 1800 cfs.

Manning's Equation (Eqn. 1);

$Q = (1.486/n) * A * R^{0.66} * S^{0.5}$

Where:

Q = Flow (cfs)
n = Coefficient (Manning's)
A = Flow Area (ft^2)
R = Hydraulic Radius (ft), and
S = Facility Slope (ft/ft).

Bernoulli's Equation (Eqn. 2);

$E = z + (P/62.4) + (V^2/2g)$

Where:

*E = Total Energy (ft*lb/lb)*
z = Elevation Head (ft)
P = Pressure (lb/ft^2)
V = Velocity (fps), and
g = Gravitational Acceleration (ft/s^2).

The energy losses across each facility type that were considered in the analyses included the respective facility entrance losses, friction losses, and exit losses.

For pipeline and box conduit segments, the different losses were calculated using the following equations:

Entrance Losses;

$h_{ent} = K_{ent} * V^2/2g$, $K_{ent} = 0.3$ for box , 0.4 for pipe (Eqn. 3)

Where:

h_{en} = Entrance losses (ft)
K_{ent} = *Entrance Loss Coefficient*
V = *Velocity (fps)*
g = *Gravitational Acceleration (ft/s^2).*

Friction Losses;

$h_f = (29n^2L/R^{1.33}) * (V^2/2g)$ (Eqn. 4)

Where:

h_f = *Friction Losses (ft)*
n = *Coefficient (Manning's)*
L = *Facility Length (ft)*
R = *Hydraulic Radius (ft)*
V = *Velocity (fps)*
g = *Gravitational Acceleration (ft/s^2)*

Exit Losses;

$h_{exit} = K_{exit} * V^2/2g$, $K_{exit} = 0.5$ for box , 0.7 for pipe (Eqn. 5)

Where:

h_{exit} = Exit losses (ft)

K_{exit} = *Exit Loss Coefficient*

V = *Velocity (fps)*

g = *Gravitational Acceleration (ft/s^2)*

For canal segments, energy losses were calculated using Manning's equation. Canal parameters such as size and geometry were input into Manning's equation along with the target flow rate to determine a required slope. Given the slope required to pass the desired flow, energy loss was calculated as the change in elevation over the length of the canal segment.

A spread sheet model was used to calculate the sum of the head losses of the individual conveyance system components and to evaluate the hydraulic profile across the system. The anticipated worst case operating condition was used to size all of the facilities. This condition assumes that the water surface elevation in the All-American Canal immediately upstream of Drop 1 (source) is at the bottom of its operating range (1157.5 feet) and the water surface elevation of the Drop 2 Reservoir is at the top of its operating range (1155.00 feet). The individual facility sizing for each system component was varied to reduce the individual system component headloss accordingly to achieve the target hydraulic gradeline (HGL) of 1155.00 feet at the terminus point of the inlet canal system. This was done independently for each alternative alignment. In most instances, several iterations of this process were needed to arrive at the final sizing for the different system components.

Results

Given the above hydraulic analyses approach, the combinations of facility types and sizes that were determined to be needed to convey a design flow of 1,800 cfs under each respective inlet canal alternative alignment are listed in Table D-1. The hydraulic loss calculations for each alternative alignment are provided in Tables D-2 to D-13 per the following index.

Table	Alternative Alignment	Page
D-9	4B	7 of 10
D-10	5A	8 of 10
D-11	6A	8 of 10
D-12	7A	9 of 10
D-13	7B	9 of 10
D-14	8A	10 of 10
D-15	9A	10 of 10

.

Table D-1
Drop 2 Inlet Conveyance Facility Sizes

Alignment	Canal Size (base x WS depth, slope)	Box Conduit Barrel Size (base x height) [A]	Pipeline Size (diameter) [B]
1A 1B	20’ x 15.4’ canal (s=.000031) 17.5’ x 13.5’ canal (s=.000062)	13’ x 13’	
2A 2B	20’ x 15.4’ canal (s=.000031) 17.5’ x 13.5’ canal (s=.000062)	13’ x 13’	
3A 3B	20’ x 15.4’ canal (s=.000031) 17.5’ x 13.5’ canal (s=.000062)	13’ x 13’	
4A 4B	18' x 13.8' canal (s=.000054) 19.5' x 15' canal (s=.000035)	14' x 14'	
5A	18.5' x 14.2' canal (s=.000046)		
6A	22.5' x 17.3' canal (s=.000016)		13'
7A 7B	17.5' x 13.5' canal (s=.000062) 18.5' x 14.2' canal (s=.000046)	14' x 14'	
8A	18'x13.8' canal (s=.000054)		
9A	18.5' x 14.2' canal (s=.000046)		

Table D-2
Hydraulic Loss Calculations for Alignment 1A

Alignment 1A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	2.30	0.08	N/A	0.12	N/A	0.12	1156.92
2	5,280	Box Conduit	1156.92	3.55	0.20	0.06	1.06	0.10	1.21	1155.71
3	17,160	Canal	1155.71	2.30	0.08	N/A	0.53	N/A	0.53	1155.18
4	2,600	Canal	1155.18	2.30	0.08	N/A	0.08	N/A	0.08	1155.10
5	400	Canal	1155.10	2.30	0.08	N/A	0.01	N/A	0.01	1155.09
Exit Structure	30	Transition	1155.09	2.30	0.08	0.08	N/A	N/A	0.08	1155.01

Table D-3
Hydraulic Loss Calculations for Alignment 1B

Alignment 1B										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	3.01	0.14	N/A	0.24	N/A	0.24	1156.80
2	5,280	Canal	1156.80	3.01	0.14	N/A	0.33	N/A	0.33	1156.47
3	17,160	Canal	1156.47	3.01	0.14	N/A	1.07	N/A	1.07	1155.40
4	2,600	Canal	1155.40	3.01	0.14	N/A	0.16	N/A	0.16	1155.24
5	400	Canal	1155.24	3.01	0.14	N/A	0.02	N/A	0.03	1155.21
Exit Structure	30	Transition	1155.21	3.01	0.14	0.14	N/A	N/A	0.14	1155.07

Table D-4
Hydraulic Loss Calculations for Alignment 2A

Alignment 2A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	2.30	0.08	N/A	0.12	N/A	0.12	1156.92
2	5,280	Box Conduit	1156.92	3.55	0.20	0.06	1.06	0.10	1.21	1155.71
3	150	Canal	1155.71	2.30	0.08	N/A	0.00	N/A	0.00	1155.71
4	17,160	Canal	1155.71	2.30	0.08	N/A	0.53	N/A	0.53	1155.18
5	2,600	Canal	1155.18	2.30	0.08	N/A	0.08	N/A	0.08	1155.10
6	400	Canal	1155.10	2.30	0.08	N/A	0.01	N/A	0.01	1155.09
Exit Structure	30	Transition	1155.09	2.30	0.08	0.08	N/A	N/A	0.08	1155.00

Table D-5
Hydraulic Loss Calculations for Alignment 2B

Alignment 2B										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	3.01	0.14	N/A	0.24	N/A	0.24	1156.80
2	5,280	Canal	1156.80	3.01	0.14	N/A	0.33	N/A	0.33	1156.47
3	150	Canal	1156.47	3.01	0.14	N/A	0.01	N/A	0.01	1156.46
3	17,160	Canal	1156.46	3.01	0.14	N/A	1.07	N/A	1.07	1155.39
4	2,600	Canal	1155.39	3.01	0.14	N/A	0.16	N/A	0.16	1155.23
5	400	Canal	1155.23	3.01	0.14	N/A	0.02	N/A	0.03	1155.20
Exit Structure	30	Transition	1155.20	3.01	0.14	0.14	N/A	N/A	0.14	1155.06

Table D-6
Hydraulic Loss Calculations for Alignment 3A

Alignment 3A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	2.30	0.08	N/A	0.12	N/A	0.12	1156.92
2	5,280	Box Conduit	1156.92	3.55	0.20	0.06	1.06	0.10	1.21	1155.71
3	17,160	Canal	1155.71	2.30	0.08	N/A	0.53	N/A	0.53	1155.18
4	2,600	Canal	1155.18	2.30	0.08	N/A	0.08	N/A	0.08	1155.10
5	400	Canal	1155.10	2.30	0.08	N/A	0.00	N/A	0.00	1155.10
Exit Structure	30	Transition	1155.10	2.30	0.08	0.08	N/A	N/A	0.08	1155.02

Table D-7
Hydraulic Loss Calculations for Alignment 3B

Alignment 3B										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	3.01	0.14	N/A	0.24	N/A	0.24	1156.80
2	5,280	Canal	1156.80	3.01	0.14	N/A	0.33	N/A	0.33	1156.47
3	17,160	Canal	1156.47	3.01	0.14	N/A	1.07	N/A	1.07	1155.40
4	2,600	Canal	1155.40	3.01	0.14	N/A	0.16	N/A	0.16	1155.24
5	400	Canal	1155.24	3.01	0.14	N/A	0.02	N/A	0.03	1155.21
Exit Structure	30	Transition	1155.21	3.01	0.14	0.14	N/A	N/A	0.14	1155.07

Table D-8
Hydraulic Loss Calculations for Alignment 4A

Alignment 4A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	2.42	0.09	N/A	0.13	N/A	0.13	1156.91
2	2,000	Canal	1156.91	2.42	0.09	N/A	0.07	N/A	0.07	1156.84
3	5,280	Box Conduit	1156.84	3.06	0.15	0.04	0.71	0.07	0.83	1156.01
4	2,600	Canal	1156.01	2.42	0.09	N/A	0.13	N/A	0.13	1155.88
5	17,160	Canal	1155.88	2.42	0.09	N/A	0.51	N/A	0.51	1155.37
6	2,600	Canal	1155.37	2.42	0.09	N/A	0.09	N/A	0.09	1155.28
7	400	Canal	1155.28	2.42	0.09	N/A	0.01	N/A	0.01	1155.26
Exit Structure	30	Transition	1155.26	2.42	0.09	0.09	N/A	N/A	0.09	1155.17

Table D-9
Hydraulic Loss Calculations for Alignment 4B

Alignment 4B										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	2.85	0.13	N/A	0.20	N/A	0.20	1156.84
2	2,000	Canal	1156.84	2.85	0.13	N/A	0.11	N/A	0.11	1156.73
3	5,280	Canal	1156.73	2.85	0.13	N/A	0.28	N/A	0.28	1156.44
4	2,600	Canal	1156.44	2.85	0.13	N/A	0.14	N/A	0.14	1156.30
5	17,160	Canal	1156.30	2.85	0.13	N/A	0.92	N/A	0.92	1155.38
6	2,600	Canal	1155.38	2.85	0.13	N/A	0.14	N/A	0.14	1155.24
7	400	Canal	1155.24	2.85	0.13	N/A	0.02	N/A	0.02	1155.22
Exit Structure	30	Transition	1155.22	2.85	0.13	0.13	N/A	N/A	0.13	1155.10

Table D-10
Hydraulic Loss Calculations for Alignment 5A

Alignment 5A											
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Slope (ft/ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	N/A	0.02	0.25	0.46	1157.04
1	3,200	Canal	1157.04	2.69	0.11	N/A	0.000046	0.18	N/A	0.18	1156.86
2	2,600	Canal	1156.86	2.69	0.11	N/A	0.000046	0.23	N/A	0.23	1156.63
3	5,680	Canal	1156.63	2.69	0.11	N/A	0.000046	0.26	N/A	0.26	1156.37
4	5,280	Canal	1156.37	2.69	0.11	N/A	0.000046	0.25	N/A	0.25	1156.12
5	17,160	Canal	1156.12	2.69	0.11	N/A	0.000046	0.80	N/A	0.80	1155.32
6	2,640	Canal	1155.32	2.69	0.11	N/A	0.000046	0.12	N/A	0.12	1155.20
7	400	Canal	1155.20	2.69	0.11	N/A	0.000046	0.02	N/A	0.02	1155.18
Exit Structure	30	Transition	1155.18	2.69	0.11	0.11	N/A	N/A	N/A	0.11	1155.07

