Sites

Topic: **Phase 2 (2019) Reservoir Committee Agenda Item 8-1** **2019 Apr 18**

1Subject: **Holthouse and Fletcher Reservoirs Appraisal-Level Study** **Hartwig/Vanderwaal**

Requested Action:

For discussion and possible direction to staff to continue advancing the study of the Fletcher Reservoir option to a feasibility level similar to that of the current Holthouse Reservoir option.

Detailed Description/Background:

In 2011 the Department of Water Resources added the Holthouse Reservoir facility to enhance power generation benefits. The Authority identified concerns associated with the Holthouse Reservoir including: Tehama-Colusa (TC) canal operations, cost to relocate Western Area Power Administration (WAPA) high voltage transmission lines, impacts to Funks Reservoir, and real estate acquisition challenges.

To address these concerns, the Authority authorized AECOM to complete a reconnaissance-level study to evaluate alternative plans to Holthouse. The study identified the Fletcher Reservoir as a viable concept warranting further evaluation. The Fletcher Reservoir facility concept consists of a small dam across Funks Creek located downstream of the proposed Golden Gate dam and to the west of the proposed Holthouse Reservoir facility.

Based upon the reconnaissance-level study the Authority requested AECOM conduct an appraisal-level study to advance the Fletcher Reservoir concept. It was determined that Fletcher has significant merits; primarily in reducing potential scope and schedule risks. AECOM has completed a working draft of the appraisal study titled "Appraisal Level Study of Options to Relocate Holthouse", March 2019. The draft is currently being reviewed by staff, the Water Facilities Work Group, and Reclamation.

If directed, staff will continue working to advance the evaluation of the Fletcher Reservoir facility to a feasibility level of analyses comparable to that being conducted for the Holthouse Reservoir facility.

Prior [Authority/Reservoir Committee] Board Action:

In 2017, the authority authorized AECOM to conduct a reconnaissance level study.

In 2018, the Authority authorized AECOM to conduct an appraisal level study to advance the Fletcher Reservoir concept.

Fiscal Impact/Funding Source:

None.

Staff Contact:

Lee Frederiksen

Attachments:

Attachment A – Figure 1 – Fletcher Reservoir Plan

Attachment B - Holthouse Reservoir Alternatives Technical Memorandum, dated January 5, 2018.

Attachment C – Sites Reservoir Project – Appraisal Level Study of Options to Relocate Holthouse Reservoir, Working Draft, dated March 2019