Table D-11
Hydraulic Loss Calculations for Alignment 6A

Alignment 6A											
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Slope (ft/ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	N/A	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	1.82	0.05	N/A	0.000016	0.06	N/A	0.06	1156.98
2	1,200	Pipeline	1156.98	4.52	0.32	0.13	N/A	0.39	0.22	0.74	1156.24
3	22,800	Canal	1156.24	1.82	0.05	N/A	0.000016	0.37	N/A	0.37	1155.86
4	1,200	Pipeline	1155.86	4.52	0.32	0.13	N/A	0.39	0.22	0.74	1155.13
5	2,640	Canal	1155.13	1.82	0.05	N/A	0.000016	0.04	N/A	0.04	1155.08
6	400	Canal	1155.08	1.82	0.05	N/A	0.000016	0.01	N/A	0.01	1155.08
Exit Structure	30	Transition	1155.08	1.82	0.05	0.05	N/A	N/A	N/A	0.05	1155.02

Table D-12
Hydraulic Loss Calculations for Alignment 7A

Alignment 7A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,000	Canal	1157.04	2.69	0.11	N/A	0.18	N/A	0.18	1156.86
2	5,280	Box Conduit	1156.86	3.06	0.15	0.04	0.71	0.07	0.83	1156.04
3	17,160	Canal	1156.04	2.69	0.11	N/A	0.80	N/A	0.80	1155.24
4	400	Canal	1155.24	2.69	0.11	N/A	0.02	N/A	0.02	1155.22
Exit Structure	30	Transition	1155.22	2.69	0.11	0.11	N/A	N/A	0.11	1155.11

Table D-13
Hydraulic Loss Calculations for Alignment 7B

Alignment 7B										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,000	Canal	1157.04	3.01	0.14	N/A	0.24	N/A	0.24	1156.80
2	5,280	Canal	1156.80	3.01	0.14	N/A	0.33	N/A	0.33	1156.47
3	17,160	Canal	1156.47	3.01	0.14	N/A	1.07	N/A	1.07	1155.40
4	400	Canal	1155.40	3.01	0.14	N/A	0.02	N/A	0.03	1155.38
Exit Structure	30	Transition	1155.38	3.01	0.14	0.14	N/A	N/A	0.14	1155.24

Table D-14
Hydraulic Loss Calculations for Alignment 8A

Alignment 8A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	1,000	Canal	1157.04	2.85	0.13	N/A	0.05	N/A	0.05	1156.99
2	3,000	Canal	1156.99	2.85	0.13	N/A	0.16	N/A	0.16	1156.82
3	5,280	Canal	1156.82	2.85	0.13	N/A	0.28	N/A	0.28	1156.54
4	2,640	Canal	1156.54	2.85	0.13	N/A	0.14	N/A	0.14	1156.40
5	17,160	Canal	1156.40	2.85	0.13	N/A	0.92	N/A	0.92	1155.48
6	2,600	Canal	1155.48	2.85	0.13	N/A	0.14	N/A	0.14	1155.34
7	400	Canal	1155.34	2.85	0.13	N/A	0.02	N/A	0.02	1155.32
Exit Structure	30	Transition	1155.32	2.85	0.13	0.13	N/A	N/A	0.13	1155.19

Table D-15
Hydraulic Loss Calculations for Alignment 9A

Alignment 9A										
Reach	Length (ft)	Facility Type	Initial HGL (ft)	Velocity (fps)	Velocity Head (ft)	Entrance Loss (ft)	Friction Loss (ft)	Exit Loss (ft)	Total Energy Loss (ft)	Final HGL (ft)
Turnout Structure	10	Transition	1157.50	3.99	0.25	0.19	0.02	0.25	0.46	1157.04
1	3,800	Canal	1157.04	2.69	0.11	N/A	0.18	N/A	0.18	1156.86
2	2,200	Canal	1156.86	2.69	0.11	N/A	0.10	N/A	0.10	1156.76
3	5,680	Canal	1156.76	2.69	0.11	N/A	0.26	N/A	0.26	1156.50
4	5,280	Canal	1156.50	2.69	0.11	N/A	0.25	N/A	0.25	1156.25
5	17,160	Canal	1156.25	2.69	0.11	N/A	0.80	N/A	0.80	1155.45
6	2,640	Canal	1155.45	2.69	0.11	N/A	0.12	N/A	0.12	1155.33
7	400	Canal	1155.33	2.69	0.11	N/A	0.02	N/A	0.02	1155.31
Exit Structure	30	Transition	1155.31	2.69	0.11	0.11	N/A	N/A	0.11	1155.20

Attachment E

Detailed Capital Cost Estimates for Alternative Inlet Canal Alignments

DETAILED CAPITAL COST ESTIMATES FOR ALTERNATIVE INLET CANAL ALIGNMENTS

This attachment includes copies of the spreadsheets that were used to calculate detailed cost estimates for each of the alternatives. The detailed cost estimates were generated by multiplying unit price estimates by facility quantity estimates.

Unit Price Estimates

The unit prices were developed from previous Reclamation construction projects with similar work. These unit prices were indexed up to current prices. The Bureau of Reclamation cost estimating manual, which includes curves for pricing earthwork for dams and canals, and concrete lining, was also used. The RSMeans cost estimating handbook was also utilized. The cost of geomembrane and gravel surfacing was obtained by contacting suppliers and obtaining quotes.

Quantity Estimates

The inlet and outlet canal quantities were based on takeoffs from the alignment layouts which were overlayed on USGS 7.5 minute quadrangle maps. Descriptions of the individual alignments and proposed facility types are provided in Attachment B.

Canal quantities consisted of excavation, canal embankment, and 3.5 inch thick unreinforced concrete lining with a 60 mil HDPE geomembrane underlayment. Unit concrete lining and geomembrane texture quantities were calculated for each alignment alternative based on proposed canal geometry and size information. The length or quantity of pipeline and concrete box conduit materials were derived from the alignment layouts. For the concrete box conduits, a preliminary design was prepared for each conduit. This was then used to estimate the quantities of concrete and steel reinforcement needed. This information was used to estimate the per lineal foot cost of the materials, forming, and placement of the concrete box conduit. For both the pipeline and the box conduits, estimates of the required trench excavating backfill and compaction were also calculated for each size facility in order to develop estimates of the respective installation costs. Shown below are the detailed cost estimates for each alignment. The below correspond to the different alternatives, as follows:

Table E-1
Preliminary Estimate of Most Probable Capital Costs

Cost Factor	Alternative Alignment	1A	1B	2A	2B	3A	3B	4A	4B	5A	6A	7A	7B	8A	9A
	Total Length (feet)	29,240	29,240	29,390	29,390	29,240	29,240	33,840	33,840	36,960	32,040	25,840	25,840	32,080	37,160
	Number of Reaches	5	5	6	6	5	5	7	7	7	6	4	4	7	7
	Facility Types	Canal / Box Conduit	Canal	Canal / Box Conduit	Canal	Canal / Box Conduit	Canal	Canal / Box Conduit	Canal	Canal	Canal / Pipeline	Canal / Box Conduit	Canal	Canal	Canal
Contract Costs	Estimate Basis	1A	1B	2A	2B	3A	3B	4A	4B	5A	6A	7A	7B	8A	9A
Construction of Conveyance Facility	Estimated	$47,277,729	$10,834,973	$47,183,010	$11,327,479	$47,120,769	$10,808,348	$50,792,315	$13,110,177	$15,118,357	$53,110,194	$46,135,747	$10,113,464	$12,535.000	14,820,117
Mobilization	5.00%	$2,363,886	$541,749	$2,359,151	$566,374	$2,356,038	$540,417	$2,539,616	$655,509	$755,918	$2,655,510	$2,306,787	$505,673	$626,774	$741,006
Allowance for Unlisted Items	15.00%	$7,091,659	$1,625,246	$7,077,452	$1,699,122	$7,068,115	$1,621,252	$7,618,847	$1,966,527	$2,267,754	$7,966,529	$6,920,362	$1,517,020	$1,880,322	$2,223,018
Contingency Allowance	25.00%	$11,819,432	$2,708,743	$11,795,753	$2,831,870	$11,780,192	$2,702,087	$12,698,079	$3,277,544	$3,779,589	$13,277,549	$11,533,937	$2,528,366	$3,133,870	$3,705,029
Subtotal	NA	$68,552,707	$15,710,711	$68,415,365	$16,424,845	$68,325,115	$15,672,105	$73,648,857	$19,009,757	$21,921,618	$77,009,781	$66,896,833	$14,664,523	$18,176,446	$21,489,170
Noncontract Costs															
Design, C.M., Administration, etc.	20.00%	$13,710,541	$ 3,142,142	$ 13,683,073	$ 3,284,969	$ 13,665,023	$ 3,134,421	$ 14,729,771	$ 3,801,951	$ 4,384,324	$ 15,401,956	$ 13,379,367	$ 2,932,905	$ 3,635,289	$ 4,297,834
ROW and Land Acquisition	Estimated	$424,242	$16,336,364	$424,242	$16,336,364	$1,212,121	$2,424,242	$606,061	$303,030	$0	$0	$303,030	$606,061	$2,607,897	$0
Environmental Mitigation	Estimated	$176,309	$176,309	$649,036	$649,036	$649,036	$649,036	$1,205,344	$1,205,344	$1,088,705	$104,683	$3,720,000	$3,720,000	$1,267,273	$1,971,570
Contingency Allowance	25.00%	$150,138	$4,128,168	$268,320	$4,246,350	$465,289	$768,320	$452,851	$377,094	$272,176	$26,171	$1,005,758	$1,081,515	$968,793	$492,893
Subtotal	NA	$14,461,230	$23,782,983	$15,024,670	$24,516,719	$15,991,469	$6,976,018	$16,994,028	$5,687,419	$5,745,205	$15,532,810	$18,408,154	$8,340,481	$8,479,252	$6,762,296
Total Capital Cost Estimate		$83,013,937	$39,493,694	$83,440,035	$40,941,563	$84,316,584	$22,648,123	$90,642,884	$24,697,175	$27,666,822	$92,542,591	$85,304,987	$23,005,004	$26,655,698	$28,251,466

Worksheet E-2
Unit Estimate Form

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Facility Construction Cost Estimate for Drop 2 Inlet Conveyance System, **Unit Estimate Form**	**PROJECT:** Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation
	REGION: **PRICE LEVEL:** Appraisal
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 22, 000 ft)					
		Excavation			cyd	$5.00	$0
		Backfill			cyd	$3.00	$0
		Unreinforced concrete lining (3-inches)			cyd	$230.00	$0
		Geomembrane HDPE 60 mil texture			syd	$5.90	$0
		Concrete Box Conduit (box conduit = 5,280 ft)					
		Structural excavation			cyd	$5.00	$0
		Structural backfill			cyd	$12.00	$0
		Concrete			cyd	$600.00	$0
		Reinforcement			lbs	$1.10	$0
		Steel Pipelines (Pipeline = 1,200 ft)					
		Excavation for pipe trench (5-ft of cover)			cyd	$5.00	$0
		Compacting backfill for pipe trench, 90% compaction			cyd	$12.00	$0
		Concrete			cyd	$600.00	$0
		Soil cement for pipe trench			cyd	$35.00	$0
		Reinforcement			lbs	$1.10	$0
		Tunnel #1, #2, and #3, 15-ft diameter, 500 ft each			lf	$4,500.00	$0
		180" steel carrier/casing pipe (t = 5/16")			lf	$2,000.00	$0
		156" steel conveyance pipe (t = 5/16")			lf	$1,800.00	$0
		Transition Structures (2 structures)					
		Structural excavation			cyd	$5.00	$0
		Structural backfill			cyd	$12.00	$0
		Concrete			cyd	$600.00	$0
		Reinforcement			lbs	$1.10	$0
		Subtotal					**$0**
		Mobilization	**5.00%**				$0
		Subtotal					**$0**
		Unlisted Items	**15.00%**				$0
		Contract Cost					**$0**
		Contingencies	**20.00%**				$0
		Total					**$0**
		Non-Contract Cost					
		Total Construction Costs					**$0**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-3
Alignment 1A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 1A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 23, 960 ft)					
		Excavation		701,347	cyd	$5.00	$3,506,735
		Backfill		1,360,231	cyd	$3.00	$4,080,693
		Unreinforced concrete lining (3-inches)		21,804	cyd	$230.00	$5,014,828
		Geomembrane HDPE 60 mil texture		173,710	syd	$5.90	$1,024,889
		Concrete Box Conduit (box conduit = 5,280 ft)					
		Structural excavation		459,555	cyd	$5.00	$2,297,775
		Structural backfill		303,306	cyd	$12.00	$3,639,672
		Concrete		34,261	cyd	$600.00	$20,556,600
		Reinforcement		4,522,452	lbs	$1.10	$4,974,697
		Transition Structures (2 structures)					
		Structural excavation		52,320	cyd	$8.00	$418,560
		Structural backfill		37,600	cyd	$12.00	$451,200
		Concrete		1,760	cyd	$600.00	$1,056,000
		Reinforcement		232,800	lbs	$1.10	$256,080
		Subtotal					**$47,277,729**
		Mobilization	**5.00%**				$2,363,886
		Subtotal					**$49,641,615**
		Unlisted Items	**15.00%**				$7,091,659
		Contract Cost					**$56,733,275**
		Contingencies	**20.00%**				$11,346,655
		Total					**$68,079,930**
		Non-Contract Cost					
		Total Construction Costs					**$68,079,930**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-4
Alignment 1B

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Facility Construction Cost Estimate for Drop 2 Inlet Conveyance System, **Alignment 1B**	**PROJECT:** Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation
	REGION: **PRICE LEVEL:** Appraisal
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 29, 240 ft)					
		Excavation		142,741	cyd	$5.00	$713,705
		Backfill		1,209,460	cyd	$3.00	$3,628,380
		Unreinforced concrete lining (3-inches)		23,392	cyd	$230.00	$5,380,160
		Geomembrane HDPE 60 mil texture		188,598	syd	$5.90	$1,112,728
		Subtotal					**$10,834,973**
		Mobilization	**5.00%**				$541,749
		Subtotal					**$11,376,722**
		Unlisted Items	**15.00%**				$1,625,246
		Contract Cost					**$13,001,968**
		Contingencies	**20.00%**				$2,600,394
		Total					**$15,602,361**
		Non-Contract Cost					
		Total Construction Costs					**$15,602,361**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-5
Alignment 2A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 2A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 24, 110 ft)					
		Excavation		705,531	cyd	$5.00	$3,527,655
		Backfill		1,361,401	cyd	$3.00	$4,084,203
		Unreinforced concrete lining (3-inches)		21,940	cyd	$230.00	$5,046,223
		Geomembrane HDPE 60 mil texture		174,798	syd	$5.90	$1,031,305
		Concrete Box Conduit (box conduit = 5,280 ft)					
		Structural excavation		459,555	cyd	$5.00	$2,297,775
		Structural backfill		303,306	cyd	$12.00	$3,639,672
		Concrete		34,261	cyd	$600.00	$20,556,600
		Reinforcement		4,522,452	lbs	$1.10	$4,974,697
		Transition Structures (2 structures)					
		Structural excavation		52,320	cyd	$5.00	$261,600
		Structural backfill		37,600	cyd	$12.00	$451,200
		Concrete		1,760	cyd	$600.00	$1,056,000
		Reinforcement		232,800	lbs	$1.10	$256,080
		Subtotal					**$47,183,010**
		Mobilization	**5.00%**				$2,359,151
		Subtotal					**$49,542,161**
		Unlisted Items	**15.00%**				$7,077,452
		Contract Cost					**$56,619,613**
		Contingencies	**20.00%**				$11,323,923
		Total					**$67,943,535**
		Non-Contract Cost					
		Total Construction Costs					**$67,943,535**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-6
Alignment 2B

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 2B

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: | **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 29, 390 ft)					
		Excavation		234,007	cyd	$5.00	$1,170,035
		Backfill		1,210,416	cyd	$3.00	$3,631,248
		Unreinforced concrete lining (3-inches)		23,512	cyd	$230.00	$5,407,760
		Geomembrane HDPE 60 mil texture		189,566	syd	$5.90	$1,118,436
		Subtotal					**$11,327,479**
		Mobilization	**5.00%**				$566,374
		Subtotal					**$11,893,853**
		Unlisted Items	**15.00%**				$1,699,122
		Contract Cost					**$13,592,975**
		Contingencies	**20.00%**				$2,718,595
		Total					**$16,311,570**
		Non-Contract Cost					
		Total Construction Costs					**$16,311,570**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-7
Alignment 3A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 3A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 23, 960 ft)					
		Excavation		701,347	cyd	$5.00	$3,506,735
		Backfill		1,360,231	cyd	$3.00	$4,080,693
		Unreinforced concrete lining (3-inches)		21,804	cyd	$230.00	$5,014,828
		Geomembrane HDPE 60 mil texture		173,710	syd	$5.90	$1,024,889
		Concrete Box Conduit (box conduit = 5,280 ft)					
		Structural excavation		459,555	cyd	$5.00	$2,297,775
		Structural backfill		303,306	cyd	$12.00	$3,639,672
		Concrete		34,261	cyd	$600.00	$20,556,600
		Reinforcement		4,522,452	lbs	$1.10	$4,974,697
		Transition Structures (2 structures)					
		Structural excavation		52,320	cyd	$5.00	$261,600
		Structural backfill		37,600	cyd	$12.00	$451,200
		Concrete		1,760	cyd	$600.00	$1,056,000
		Reinforcement		232,800	lbs	$1.10	$256,080
		Subtotal					**$47,120,769**
		Mobilization	**5.00%**				$2,356,038
		Subtotal					**$49,476,808**
		Unlisted Items	**15.00%**				$7,068,115
		Contract Cost					**$56,544,923**
		Contingencies	**20.00%**				$11,308,985
		Total					**$67,853,908**
		Non-Contract Cost					
		Total Construction Costs					**$67,853,908**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-8
Alignment 3B

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 3B

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 29, 240 ft)					
		Excavation		137,416	cyd	$5.00	$687,080
		Backfill		1,209,460	cyd	$3.00	$3,628,380
		Unreinforced concrete lining (3-inches)		23,392	cyd	$230.00	$5,380,160
		Geomembrane HDPE 60 mil texture		188,598	syd	$5.90	$1,112,728
		Subtotal					**$10,808,348**
		Mobilization	**5.00%**				$540,417
		Subtotal					**$11,348,766**
		Unlisted Items	**15.00%**				$1,621,252
		Contract Cost					**$12,970,018**
		Contingencies	**20.00%**				$2,594,004
		Total					**$15,564,021**
		Non-Contract Cost					
		Total Construction Costs					**$15,564,021**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-9
Alignment 4A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 4A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 28, 560 ft)					
		Excavation		695,350	cyd	$5.00	$3,476,750
		Backfill		1,533,053	cyd	$3.00	$4,599,159
		Unreinforced concrete lining (3-inches)		25,133	cyd	$230.00	$5,780,544
		Geomembrane HDPE 60 mil texture		201,919	syd	$5.90	$1,191,323
		Concrete Box Conduit (box conduit = 5,280 ft)					
		Structural excavation		503,066	cyd	$5.00	$2,515,330
		Structural backfill		327,066	cyd	$12.00	$3,924,792
		Concrete		36,607	cyd	$600.00	$21,964,200
		Reinforcement		4,832,124	lbs	$1.10	$5,315,336
		Transition Structures (2 structures)					
		Structural excavation		52,320	cyd	$5.00	$261,600
		Structural backfill		37,600	cyd	$12.00	$451,200
		Concrete		1,760	cyd	$600.00	$1,056,000
		Reinforcement		232,800	lbs	$1.10	$256,080
		Subtotal					**$50,792,315**
		Mobilization	**5.00%**				$2,539,616
		Subtotal					**$53,331,930**
		Unlisted Items	**15.00%**				$7,618,847
		Contract Cost					**$60,950,778**
		Contingencies	**20.00%**				$12,190,156
		Total					**$73,140,933**
		Non-Contract Cost					
		Total Construction Costs					**$73,140,933**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-10
Alignment 4B

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Facility Construction Cost Estimate for Drop 2 Inlet Conveyance System, **Alignment 4B**	**PROJECT:** Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation
	REGION: **PRICE LEVEL:** Appraisal
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 33, 840 ft)					
		Excavation		279,713	cyd	$5.00	$1,398,565
		Backfill		1,339,216	cyd	$3.00	$4,017,648
		Unreinforced concrete lining (3-inches)		27,749	cyd	$230.00	$6,382,224
		Geomembrane HDPE 60 mil texture		222,329	syd	$5.90	$1,311,740
		Subtotal					**$13,110,177**
		Mobilization	**5.00%**				$655,509
		Subtotal					**$13,765,686**
		Unlisted Items	**15.00%**				$1,966,527
		Contract Cost					**$15,732,212**
		Contingencies	**20.00%**				$3,146,442
		Total					**$18,878,655**
		Non-Contract Cost					
		Total Construction Costs					**$18,878,655**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-11
Alignment 5A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 5A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: | **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 36, 960 ft)					
		Excavation		437,227	cyd	$5.00	$2,186,135
		Backfill		1,443,507	cyd	$3.00	$4,330,521
		Unreinforced concrete lining (3-inches)		31,046	cyd	$230.00	$7,140,672
		Geomembrane HDPE 60 mil texture		247,632	syd	$5.90	$1,461,029
		Subtotal					**$15,118,357**
		Mobilization	**5.00%**				$755,918
		Subtotal					**$15,874,275**
		Unlisted Items	**15.00%**				$2,267,754
		Contract Cost					**$18,142,028**
		Contingencies	**20.00%**				$3,628,406
		Total					**$21,770,434**
		Non-Contract Cost					
		Total Construction Costs					**$21,770,434**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-12
Alignment 6A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 6A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 29, 640 ft)					
		Excavation		471,387	cyd	$5.00	$2,356,935
		Backfill		1,528,667	cyd	$3.00	$4,586,001
		Unreinforced concrete lining (3-inches)		29,936	cyd	$230.00	$6,885,372
		Geomembrane HDPE 60 mil texture		238,009	syd	$5.90	$1,404,254
		Steel Pipelines (Pipeline = 1,200 ft)					
		Excavation for pipe trench (5-ft of cover)		95,024	cyd	$5.00	$475,120
		Compacting backfill for pipe trench		74,396	cyd	$12.00	$892,752
		Tunnel #1, #2, #3, #4 #5 and #6, 15-ft diameter, 500 ft each		3,000	lf	$4,500.00	$13,500,000
		180" steel carrier/casing pipe (t = 5/16")		3,000	lf	$2,000.00	$6,000,000
		156" steel conveyance pipe (t = 5/16")		7,200	lf	$1,800.00	$12,960,000
		Transition Structures (4 structures)					
		Structural excavation		104,640	cyd	$5.00	$523,200
		Structural backfill		75,200	cyd	$12.00	$902,400
		Concrete		3,520	cyd	$600.00	$2,112,000
		Reinforcement		465,600	lbs	$1.10	$512,160
		Subtotal					**$53,110,194**
		Mobilization	**5.00%**				$2,655,510
		Subtotal					**$55,765,704**
		Unlisted Items	**15.00%**				$7,966,529
		Contract Cost					**$63,732,233**
		Contingencies	**20.00%**				$12,746,447
		Total					**$76,478,680**
		Non-Contract Cost					
		Total Construction Costs					**$76,478,680**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-13
Alignment 7A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 7A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 21, 360 ft)					
		Excavation		630,518	cyd	$5.00	$3,152,590
		Backfill		754,575	cyd	$3.00	$2,263,725
		Unreinforced concrete lining (3-inches)		17,942	cyd	$230.00	$4,126,752
		Geomembrane HDPE 60 mil texture		143,753	syd	$5.90	$848,142
		Concrete Box Conduit (box conduit = 5,280 ft)					
		Structural excavation		503,066	cyd	$5.00	$2,515,330
		Structural backfill		327,066	cyd	$12.00	$3,924,792
		Concrete		36,607	cyd	$600.00	$21,964,200
		Reinforcement		4,832,124	lbs	$1.10	$5,315,336
		Transition Structures (2 structures)					
		Structural excavation		52,320	cyd	$5.00	$261,600
		Structural backfill		37,600	cyd	$12.00	$451,200
		Concrete		1,760	cyd	$600.00	$1,056,000
		Reinforcement		232,800	lbs	$1.10	$256,080
		Subtotal					**$46,135,747**
		Mobilization	**5.00%**				$2,306,787
		Subtotal					**$48,442,534**
		Unlisted Items	**15.00%**				$6,920,362
		Contract Cost					**$55,362,896**
		Contingencies	**20.00%**				$11,072,579
		Total					**$66,435,476**
		Non-Contract Cost					
		Total Construction Costs					**$66,435,476**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-14
Alignment 7B