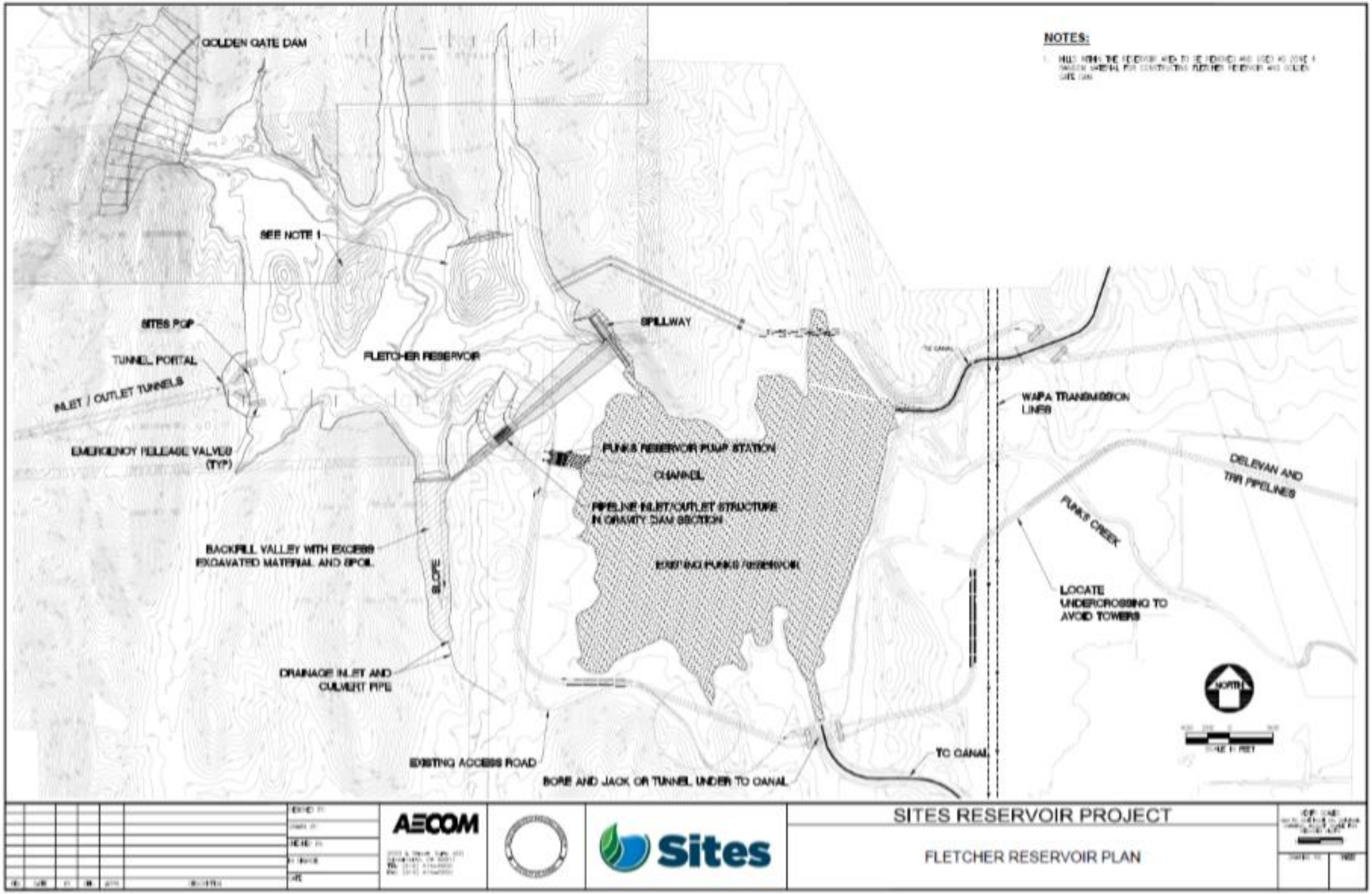

Figure 1 **Fletcher Reservoir Plan**

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Technical Memorandum

Prepared for:	Sites Authority
Project:	Sites Reservoir Project
Date:	January 5, 2018
Subject:	Holthouse Reservoir Alternative
Prepared by:	Joseph Barnes, PE
Reviewed by:	Jeff Herrin, Rich Millet
Revision:	Draft January 5, 2018

1. Introduction

The construction of the proposed Holthouse Dam and Reservoir expands the capacity of Funks Reservoir, which allows the Sites Pumping-Generating Plant (Sites PGP) to operate as a pumped-storage project. However, there are concerns associated with constructing and operating Holthouse Reservoir at its currently proposed location that include the following

a. Real estate acquisition challenges.

b. Loss of Funks Reservoir as a canal regulating reservoir during construction of Holthouse Reservoir and the Sites PGP.

c. The need for a temporary bypass siphon pipeline to continue to serve the TC Canal south of Funks Reservoir during the summer while Funks Reservoir is out of service.

d. The possible need to continue to use the siphon pipeline after construction to serve the canal segment south of the new reservoir if water levels drop is too low to supply the canal by gravity because of pumped-storage operations.

e. The need to relocate WAPA 500 KV and 230 KV transmission lines carried on seven towers falling within the current Holthouse Reservoir limits.

f. Current lack of geotechnical data to support Holthouse Dam design and cost estimating.

To address these concerns, a reconnaissance-level study was conducted to determine if there are on-site locations where a new storage reservoir could be constructed in the vicinity of the Sites PGP. Such a reservoir could reduce or eliminate operational impacts to Funks Reservoir and the Tehema-Colusa Canal (TC Canal) during and after construction. On-site as used here refers to areas that fall within the project boundaries defined in the current environmental documentation where adequate storage could be build.

This Technical Memorandum (TM) documents the reconnaissance-level study, which has identified potential alternative reservoir sites west of Funks Reservoir. The evaluation described in this TM is at a high level and is intended only to identify a potential site. Additional investigations are needed during the next design phase for the Sites Reservoir Project (Project) to verify viability of the alternative and to support an informed decision by the Agency to adopt an alternative site as a part of the Project. Investigations needed would include system operational studies, geotechnical investigations and testing, and conceptual designs.