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Facility Construction Cost Estimate for Drop 2 Inlet Conveyance System, **Alignment 7B**	**PROJECT:** Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation
	REGION: **PRICE LEVEL:** Appraisal
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 26, 640 ft)					
		Excavation		290,783	cyd	$5.00	$1,453,915
		Backfill		914,668	cyd	$3.00	$2,744,004
		Unreinforced concrete lining (3-inches)		21,312	cyd	$230.00	$4,901,760
		Geomembrane HDPE 60 mil texture		171,828	syd	$5.90	$1,013,785
		Subtotal					**$10,113,464**
		Mobilization	**5.00%**				$505,673
		Subtotal					**$10,619,137**
		Unlisted Items	**15.00%**				$1,517,020
		Contract Cost					**$12,136,157**
		Contingencies	**20.00%**				$2,427,231
		Total					**$14,563,388**
		Non-Contract Cost					
		Total Construction Costs					**$14,563,388**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-15
Alignment 8A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
Facility Construction Cost Estimate for
Drop 2 Inlet Conveyance System,
Alignment 8A

PROJECT:
Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation

REGION: **PRICE LEVEL:** Appraisal

FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 32, 080 ft)					
		Excavation		309,534	cyd	$5.00	$1,547,670
		Backfill		1,231,335	cyd	$3.00	$3,694,005
		Unreinforced concrete lining (3-inches)		26,306	cyd	$230.00	$6,050,288
		Geomembrane HDPE 60 mil texture		210,766	syd	$5.90	$1,243,517
		Subtotal					**$12,535,480**
		Mobilization	**5.00%**				$626,774
		Subtotal					**$13,162,254**
		Unlisted Items	**15.00%**				$1,880,322
		Contract Cost					**$15,042,576**
		Contingencies	**20.00%**				$3,008,515
		Total					**$18,051,091**
		Non-Contract Cost					
		Total Construction Costs					**$18,051,091**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Worksheet E-16
Alignment 9A

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: Facility Construction Cost Estimate for Drop 2 Inlet Conveyance System, **Alignment 9A**	**PROJECT:** Drop 2 Reservoir Inlet Canal/Pipeline Alignment Evaluation
	REGION: **PRICE LEVEL:** Appraisal
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION Calculation Info	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Inlet Canal (Inlet canal = 37, 160 ft)					
		Excavation		390,390	cyd	$5.00	$1,951,950
		Backfill		1,406,640	cyd	$3.00	$4,219,920
		Unreinforced concrete lining (3-inches)		31,214	cyd	$230.00	$7,179,312
		Geomembrane HDPE 60 mil texture		248,972	syd	$5.90	$1,468,935
		Subtotal					**$14,820,117**
		Mobilization	**5.00%**				$741,006
		Subtotal					**$15,561,123**
		Unlisted Items	**15.00%**				$2,223,018
		Contract Cost					**$17,784,140**
		Contingencies	**20.00%**				$3,556,828
		Total					**$21,340,968**
		Non-Contract Cost					
		Total Construction Costs					**$21,340,968**

QUANTITIES			PRICES	
BY	N. Boswell / S. Sen	CHECKED	BY	CHECKED
DATE PREPARED	May 4, 2005	PEER REVIEW	DATE PREPARED	PEER REVIEW

Attachment F

Earthwork Calculations

Earthwork Calculations

This attachment includes copies of the spreadsheets that were used to calculate the earthwork quantities for each of the alternatives. Each of the alternative alignments and respective facilities were laid out on USGS 7.5 quadrangle minute maps. Descriptions of the individual alignments and proposed facility types are provided in Attachment B.

Takeoffs of the cut and fill were then calculated from cross sections drawn of the inlet canal (or pipeline) alignments at 5,000 foot intervals. The following information was collected at 5,000 foot increments:

- canal geometry/size
- canal invert elevation,
- existing ground surface elevation

The calculation of the earthwork quantities was simplified with the use of an MS Excel spreadsheet. The information noted above was inputted into the spreadsheet model. The spreadsheet was used to calculate the cut and fill volumes for each pair of adjoining stations. These values were then averaged and multiplied by the distance between the two stations to estimate the total cut and fill volumes for the respective segment. The values for all of the segments within each alternative were then totaled to estimate the cut and fill volume for that respective alternative alignment.

The output from the spreadsheet used to calculate the earthwork quantities for each alternative is included in the following pages. The tables correspond to the different alternatives, as follows:

Table F-1
Earthwork Calculations for Alternative 1A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 1A	1	3,800	Canal	b = 20.0, h=15.4	3,800	1155.00	1141.64	-59,641	87,847	-1,360,231	701,347
	2	5,280	Box Conduit	b = 13, h=13	5,280	1155.00	N/A	-303,306	459,555		
	3	17,160	Canal	b = 20.0, h=15.4	5,280	1150.00	1140.31	-161,112	74,616		
					5,280	1145.00	1140.31	-301,603	26,942		
					5,280	1145.00	1140.31	-301,603	26,942		
	4	2,600	Canal	b = 20.0, h=15.4	3,920	1145.00	1139.78	-211,566	23,046		
	5	400	Canal	b = 20.0, h=15.4	400	1145.00	1139.70	-21,400	2,400		

Table F-2
Earthwork Calculations for Alternative 1B

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 1B	1	3,800	Canal	b = 17.5, h=13.5	3,800	1155.00	1143.54	-59,641	65,193	-1,209,460	142,741
	2	5,280	Canal	b = 17.5, h=13.5	5,280	1155.00	1143.30	-78,537	5,280		
	3	17,160	Canal	b = 17.5, h=13.5	5,280	1150.00	1142.97	-180,007	43,361		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.97	-326,463	8,544		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.97	-326,463	8,544		
	4	2,600	Canal	b = 17.5, h=13.5	3,920	1145.00	1141.90	-216,631	10,660		
	5	400	Canal	b = 17.5, h=13.5	400	1145.00	1141.74	-21,719	1,160		

Table F-3
Earthwork Calculations for Alternative 2A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 2A	1	3,800	Canal	b = 20.0, h=15.4	3,800	1155.00	1141.64	-59,641	87,847	-1,361,401	705,531
	2	5,280	Box Conduit	b = 13, h=13	5,280	1155.00	N/A	-303,306	459,555		
	3	150	Canal	b = 20.0, h=15.4	150	1155.00	1140.31	-1,697	4,030		
	4	17,160	Canal	b = 20.0, h=15.4	5,280	1150.00	1140.31	-161,000	74,669		
					5,280	1145.00	1140.31	-301,455	26,977		
					5,280	1145.00	1140.31	-301,455	26,977		
	5	2,600	Canal	b = 20.0, h=15.4	3,920	1145.00	1139.78	-211,458	23,073		
	6	400	Canal	b = 20.0, h=15.4	400	1145.00	1139.70	-21,389	2,403		

Table F-4
Earthwork Calculations for Alternative 2B

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 2B	1	3,800	Canal	b = 17.5, h=13.5	3,800	1155.00	1143.54	-59,641	65,193	-1,210,416	234,007
	2	5,280	Canal	b = 17.5, h=13.5	5,280	1155.00	1143.30	-78,537	93,545		
	3	150	Canal	b = 17.5, h=13.5	150	1155.00	1142.97	-2,064	2,776		
	4	17,160	Canal	b = 17.5, h=13.5	5,280	1150.00	1142.96	-179,768	43,445		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.96	-326,150	8,591		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.96	-326,150	8,591		
	5	2,600	Canal	b = 17.5, h=13.5	3,920	1145.00	1141.89	-216,410	10,701		
	6	400	Canal	b = 17.5, h=13.5	400	1145.00	1141.73	-21,697	1,165		

Table F-5
Earthwork Calculations for Alternative 3A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 3A	1	3,800	Canal	b = 20.0, h=15.4	3,800	1155.00	1141.64	-59,641	87,847	-1,360,231	701,347
	2	5,280	Box Conduit	b = 13, h=13	5,280	1155.00	N/A	-303,306	459,555		
	3	17,160	Canal	b = 20.0, h=15.4	5,280	1150.00	1140.31	-161,112	74,616		
					5,280	1145.00	1140.31	-301,603	26,942		
					5,280	1145.00	1140.31	-301,603	26,942		
	4	2,600	Canal	b = 20.0, h=15.4	3,920	1145.00	1139.78	-211,566	23,046		
	5	400	Canal	b = 20.0, h=15.4	400	1145.00	1139.70	-21,400	2,400		

Table F-6
Earthwork Calculations for Alternative 3B

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 3B	1	3,800	Canal	b = 17.5, h=13.5	3,800	1155.00	1143.54	-59,641	65,193	-1,209,460	137,461
	2	5,280	Canal	b = 17.5, h=13.5	5,280	1155.00	1143.30	-78,537	0		
	3	17,160	Canal	b = 17.5, h=13.5	5,280	1150.00	1142.97	-180,007	43,361		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.97	-326,463	8,544		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.97	-326,463	8,544		
	4	2,600	Canal	b = 17.5, h=13.5	3,920	1145.00	1141.90	-216,631	10,660		
	5	400	Canal	b = 17.5, h=13.5	400	1145.00	1141.74	-21,719	1,160		

Table F-7
Earthwork Calculations for Alternative 4A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 4A	1	3,800	Canal	b = 18.0, h=13.8	3,800	1155.00	1143.24	-59,641	68,720	-1,533,053	695,350
	2	2,000	Canal	b = 18.0, h=13.8	2,000	1155.00	1143.04	-29,975	37,159		
	3	5,280	Box Conduit	b = 14.0, h=14.0	5,280	1155.00	N/A	-327,066	503,066		
	4	2,600	Canal	b = 18.0, h=13.8	3,730	1150.00	1142.10	-117,076	36,887		
	5	17,160	Canal	b = 18.0, h=13.8	4,840	1145.00	1142.10	-282,060	12,371		
			Canal	b = 18.0, h=13.8	4,840	1145.00	1142.10	-282,060	12,371		
			Canal	b = 18.0, h=13.8	4,840	1145.00	1141.90	-276,151	13,450		
	6	2,600	Canal	b = 18.0, h=13.8	2,640	1145.00	1141.12	-138,382	9,775		
	7	400	Canal	b = 18.0, h=13.8	400	1145.00	1140.98	-20,642	1,551		

Table F-8
Earthwork Calculations for Alternative 4B

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 4B	1	3,800	Canal	b = 18.0, h=13.8	3,800	1155.00	1143.24	-59,641	68,720	-1,339,216	279,713
	2	2,000	Canal	b = 18.0, h=13.8	2,000	1155.00	1143.04	-29,975	37,159		
	3	5,280	Canal	b = 18.0, h=13.8	5,280	1155.00	1142.93	-77,195	99,489		
	4	2,600	Canal	b = 18.0, h=13.8	3,730	1150.00	1142.64	-126,651	33,240		
	5	17,160	Canal	b = 18.0, h=13.8	4,840	1145.00	1142.44	-292,321	10,590		
			Canal	b = 18.0, h=13.8	4,840	1145.00	1142.44	-292,321	10,590		
			Canal	b = 18.0, h=13.8	4,840	1145.00	1142.44	-292,321	10,590		
	6	2,600	Canal	b = 18.0, h=13.8	2,640	1145.00	1141.66	-146,871	8,049		
	7	400	Canal	b = 18.0, h=13.8	400	1145.00	1141.52	-21,919	1,285		

Table F-9
Earthwork Calculations for Alternative 5A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 5A	1	3,200	Canal	b = 18.5, h=14.2	3,800	1155.00	1142.84	-59,641	73,282	-1,443,507	437,227
	2	2,600	Canal	b = 18.5, h=14.2	5,000	1155.00	1142.66	-75,414	98,631		
	3	5,680	Canal	b = 18.5, h=14.2	5,680	1150.00	1142.43	-197,982	53,560		
	4	5,280	Canal	b = 18.5, h=14.2	5,280	1155.00	1142.17	-70,815	110,834		
	5	17,160	Canal	b = 18.5, h=14.2	5,280	1150.00	1141.92	-171,193	54,747		
			Canal	b = 18.5, h=14.2	5,280	1145.00	1141.92	-314,902	14,841		
			Canal	b = 18.5, h=14.2	5,280	1145.00	1141.92	-314,902	14,841		
	6	2,640	Canal	b = 18.5, h=14.2	3,960	1145.00	1141.12	-217,027	14,920		
	7	400	Canal	b = 18.5, h=14.2	400	1145.00	1141.00	-21,631	1,569		

Table F-10
Earthwork Calculations for Alternative 6A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 6A	1	3,800	Canal	b = 22.5, h=17.3	3,800	1155.00	1139.74	-59,641	113,871	-1,528,667	471,387
	2	1,200	Pipeline	b = 17.5, h=13.5	1,200	N/A	N/A	-37,198	47,512		
	3	22,800	Canal	D = 13	5,280	1150.00	1138.94	-174,105	96,522		
			Canal	b = 22.5, h=17.3	5,280	1145.00	1138.94	-318,728	41,038		
			Canal	b = 22.5, h=17.3	5,280	1145.00	1138.94	-318,728	41,038		
			Canal	b = 22.5, h=17.3	6,960	1145.00	1138.94	-420,141	54,096		
	4	1,200	Pipeline	D = 13	1,200	N/A	N/A	-37,198	47,512		
	5	2,640	Canal	b = 22.5, h=17.3	2,640	1145.00	1137.83	-141,579	25,848		
	6	400	Canal	b = 22.5, h=17.3	400	1145.00	1137.78	-21,349	3,949		

Table F-11
Earthwork Calculations for Alternative 7A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 7A	1	3,800	Canal	b = 18.5, h=14.2	3,800	1155.00	1142.84	-59,641	73,282	-754,575	630,518
	2	5,280	Box Conduit	b = 14, h=14	5,280	1150.00	N/A	327,066	503,066		
	3	17,160	Canal	b = 18.5, h=14.2	5,280	1145.00	1141.74	-308,988	15,951		
			Canal	b = 18.5, h=14.2	5,280	1145.00	1141.74	-308,988	15,951		
			Canal	b = 18.5, h=14.2	5,280	1145.00	1141.74	-308,988	15,951		
	4	400	Canal	b = 18.5, h=14.2	1,720	1145.00	1141.20	-95,036	6,318		

Table F-12
Earthwork Calculations for Alternative 7B

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 7B	1	3,800	Canal	b = 17.5, h=13.5	3,800	1155.00	1143.54	-59,641	65,193	-914,668	290,783
	2	5,280	Canal	b = 17.5, h=13.5	5,280	1155.00	1143.30	-78,488	93,579		
	3	17,160	Canal	b = 17.5, h=13.5	5,280	1155.00	1142.44	-63,527	104,682		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.44	-308,988	11,324		
			Canal	b = 17.5, h=13.5	5,280	1145.00	1142.44	-308,988	11,324		
	4	400	Canal	b = 17.5, h=13.5	1,720	1145.00	1141.90	-95,036	4,680		

Table F-13
Earthwork Calculations for Alternative 8A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 8A	1	1,000	Canal	b = 18.0, h=13.8	1,000	1155.00	1143.24	-15,695	18,084	-1,231,335	309,534
	2	3,000	Canal	b = 18.0, h=13.8	3,000	1155.00	1143.04	-44,963	55,738		
	3	5,280	Canal	b = 18.0, h=13.8	5,280	1155.00	1142.93	-77,195	99,489		
	4	2,640	Canal	b = 18.0, h=13.8	2,640	1155.00	1142.64	-36,081	51,600		
	5	17,160	Canal	b = 18.0, h=13.8	5,280	1150.00	1142.50	-175,701	48,377		
			Canal	b = 18.0, h=13.8	5,280	1145.00	1142.50	-320,822	11,231		
			Canal	b = 18.0, h=13.8	5,280	1145.00	1142.50	-320,822	11,231		
	6	2,600	Canal	b = 18.0, h=13.8	3,960	1145.00	1141.58	-218,334	12,459		
	7	400	Canal	b = 18.0, h=13.8	400	1145.00	1141.44	-21,722	1,325		

Table F-14
Earthwork Calculations for Alternative 9A

	Reach	Reach Length (ft)	Facility Type	Facility Size (ft)	Segment Length (ft)	Ex Grade	Canal IE	Segment Fill Volume (cyd)	Segment Cut Volume (cyd)	Total Fill (cyd)	Total Cut Volume (cyd)
Alignment 9A	1	3,800	Canal	b = 18.5, h=14.2	3,800	1155.00	1142.84	-59,641	73,282	-1,406,640	390,390
	2	2,200	Canal	b = 18.5, h=14.2	2,200	1155.00	1142.66	-33,182	43,398		
	3	5,680	Canal	b = 18.5, h=14.2	5,680	1150.00	1142.43	-197,982	53,560		
	4	5,280	Canal	b = 18.5, h=14.2	5,680	1155.00	1142.17	-76,179	119,231		
	5	17,160	Canal	b = 18.5, h=14.2	5,280	1150.00	1141.92	-171,193	54,747		
			Canal	b = 18.5, h=14.2	5,280	1145.00	1141.92	-314,902	14,841		
			Canal	b = 18.5, h=14.2	5,280	1145.00	1141.92	-314,902	14,841		
	6	2,640	Canal	b = 18.5, h=14.2	3,960	1145.00	1141.12	-217,027	14,920		
	7	400	Canal	b = 18.5, h=14.2	400	1145.00	1141.00	-21,631	1,569		

Attachment G

Caltrans Encroachment Permit Manual
Section 623 – Requirements for Funneling

623 TRENCHLESS TECHNOLOGIES

Bore & Jack / Horizontal Directional Drilling / Micro-Tunneling / Pipe Ramming / Pipe Bursting

Permit Code UJ

The establishment of a "Survey Grid Line" is required on installations with diameters > 30", and may be required on installations with diameters < 30" if warranted. All transverse-crossings of State Highway right-of-way require encasement.

623.0 Introduction

Utility installations and service installations are not permitted within culverts or drainage structures within State highway right-of-way.

The installation of underground utilities within State highway right-of-way shall be performed by the use of a trenchless technology, in most cases. Open-cut installations will only be allowed as a last resort, by issuance of a "UT" permit. The requirement for encasement of utility installations is for the protection of the traveling public and to minimize the amount of disturbance to the structural integrity of the roadbed.

In specific cases encasement may cause a reduction in cathodic protection to the carrier pipe, which may result in corrosion to the pipeline. In these specific cases when authenticated and warranted, encasement of said facility may be waived. Encasement requirements are shown in Table 6.8.

Encasement may be required for longitudinal utility installations within city or county roadways that cross within State highway right-of-way.

623.1 Bore & Jack

Utility installations placed by the bore & jack method shall be monitored to ensure that the integrity of the existing roadway elevations are maintained.

Bore & Jack consists of cutting of the soil, generally 6" to 8" ahead of the pipe being jacked simultaneously, by an auger placed within the encasement. The encasement should generally support the integrity of the hole. When the encasement is also to serve as the carrier facility for hazardous materials, the use of another trenchless installation is recommended. Potential damage could occur during the jacking process, rendering the use of that facility as the carrier pipe useless.

Table 6.8
Encasement Considerations

Encasement Requirements based on:
Installation Method, Type of Highway Facility, and Material Transported in Carrier

	Bore and Jack		Directional Drilling		Trenching	
Facility Type	**Frwy/Expwy**	**Conventional**	**Frwy/Expwy**	**Conventional**	**Frwy/Expwy**	**Conventional**
High Risk (Section 605)	Encase	Encase	Encase	Encase	Encase	Encase
Low Risk (Section 605)	Encase	Encase	Encase	Encase	Encase	Optional
Exempt Facilities (Section 605)	Encase	Encase	Optional	Optional	Optional	Optional
Pressurized Fluids	Encase	Encase	Encase	Encase	Encase	Encase
Natural Gas Lines Minimum 7.5' Depth (Appendix H)	Optional	Optional	Optional	Optional	Optional	Optional
Gravity Flows	Encase	Encase	Encase	Encase	Optional	Optional

Note: "Optional" means at the option of the District Permit Engineer. **Transverse crossings require encasement.**

623.1A Encasements

Encasements that house carrier pipes under pressure shall be steel pipe with a minimum inside diameter sufficiently larger than the outside diameter of the pipe or duct to accommodate placement and removal and shall conform to Caltrans' Standard Specifications. The steel encasement can be either new or used, or of the approved connector system. Used steel casing shall be pre-approved by a Caltrans' representative prior installation.

When the method of Horizontal Directional Drilling is used to install the encasement, the use of High Density Polyethylene Pipe (HDPE) as the encasement is acceptable. In specific instances the approval of Headquarters Office of Encroachment Permits, may be required.

Reinforced Concrete Pipe (RCP) in compliance of State Standard Specifications is an acceptable carrier for storm drain gravity flow or non-pressure flow. RCP when installed by Bore & Jack shall have rubber gaskets at the joints, and holes for the grouting of voids left by jacking operations (see grouting requirements in # 4 below).

Encasement requirements:

1. All transverse crossings, single ducts or pipes 6" or greater (150 mm) in diameter shall be encased. Installation of multiple ducts or pipes, regardless of diameters, shall require encasement (for exceptions see Appendix H).

2. The minimum wall thickness required for steel encasements is based on lengths and diameters of pipes is shown in Table 6.9.

3. Encasement ends shall be plugged with un-grouted bricks or other suitable material approved by the Caltrans' representative.

4. The Caltrans' representative may require the permittee to pressure grout, filling any voids generated in the course of the permitted work. Grouting shall be at the expense of the permittee. Grout holes when placed inside the of the pipe, generally on diameters of 36" or greater, shall be on 8' (2.43 m) centers, longitudinally and offset 22 degrees from vertical, and staggered to the left and right of the top longitudinal axis of the pipe. Grout pressure shall not exceed five (5) psig (34.5 kPa) for a duration sufficient to fill all voids.

5. There is a spacing requirement when placement of multiple encasements is requested. The distance between multiple encasements shall be the greater of either 24" (610mm) or twice that of the diameter of the larger pipe being installed.

6. Wing cutters when used shall only add a maximum of 1" (25.4 mm) in diameter to the outside diameter of the encasement pipe. Voids in excess of the Standard Specifications shall be grouted.

7. A band welded to the leading edge of the encasement pipe should be placed square to the alignment and not on the bottom edge of pipe. A flared lead section on bores over 100' (30.48 m) shall not be permitted.

8. The length of the auger strand shall be equal to that of the section of encasement pipe.

9. Encasements placed within conventional highway right-of-way shall extend 5' (1.52 m) beyond the edge of the paved shoulder, back of curb, or to the highway right-of-way line.

10. Encasements placed across controlled access right-of-way shall extend to the highway right-of-way lines.

Table 6.9
Required Thickness for Steel Pipe Casings

Minimum Wall Thickness		
Casing Diameter	Up to 150' (45.7 m) Length	Over 150' (45.7 m) Length
6" to 28" (152 mm to 711 mm)	1/4" (6 mm)	1/4" (6 mm)
30" to 38" (762 mm to 965 mm)	3/8" (10 mm)	1/2" (13 mm)
40" to 60" (102 mm to 152 mm)	1/2" (13 mm)	3/4" (19 mm)
62" to 72" (1575 mm to 1829 mm)	3/4" (19 mm)	3/4" (19 mm)

623.1B Bore and Receiving Pits

Requirements:

1. Shall be located a minimum of 10' (3.04 m) from the edge of pavement in rural areas, or at least 5' (1.52 m) beyond the concrete curb and gutter or AC dike in urban areas, or at least 5' (1.52 m) beyond the toe of slope of embankments.

2. Shall be located outside of controlled access highway right-of-way. EXCEPT, when approved by the district for direct crossings that are excessively long, or there is restricted space available for placement, outside of the right-of-way. Those portions of the installation not placed by Bore & Jack shall be encased by the open trench method.

3. Protected by placement of 6' (1.82 m) chain link fence or Type-K barrier around them.

4. Shored in accordance to Cal-OSHA requirements. Shoring of pits located within 15' (4.57 m) of lanes within State highway right-of-way shall not extend more than 36" (914 mm) in height above the pavement grade, unless authorized by a Caltrans representative.

5. Reflectors shall be affixed to the shoring on all sides facing traffic.

6. Pits shall not affect any State facilities, or create a hazard to the traveling public. Damaged State facilities shall be replaced in-kind or repaired to their original state.

7. All pits should have crushed-rock and sump areas to clear groundwater and water used to clean the casings. Pits shall be lined with filter fabric when groundwater is found and pumping is required.

8. Temporary Type-K railing shall be placed at a 20:1 taper or as otherwise directed by the Caltrans' representative to maintain the integrity of the adjacent travel lane.

A tunnel is defined as any installation that is 30" (762 mm) or larger in diameter (see Section 518, and Table 5.24 - Permit Code TN).

623.2 Horizontal Directional Drilling

Horizontal Directional Drilling is another trenchless method for the placement of encasement or carrier pipe under, across or within existing highway right-of-way.

623.2A BACKREAMER DETECTION

JANUARY 1, 2000, sonde detection on the backreamer is required. **(see Appendix "E".)**

623.2B Documentation of Projected Path

The permittee shall provide a copy of the bore-log showing horizontal and vertical alignment (depth). A bore-log shall be kept for both the pilot bore and the reaming process. These records shall be provided to the Department's representative daily. The bore-log shall depict a plan profile of the actual bore path.

623.2C Safety Requirements

All drilling units **should be equipped with** an electrical strike safety package. This package at minimal **should contain** a warning sound alarm and shall be tested upon setup of the job.

Protective safety gear IS REQUIRED for all members of the contractor's crew, (Die-Electric boots are required. At all HDD operation sites, Safety electric overshoes **shall** be worn by all member's of the crew and by the inspector, at all times.

623.2D Permit Application Submittal

All utilities that are installed by HDD shall provide "As-Builts" upon completion of the job.

The permit application package should contain the following information in support of the permit application; construction plan, site layout plan, project schedule, communication plan, safety procedures, emergency procedures, company experience record, contingency plan and a drilling fluid management plan in support of the permit application.

1. Location of entry and exit point.
2. Equipment and pipe layout areas.
3. Proposed drill path alignment (both plan & profile view).
4. Location, elevations and proposed clearances of all utility crossings and structures.
5. Proposed Depth of cover.

6. Soil analysis **.
7. Product material (HDPE/steel), length, diameter-wall thickness, reamer diameter.
8. Detailed pipe calculations, confirming ability of product pipe to withstand installation loads and long term operational loads including H20.
9. Proposed composition of drilling fluid (based on soil analysis) viscosity and density.
10. Drilling fluid pumping capacity, pressures, and flowrates proposed.
11. State right-of-way lines, property, and other utility right-of-way or easement lines.
12. Elevations.
13. Type of tracking method/system.
14. Survey Grid establishment for monitoring ground surface movement (settlement or heave) due to the drilling operation.

Note: ** *May be waived by the District Permit Engineer on HDD jobs of less than 200mm (6") in diameter and on a transverse crossing less than 150' in length.*

ALL ADDITIONAL PERMIT CONDITIONS SHALL BE SET FORTH IN THE SPECIAL PROVISIONS OF THE PERMIT.

The following, outlines recommended depths for various pipe diameters:

RECOMMENDED MINIMUM DEPTH OF COVER	
DIAMETER	**DEPTH OF COVER**
50mm (2 inches) to 150mm (6 inches)	1.2 meters (4 feet)
200mm (8 inches) to 350mm (14 inches)	1.8 meters (6 feet)
375mm (15 inches) to 600mm (24 inches)	3.0 meters (10 feet)
625mm (25 inches) to 1200mm (48 inches)	4.5 meters (15 feet)

The permittee/contractor shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring.

Upon completion of the work, the permittee shall provide an accurate **"As-Built"** drawing of the installed pipe.

623.2E Soils Investigation

A soil investigation should be undertaken, suitable for the proposed complexity of the installation to confirm ground conditions.

Definition: Soil Analysis

Common sense must be utilized when requiring the extensiveness of the soil analysis. A soil analysis is required in order to obtain information on the ground conditions that the contractor will encounter during the HDD operation.

If, the contractor can go to the project site and do an excavation with a backhoe to one foot below the proposed depth of the bore, that is a soil investigation. In all cases when an excavation is made in creating of an entrance and exit pit for a HDD project, that is an example of a soil investigation. The HDD process is in itself a continual and extensive soil analysis as the pilot bore is made and it encounters the varying soils and formations the drilling slurry will change colors, therefore providing the contractor with continual additional information.

The purpose and intent of the soil analysis is to assist the contractor in developing the proper drilling fluid mixture, and to ensure Caltrans that the contractor is aware of the conditions that do exist in the area of the proposed project. This prepares the contractor in the event they should encounter a zone of pre-tectonics, and that they would need additives or preventive measures in dealing with inadvertent returns (frac-outs).

The discretion on the extensiveness of the soil analysis is left to each individual District Permit Engineer (DPE) respectfully, for their respective areas. The inspectors play a large role in assisting the DPE in making decisions on the extensiveness. Each individual inspector has a general knowledge of the soil conditions in their area of responsibility.

In many circumstances the soil information has already been prepared, either by Caltrans or by City and County Entities. This information if existing should be provided to the requesting permittee, if there is a structure within 1/2 mile of the proposed project, then Caltrans has already done an extensive soil analysis and the information is stored in our Maps & Records Branch. As-Builts, on our freeways and highways provide stationing and detailed information regarding soil information, cut and fill areas.

623.2F Determination of Soil Investigations

The District Permit Engineer (DPE) should determine the extensiveness of the Soil Investigation to be performed based on the complexity of the HDD operation, the DPE may recommend according to the guidelines listed below, a combination of, or modify the guideline to fit the respective area:

Projects less than 500' in length, where the product or casing is 8" or less in diameter:

A field soil sampling investigation to a depth of one foot below the proposed drilling.
a) subsurface strata, fill, debris and material

Projects less than 800' in length, where the product or casing is 14" or less in diameter:

A field soil sampling investigation to a depth of one foot below the proposed drilling.
a) subsurface strata, fill, debris and material
b) particle size distribution (particularly percent gravel and cobble)

Projects where the product or casing is 16" or greater in diameter:

A geotechnical evaluation by a qualified soil engineer to determine the following.
a) subsurface strata, fill, debris and material,
b) particle size distribution (particularly percent gravel and cobble),
c) cohesion index, internal angle of friction, and soil classification,
d) plastic and liquid limits (clays), expansion index (clays), soil density
e) water table levels, and soil permeability,

Projects where the product or casing is 24" or greater in diameter:

A geotechnical evaluation by a qualified soil engineer to determine the following.
a) subsurface strata, fill, debris and material
b) particle size distribution (particularly percent gravel and cobble)
c) cohesion index, internal angle of friction, and soil classification
d) plastic and liquid limits (clays), expansion index (clays), soil density, and penetration tests,
e) rock strength, rock joint fracture and orientation, water table levels, and soil permeability,
f) areas of suspected and known contamination should also be noted and characterized.

Boreholes or test pits should be undertaken at approximately 75 to 125 meter (250 to 410 feet) intervals where a proposed installations greater than 1000' feet in length and parallel an existing road. For road crossings a borehole or test pit shall be undertaken on either side with one or more additional boreholes or test pits in the median where conditions permit. Additional boreholes or test pits should be considered if substantial variation in soil conditions are encountered.

Should the soil investigation determine the presence of gravel, cobble, and/or boulders, care should be exercised in the selection of drilling equipment and drilling fluids. In such ground conditions the use of casing pipes or washover pipes may be required or specialized drilling fluids utilized. Fluid jetting methods used as a means of cutting **should only be considered** where soils have a high cohesion such as stiff clays.

Directional drilled gravity sewers shall only be considered where suitable soil conditions are present. Suitable soil conditions include homogenous soils consisting of clays, silts, silty sands, and sands that would allow for good control of the drill head during the pilot hole drilling.

623.3 Microtunneling

Microtunneling is a hybrid of the tunneling industry (miniaturization of tunnel boring machines) and the pipeline industry where pipe jacking has been used for more than 100 years. Microtunneling does not require personnel entry into the tunnel.

623.3A Introduction

Microtunneling is a special construction method suitable for many conditions where open cut construction methods are not cost effective, too disruptive, or not physically possible.

623.3B Microtunneling Permit Application Submittal

The encroachment permit application package submittal, shall consist of two separate submittals. The first submittal shall be by the Owner of the installation (623.3B). The second submittal required shall be by the owner's contractor, when applying for the "DP" (623.3C).
The encroachment permit application package shall contain a construction plan, site layout plan, project schedule, communication plan, safety procedures, emergency procedure, company experience record, in addition to the information listed as follows:

The first submittal by the owning agency shall contain the following plans and information:

1. Drive lengths
2. Proposed depth
3. Shaft; jacking and receiving shafts, manhole construction, shaft backfill, and shoring removal;
    - Type of shaft;
        a) Sheet Pile
        b) Beams and Lagging
        c) Trench Box
        d) Auger Drilled and Lined
        e) Caissons
4. Intermediate jacking stations;
    - Number of Stations;
        a) Required by Specifications
        b) On site
5. Geotechnical; including ground water information
    - Geotechnical evaluation by a qualified soil engineer to determine the following;
        a) Boring logs & plan locations of borings and cross sections, Subsurface strata, fill and ground water elevations

b) Particle size distribution (particularly percent rock and cobble),
c) Cohesion index, internal angle of friction, and soil classification,
d) Plastic and liquid limits (clays), expansion index (clays), soil density, and penetration tests,
e) Rock strength, rock joint fracture and orientation, water table levels, and soil permeability,
f) Areas of suspected and known contamination should also be noted and characterized.

- Should the soil investigation determine the presence of rock, cobbles, and/or boulders, determination of the following information would be required;
  a) Depth and extent of rock
  b) Rock type
  c) Rock strength
  d) Rock joint/fracture spacing
  e) Hardness
  f) RQD
  g) Estimated range of sizes & frequency of occurrence of cobbles and boulders.

Boreholes or test pits for road crossings shall be undertaken on both sides with one or more additional boreholes or test pits in the median where conditions permit. Additional boreholes or test pits should be considered if substantial variation in soil conditions are encountered. Where a proposed installation parallels an existing road, boreholes or test pits should be undertaken at approximately 75 to 125 meter (250 to 410 feet) intervals.

623.3C Contractor's Submittal

The second submittal by the owner's contractor shall contain the following plans and information:

1. Shaft; soil stability at portals and ground improvement.
2. Dewatering plans for jacking and receiving shafts, if any.
3. Shoring design for jacking and receiving shafts.
4. Survey control plan: lasers, laser mounting, laser checking.
5. Ground surface settlement monuments and subsurface settlement monuments monitoring program plan.
   - Buried points
     - Rebar points, or
     - MPBX (Multi-point borehole extensometers)
6. Recycling information; slurry mix and polymer additives, slurry separation plant type, and spoils disposal;
   - Removal of slurry in dump trucks.
   - Removal of slurry in tankers.
   - Settlement ponds.
   - Muck piles on site.

7. Contingency plan information;
    - Ground improvement plans when required at portals and/or behind thrust block/reaction wall due to weak and unstable soil conditions.
    - Obstruction removal through emergency (911) shafts or other means.
    - Mechanical breakdowns and recovery of the MTBM through 911 shafts or other means.
    - Control of hydrofracture and slurry loss.
    - Remediation of loss of ground and excessive ground surface settlement.

623.4 Pipe Ramming

Pipe Ramming pit requirements are identical to those for Bore & Jack.

Establishment of a survey-grid line is required.

Before any project begins, exploration bore-holes and a complete geotechnical investigation shall be conducted to determine possible difficulties in order to determine the drilling trajectory.

The casing shall be rammed open ended, except when the diameter is 6" or smaller. Pipes 6" or smaller may be rammed open ended or closed.

A soil shoe may be installed on the leading edge of the casing, either by fabrication on site or obtained from the manufacturer. A soil shoe shall not be utilized on those installations at depths or 18" or less from the surface.

Lubrication shall only be utilized to reduce friction and increase production. The amount of lubrication directed to the outside of the pipe shall only be of a sufficient amount required to fill the void between the outside of the pipe and soil, as created by the soil shoe.

Lubrication to the inside of the casing shall only be an amount adequate to assist in spoil removal when the ram is completed.

Welding of the casing at joints shall be as per the manufacturer's recommendations.

The use of straps at each joint on pipe diameters of 12" or larger is required as is the use of the manufacturer's specified welding wire or rod.

Spoil removal for rammed encasements of 30" in diameter or less, may utilize pressurized air or water.

Air pressure shall not exceed 150 psi and water pressure shall not exceed 300 psi.

Encasements larger than 30" in diameter shall have the spoils removed by other means than by pressurizing of the pipe, such as, manual, auguring, vacuum, washing or other means.

The Receiving Pit shall be steel plated entirely when the spoils are to be removed from within the encasement by means of air or water pressurized methods.

623.5 Pipe Bursting

Pipe Bursting operations generally are only performed by the owning utility when they have exceeded the operating capacity of their existing facilities. In most cases pipe bursting allows the utility owners the advantage of upgrading their existing facilities by up to 50%.

On installations of diameters 12" or greater it is necessary to establish a survey-grid line and establish the existing elevation points over the existing area of installation.

A soil analysis should be required and review of the information to identify any locations of difficulty, density, water table, changes in soil formation that could present or create greater friction resistance.

Request information of the proposed project as to:

1. the ratio of the proposed upgrade to determine difficulty, generally up to 25% increase in diameter is common. An increase of 25% - 50% is considered challenging, and an increase of 50% or greater is considered experimental.

2. the existing depth of cover, "rule of thumb" depth of cover should be at least 10X the difference in the upgrade of the existing diameter to be burst.

3. whether or not the existing line has been viewed by video, do not allow line to be burst blind.

4. is this proposed line straight or are there bends in the line.

5. if bends are existing in the line, the location of the bend will have to be excavated and new pits re-established at those locations.

6. require that the contractor provide a list of equipment to be on site to handle an emergency, in the event that bypass pumping is required to maintain the existing service in the event of a problem.

7. as to what method will be utilized (static, pneumatic, burst and jack, or hydraulic).

623.6 Tunneling - Rib & Lagging

NOTE: All projects will vary in their own characteristics. General similarities are listed below to provide a general understanding of these types of projects.

Establishment of a survey-grid line and existing elevation points shall be over the centerline and wing points of the installation.

Designed plans and specifications, calculations and details (liner plates, rib & lagging, bracing, etc.) shall be stamped by a Registered Structural Engineer, or a Registered Civil Engineer, with a minimum of five (5) years experience in sub-structural design of tunnels. Proof of experience shall be submitted on "Certification of Structural Experience," form TR-0133, in conjunction with project package submittal.

A geotechnical investigation and soil analysis by a licensed geotechnical engineer/engineering geologist is required. It shall provide identification of any locations of difficulty, changes in soil formation, or mixed face conditions that could present or create ground loss, exploratory soil corings and logs are required along the tunnel alignment at intervals of twenty-five to one-hundred feet {25' to 100'}.

When the length of the tunnel is greater than four hundred feet (> 400'), alignment holes may be required. Alignment holes shall be drilled at a maximum spacing of two-hundred feet (200') and a casing of four to six inches (4" to 6") in diameter installed vertically, to a depth necessary for the installed casing to extend into the tunnel excavation. When alignment holes fall within the pavement area of the roadway, the pavement shall be saw-cut, a cover shall be placed over the end of the casing at grade, and the space around the casing within the roadway filled with concrete (EXCEPT in controlled access right-of-way).

623.6A CAL/OSHA Requirements

The California Code of Regulations (CCR) mandates the following requirements for Tunneling Projects.

The Owner or Local Entity proposing the construction of the tunnel shall make a full submittal to the Department of Industrial Relations, Cal/OSHA, to determine tunnel classification (CCR 8422).

Development of a check-in/check-out procedure to ensure an accurate account of personnel underground in the event of an emergency (CCR 8410).

Development of an Emergency Plan, that outlines duties and responsibilities of all personnel on the project during an emergency. The plan shall include ventilation controls, fire fighting equipment, rescue procedures, evacuation plans and communications (CCR 8426).

Cal/OSHA requires a State of California certified person performing the duties of gas tester or safety representative to be certified by passing a written and an oral examination administered by the Cal/OSHA Mining & Tunneling Unit (CCR 8406(f), (h)).

A certified safety representative shall direct the required safety and health program and must be on-site while employees are engaged in operations during which the Tunnel Safety Orders (TSO) apply (CCR 8406(f)).

The certified safety representative must have knowledge in underground safety, must be able to recognize hazards, and must have the authority to correct unsafe conditions and procedures subject to the TSO (CCR 8406(f)).

A State of California certified gas tester is required for the following operations:
- All classifications other than non-gassy
- Projects during which diesel equipment is used underground
- Hazardous underground gas conditions (CCR 8470).

623.6B Tunnel

Tunnel construction is accomplished by the method of Hand-mining, or by Mechanical means, and the use of a protective shield.

Continuous monitoring and observation of the ground surface above the tunnel is required. In some cases it may be required to survey and record elevations along the survey grid line, several times a day, or daily.

Generally, when tunneling in good ground, tunnels with a diameter of less than eight-feet (< 8') and less than three-hundred feet to four-hundred feet (300' to 400') in length may be holed-through (excavated completely) before concreting the interior of the tunnel, when placement of pre-fabricated or pre-cast pipe is to be installed. When this is proposed, hole-through (unsupported length) before concreting of the interior of the tunnel, it shall be justified by the original subsurface geotechnical investigation and design.

Tunnel lining and bracing should consist of steel ribs and steel spreaders (dutchmen) with wood, concrete, or steel lagging, or with bolted steel liner plates.

Fireproof materials should be utilized in all construction of plant structures, above ground, within one hundred feet (100') of the shaft or tunnel. The use of flammable materials or wood shoring would require that adequate fire protection be provided.

Ventilation systems shall be established and provide a minimum of two hundred (200) cfm per worker.
- All equipment shall maintain a minimum clearance of twenty-five feet (25') from opening.
- An established contingency plan in the event of ground loss.
- Cranes utilized in operations shall maintain minimum required clearances.

623.6C Tunnel Shield

- The face of the shield shall be provided with a hood or an approved grid system.
- The excavation face shall have a sufficient length to allow for the installation of one (1) complete ring of liner plates, or one (1) complete set of ribs and lagging before advancing.
- The contractor shall submit details and design information of the shield.

623.6D Tunnel Lining

Tunnel lining and bracing should consist of steel ribs and steel spreaders with wood lagging and concrete, or steel lagging, or with bolted steel liner plates.

The tunnel liner and bracing shall be designed (calculations provided) of an adequate strength based upon the geotechnical investigation, soil analysis, loading, and the diameter and depth of cover to provide adequate support of the tunnel.

- A ring expander shall be used to expand the rib continuously outward and upward.
- Liner plates shall be designed based on joint strength, minimum stiffness, critical buckling of the liner plate wall, and deflection or flattening of the tunnel section.
- On tunnels with a diameter greater than ten feet (> 10'), the placement of ribs inside of liner plate may be required.
- When the geotechnical investigation has determined that silts and fine sands exist, that may flow under pressure, all liner plates shall include a neoprene gasket adhered to each flange face.

623.6E Lagging

Lags are generally started at spring line and continue upwards towards the crown.

Lag spacing consists of three methods:
1. Wedging – done by driving a block of wood between the earth and the lag at each end, or by driving a wedge between the rib and the lag.
2. Stops – by welding small angles to the ribs outer flange to prevent sliding.
3. Clamps – which are applied to wood or steel lags.

If the spacing of lags between ribs is used in tunnel construction, packing between lags with filler may be required.
- Lags are boards of steel plates placed longitudinally against the roof and walls of the tunnel excavation.
- Steel lagging may consist of channel, liner plate or corrugated metal.
- Steel lagging thickness shall be designed on strength based upon the geotechnical investigation, soil analysis, and loading.

- Wood lagging thickness shall be designed on strength based upon the geotechnical investigation, soil analysis, loading. Generally wooden lags common size are three-inches by six-inches (3" x 6"), and the length is cut according to the spacing of the ribs.
- A minimum of one liner plate per ring with a two-inch (2") diameter coupling for grouting is required.

623.6F The Construction of Shafts / Pits

Shafts / pits should be constructed of a proper size and shape, and equipped as to allow work to be carried on safely.

- Shafts shall be constructed of driven steel sheet pilings, steel bracing and tight wood, or steel lagging or steel liner plates and ribs.
- The removal of spoils should be accomplished by mechanical means (muck box).
- All shafts shall be provided with guardrail and a toeboard.
- When ladders are utilized within the shaft or pit, cages and/or safety devices shall be provided on depths of fifteen to twenty feet (15' to 20'), platforms shall be provided at depths of greater than twenty feet (20'+).
- Ventilation systems shall be established and provide a minimum of two hundred (200) cfm per worker.
- All equipment shall maintain a minimum clearance of twenty-five feet (25') from openings.
- Upon completion of project all shafts, pits and drifts that are not part of the finished product shall be backfilled.

623.6G Placement of Shafts / Pits

Shafts / pits shall be:

- Located a minimum of ten feet (10') measured laterally from the edge of pavement on conventional highways in rural areas.
- Located at least five feet (5') measured laterally beyond the concrete curb or AC dike on conventional highways in urban areas.
- Located at least five feet (5') measured laterally beyond the toe of slope of embankments.
- Located outside of controlled access right-of-way.
- Adequately fenced or have a Type-K barrier placed around them at a 20:1 taper or as otherwise directed.
- Shored according to Cal-OSHA minimum requirements. Located within fifteen feet (15') of traffic lanes on a State highway shall not extend more than thirty-six inches (36") above the pavement grade unless otherwise authorized by the State representative. Reflectors shall be affixed to the sides facing traffic, and placement around the perimeter of a six-foot (6') chain link fence during non-working hours.
- Are only allowed in controlled access right-of-way for direct freeway crossings that are excessively long or that have restricted space available outside the rights-of-way.

- They shall not Affect State facilities or create a hazard to the traveling public. When placement is approved within controlled access rights-of-way, damaged State facilities shall be replaced or repaired according to State Standard Specifications.
- Shall have crushed-rock and sump areas to clear groundwater and water used to clean. They shall be lined with filter fabric when groundwater is found and pumping is required.

623.6H Excavation

In some locations Soil Stabilization may be required. It may become necessary at the direction of the Engineer to either pressure grout or freeze the soil area of the project to control water, to prevent loss of ground, to prevent settlement or displacement of an embankment. When required, a Registered Geotechnical Engineer shall prepare and stamp the plans determining the material and method for use.

In some projects masonry sections are installed, the amount of excavation of the tunnel should not exceed the amount needed for placement of a full masonry section after all lining is in place.

All excavated material shall be considered as unclassified material.

- In the event of any ground movement over or adjacent to construction, all work shall be suspended, except that which will assist in making the construction site secure and prevent any further additional movement of the ground.
- Excavation should not be advanced beyond the edge of the shield, except in rock.
- The geotechnical engineer/engineering geologist shall determine the allowable amount of tunnel length unsupported by bracing, based on the geotechnical investigation and design.
- All voids between the excavation and the liner shall be grouted after setting of ribs and lagging, if not expanded to full contact with the surrounding ground, as determined by the Safety Engineer.
- A log shall be maintained of all surrounding utilities and facilities.

623.6I Dewatering

When ground water is anticipated, pumps of sufficient capacity to handle the flow shall be maintained at the site. Observation shall be maintained to detect any settlement, displacement or washing of fines into the pit, shaft or tunnel.

623.6J Grouting

Grouting should be kept close to the heading (working front of tunnel).

It may be required to add pea-gravel and fly ash to the grout. The pea-gravel would assist in consolidation and the filling of the voids, fly-ash works as a lubricant allowing the grout to free-flow.

- The use of grout stops may be utilized if necessary or if required by the Safety Engineer.
- Grouting shall be performed when ordered by the Safety Engineer.
- At no time shall progression of the tunnel exceed six feet (6') beyond the grouting of the exterior void.
- Pressure on the grouting gauge should not exceed the capacity of the lining, sufficient to fill all voids.
- A gauge shall be provided which will accurately indicate working pressure and shall be monitored constantly during grouting procedures.
- Grouting shall start at the lowest point and proceed upwards simultaneously on alternating sides.
- When grouting is complete at that location a threaded plug shall be installed into the coupling.

623.6K Materials

The form "Notice of Materials to be used," form CEM-3101 is required.

- The manufacturer shall provide a Certificate of Compliance, to ensure tensile and yield strengths.
- Steel lagging may consist of channel, liner plate or corrugated metal.
- Steel lagging thickness shall be designed on strength based upon the geotechnical investigation, soil analysis, and loading.
- Wood lagging thickness shall be designed on strength based upon the geotechnical investigation, soil analysis, loading. Generally wooden lags common size are three-inches by six-inches (3"x 6"), and the length is cut according to the spacing of the ribs.
- When the geotechnical investigation has determined that silts and fine sands exist, that may flow under pressure, all liner plates shall include a neoprene gasket adhered to each flange face.
- Ensure Manufacturer's Specification Data Sheets (MSDS) are provided stipulating recommended:
  - Specifications of steel spreaders (spacing, tolerances).
  - Specifications of steel rib (section lengths, spacing, etc.)

623.6L Project Owner/Permittee Responsibilities

The project owner/permittee is responsible for providing:

A full-time Safety Engineer;

Shall be a Registered Structural Engineer, or a Registered Civil Engineer, with a minimum of five years experience in sub-structural design or inspection of tunnels. Proof of experience shall be submitted on "Certification of Structural Experience," form TR-0133, **OR**

A full-time Safety Representative;

State certified by Department of Industrial Relations, Cal/OSHA, proof of certification is required.

Cal/OSHA requires persons performing the duties of gas tester or safety representative to be certified by passing a written and an oral examination administered by the M&T Unit. CCR 8406(f), (h)

- Project drawings and specifications, calculations and details stamped by a Registered Structural Engineer, or a Registered Civil Engineer, with a minimum of five (5) years experience in sub-structural design of tunnels.
- An geotechnical investigation by a licensed geotechnical engineer to determine the following;
- Storm Water Pollution Prevention Plan (SWPPP) or Water Pollution Control Plan (WPCP).
- De-Watering Plan, if needed.
- Ground water information
- Boring and soil analysis logs, location plan of borings, cross sections, subsurface strata, fill and ground water elevations;
  - Particle size distribution (particularly percent rock and cobble),
  - Cohesion index, internal angle of friction, and soil classification,
  - Plastic and liquid limits (clays), expansion index (clays), soil density, and penetration tests,
  - Rock strength, rock joint fracture and orientation, water table levels, and soil permeability,
  - Areas of suspected and known contamination should also be noted and characterized.
- The soil investigation shall also determine the presence of rock, cobbles, and/or boulders, and the following;
  - Depth and extent of rock
  - Rock type
  - Rock strength
  - Rock joint/fracture spacing
  - Hardness
  - RQD
  - Estimated range of sizes & frequency of occurrence of cobbles and boulders.

623.6M Contractor's Responsibilities

The contractor is responsible for providing:

- Tunnel project construction plans and specifications, calculations and details, method of construction, to include the adequacy of the shield and liner material stamped by a Registered Structural Engineer, or a Registered Civil Engineer, with a minimum of five (5) years experience in sub-structural design of tunnels.
- "Notice of Materials to be used," form CEM-3101.
- Method of construction plan.

- A Licensed Surveyor.
- Proof of rib expanders and/or liner supports.
- Working schedule of the project.
- Contingency plan for dealing with ground loss work.
- Shaft; soil stability at portals and ground improvement plan.
- Dewatering plans for entry and exit shafts/pits, if needed.
- Installation and monitoring of SWPPP or WPCP facilities and conditions.
- Shoring design for entry and exit shafts/pits.
- Survey control plan: lasers, laser mounting, laser checking.
- Ground surface settlement monuments and subsurface settlement monuments monitoring program plan.
  - Buried points

623.6N Key Points of Inspection

Meet and confer with the Safety Engineer hired by the Owner/Permittee, explain exactly what is expected and required on a daily report, and any issues of concern.

State Representative and Safety Engineer/Safety Representative, together both should:

1. Review the geotechnical investigation.
2. Review the emergency and contingency plans.
3. Inspect the roadway and shoulder area for existing cracks in the ground and mark them.
4. Inspect the area for all-existing utility facilities and sub-structures.
5. Check and confirm any requirements or concessions requested by any Utility companies with the owner and the contractor.
6. Ensure that a Survey Grid line has been established over proposed alignment of tunnel.
7. Make a determination on the frequency of surface monitoring that will be required, and identify what would constitute additional monitoring and/or surveying.
8. Inspect and ensure there is sufficient space for the staging area, that equipment and workers can work safely.
9. Establish the limits of minimum clearance.

Safety Engineer/Safety Representative – start of project and construction of shafts/pits.

A. Request to see OSHA permit and tunnel classification sheet.
B. Ensure the contractor has equipment on site to handle an emergency, and in the event that ground loss occurs.
C. Inspect installation of SWPPP or WPCP facilities and conditions.
D. Have knowledge of the soil conditions, density and water table (sand, clay, cobble, etc.).
E. Inspect the shafts/pits for Cal OSHA (trenching and shoring) requirements.
F. Ensure that guardrails and toe-boards are secured around shafts.
G. Ensure the flooring of the shaft/pit is lined with gravel or ballast rock.
H. Ensure that the sump pumps setup and that they are adequate for dewatering.

I. Ensure all electrical cords and facilities are properly secured.
J. Inspect materials to be used against list provided by contractor.
K. Obtain receipt of the certificates of compliance from the manufacturer on all materials delivered and to be used for the project.
L. Ensure that ventilation system is adequate and installed.
M. Ensure a location is designated for spoils, that they are adequately stockpiled and removed.

Safety Engineer/Safety Representative – daily inspection

1. Ensure that laser is verified every morning prior to start of work.
2. Inspect SWPPP or WPCP facilities and conditions
3. Check traffic control, signs and delineation.
4. When warranted request line to be re-surveyed to determine heaving or subsidence, if greater than 5mm take corrective measures.
5. Visually inspect gauge during grouting operations.
6. Inspect ventilation equipment, request copies of contractor's records of maintenance.
7. Ensure safety equipment is worn at all times by everyone.
8. Notify State Representative in the event of an incident or accident.
9. Ensure that all excavations are adequately protected with Type-K barrier and chain link fence around them or covered with steel plates.

State Representative and Safety Engineer/Safety Representative – close of project

A. Upon completion, visually inspect the area of installation, highway and shoulder area to ensure no new cracks, heaving or subsidence have occurred.
B. Require line to be re-surveyed to determine heaving or subsidence.
C. Ensure that all excavations were backfilled.
D. Work site and staging areas are restored to their original condition.
E. Establish a checklist if necessary for completion points (i.e. repairs or corrections).

623.7 PROCEDURAL REQUIREMENTS FOR STRUCTURAL AND SUB-STRUCTURAL DESIGN AND CALCULATIONS

All submittals shall be stamped by a Registered Structural Engineer, or a Registered Civil Engineer, with a minimum of five years experience in structural design and preparation of calculations, proof of experience is required by use of Encroachment Permits form "Certification of Structural Experience," TR-0133, to be included within the project package submittal.

Sub-structural projects may consist of, but are not limited to; drainage boxes & systems, tunneling projects (mechanical or manual tunnel excavations for the placement of tunnel supports), and Trenchless Technologies for the installation of utilities when the diameter is 30" or larger (jack & bore, micro-tunneling, horizontal directional drilling, or pipe-ramming).

623.7A Structural Design and Calculations

All Structural Project submittals (structures and structural falsework) will require review by Structures Maintenance, for construction under an encroachment permit and require the following:

- Designed plans and specifications, calculations and details (structural and falsework).
- A geotechnical investigation and soil analysis by a licensed geotechnical engineer is required. It shall provide identification of any locations of difficulty, changes in soil formation, or mixed face conditions that could present or create ground loss, exploratory soil corings and logs are required along the alignment of the project.

Construction or Structures Construction may provide oversight.

623.7B Sub-structural Design and Calculations

When the distance between the tunnel and an existing structure is less than twenty times its diameter, it shall be sent to Structures Maintenance for review of the potential lateral loading effects to the pilings and foundation.

Otherwise, Sub-structural Project submittals, listed below and submitted with the "Certification of Experience," TR-0133, **do not** require review by Structures Maintenance or Underground Structures.

1. Micro-tunneling projects.
2. Bore & Jack, HDD, or Pipe Ramming (diameter is 30" or larger and requiring structural/sub-structural design, investigations and calculations)
3. Tunneling for the placement of tunnel support systems (rib & lagging, or steel liner plate requiring structural/sub-structural design, investigations and calculations).
4. Drainage boxes and systems.

All Sub-structural Project submittals require the following:

- The District Encroachment Permits Office is responsible for verification of the Registered Engineers stamp, validation of the date of expiration against the dated plan set and calculations. The permit office engineer shall validate the RE's stamp at the web site listed below, by entering the RE's number. A copy of the results shall be printed and included within the permit file. The encroachment permit may be issued, upon completion of the normal review process (Traffic, Environmental, R/W, etc.).

http://www2.dca.ca.gov/pls/wllpub/wllqrynaSlccv2.startup?p_qte_code=ENG&p_qte_pgm_code=7500

- Designed plans and specifications, calculations and details (liner plates, rib & lagging, bracing, etc.).

- A geotechnical investigation and soil analysis by a licensed geotechnical engineer is required. It shall provide identification of any locations of difficulty, changes in soil formation, or mixed face conditions that could present or create ground loss, exploratory soil corings and logs are required along the alignment of the project.

- When the length of the tunnel is greater than four hundred feet (> 400'), alignment holes may be required. Alignment holes shall be drilled at a maximum spacing of two-hundred feet (200') and a casing of four to six inches (4" to 6") in diameter installed vertically, to a depth necessary for the installed casing to extend into the tunnel excavation. When alignment holes fall within the pavement area of the roadway, the pavement shall be saw-cut, a cover shall be placed over the end of the casing at grade, and the space around the casing within the roadway filled with concrete (EXCEPT in controlled access right-of-way).

623.7C Project Owner's Responsibilities

On projects deemed by the Department as requiring full time inspection, the project owner is responsible for providing a third-party full time inspector.

On projects over 30" in diameter and deemed as requiring full time inspection, the project owner is responsible for providing:

A full-time Safety Engineer:

A Registered Structural or Civil Engineer, with a minimum of five years experience in design or inspection of Sub-structural Projects (tunnels). Proof of experience shall be submitted on Encroachment Permits form "Certification of Structural Experience," form TR-0133,

OR

A full-time Safety Representative:

State certified by Department of Industrial Relations, Cal/OSHA Mining & Tunnel Unit, proof of certification is required. California Code of Regulations 8406(f), (h)

623.7D Contractor's Responsibilities

Prior to issuance of the "DP" permit the following shall be submitted:

- Proof of experience, as stipulated by the District Office, in respect to diameter and length of proposed project.
- Tunnel support system construction plans and specifications, calculations and details, method of construction, to include the adequacy of the shield and liner material stamped by a Registered Structural Engineer, or a Registered Civil Engineer, with a minimum of five (5) years experience in sub-structural design and preparation of calculations.
- "Notice of Materials to be used," form CEM-3101.
- Method of construction plan.
- A Licensed Surveyor.
- Proof of rib expanders and/or liner supports.

- Working schedule of the project.
- Contingency plan for dealing with ground loss work.
- Shaft; soil stability at portals and ground improvement plan.
- Dewatering plans for entry and exit shafts/pits, if needed.
- Installation and monitoring of SWPPP or WPCP facilities and conditions.
- Shoring design for entry and exit shafts/pits.
- Survey control plan: lasers, laser mounting, laser checking.
- Ground surface settlement monuments and subsurface settlement monuments monitoring program plan.
  - Buried points

624 OPEN-CUT ROAD
Permit Code UT

Encroachment Permit policy dictates that underground installations and crossings within State highway right-of-way shall be performed by methods of trenchless technologies, either Bore & Jack, HDD, Micro-Tunneling, Pipe Bursting or Pipe Ramming, unless specified otherwise by permit. Open trenching is authorized only when the applicant demonstrates that all alternatives have been investigated and that installation by a trenchless technology is not feasible. Procedures that shall be followed in evaluating applications for open trenching are shown in Table 6.10.

The Reclamation Board, in maintaining the integrity of the State's levee system, issues permits for construction of facilities within the levee prism. Caltrans and the Reclamation Board cooperatively have developed procedures for controlling installation of underground facilities where a State highway is on or crosses a levee. The Board prefers open cut highway crossings to ensure the integrity of the levee. Caltrans issues permits that conform to Board requirements.

Authorized open trenching must be noted clearly in the encroachment permit or permit rider. Traffic controls must conform to State standards and recommendations of Highway Operations or Permits. Unless otherwise specified in the permit, work must be accomplished one lane-width at a time on conventional two-lane highways. If determined acceptable, two lanes of a multi-lane highway may be used for the work when one full lane width in each direction is available for traffic. Trenching, backfilling, and paving operations shall conform to Caltrans' standards.

Transverse trenching is not authorized on freeways or expressways without headquarters approval as an exemption to policy.

624.1 Backfill of Excavations and Trenches

Backfilling of excavations and trenches shall comply with Caltrans Standard Specifications. The specification for Controlled Low Strength Material (CLSM) is shown in Appendix H.