It is possible that other reservoir sites may exist outside the current Project boundaries, including a new one on the TC Canal itself to replace Funks Reservoir. These alternative locations are outside the scope of this TM, but could be included in future studies.

2. Approach

The primary target areas evaluated for an alternative reservoir in this TM were located to the west of Funks Reservoir where topography relief and existing drainages could provide reservoir storage. The following considerations factored into reservoir siting:

a. Should be constructible with little or no impact to Funks Reservoir and the TC Canal during construction.

b. Reservoir operation would not be constrained by the current operating water levels in Funks Reservoir that allows the TC system to operate by gravity.

c. Should interface with the Sites PGP as currently planned without requiring a relocation of the plant or the Inlet/Outlet Tunnel to Sites Reservoir. The current location for the Sites PGP was selected to avoid mapped faults in the ridge that forms the east side of Sites Reservoir based on currently available geological data collected by DWR.

d. No constraint on raising the elevation of the Sites PGP to be compatible with an alternative reservoir as long as raising the Inlet/Outlet Tunnel with the plant does not encroach into or reduce the planned active storage volume within Sites Reservoir.

e. The useable storage for the alternative reservoir should be approximately 3,000 acre-feet.

f. The dam for the alternative reservoir would include an inlet/outlet facility for the Delevan and TRR pipelines and a gated spillway sized for the emergency Sites Reservoir release (approximately 15,000 cfs) similar to the facilities currently incorporated in the design for the currently proposed Holthouse Dam.

3. Alternative Reservoirs

Based on the review of topography west of Funks Reservoir, there are two options for a reservoir. One option would be to construct a dam across Funks Creek at a location just west of Funks Reservoir (Option 1). The other option would be to construct a dam following along the south side of Funks Creek to take advantage of a natural drainage that flows into Funks Creek (Option 2). The options are presented in the following paragraphs. Other stream channels in the area are too small to provide needed operational storage without major dam construction.

3.1 Option 1 - Dam Across Funks Creek

Figure 1 provides a plan view of a proposed alternative dam across Funks Creek. To provide approximately 3,000 acre-feet of storage, the operating water level would need to be at approximately elevation 255.0 feet. Allowing six feet for freeboard, the crest of the dam would be at approximate elevation 261.0 feet. Because the Funks Creek channel slope is relatively flat between the downstream face of Golden Gate Dam and the proposed alternative dam site for this option, the downstream face of Golden Gate Dam would be inundated to a maximum depth of approximately 30 feet and would be subjected to daily water level fluctuations due to pumped-storage operation. It is likely that both DSOD and FERC would be concerned with such inundation of the downstream face of Golden Gate Dam. Inundation would impede the inspection and monitoring of seepage at this critical location at the base of Sites Reservoir's largest main dam. For this reason, Option 1 is not pursued further at this time.

AECOM recognizes that it would be possible to build a dike at the upstream end of the alternative reservoir to prevent inundation of the downstream face of Golden Gate Dam. This would form a pocket area between Golden Gate Dam and the alternative reservoir that would collect seepage and a small amount of natural local runoff that may have to be pumped out. If the Agency determines that Option 1 is a viable alternative, it can be further evaluated in the next design phase of the Project in consultation with DSOD and FERC.

3.2 Option 2

As shown on Figure 2, a clay core and rockfill shell dam could be constructed generally following along the southerly bank of Funks Creek to inundate two local drainage channels and form a reservoir with suitable storage. At one location, the dam would cross a meander loop in Funks Creek, but there is adequate room to relocate the creek away from the downstream toe of the proposed dam.

Embankment Details: Figure 3 presents an area capacity curve for the reservoir site for different top of dam elevations. For this study, it is assumed that the reservoir would have a normal maximum water level at approximately elevation 268.0 feet to provide 3,000 acre-feet of capacity. Allowing six feet for freeboard, the dam crest would be located at approximately elevation 274 feet. The length of the dam as shown on Figure 2 would be approximately 4,600 feet. The average height would be approximately 35 feet and the maximum height would be approximately 45 feet where the downstream toe approaches or crosses Funks Creek.

The topography along the ridge forming the east side of the reservoir is at approximate elevation 280 feet. It is likely that a clay filled core trench excavation and some ridge grouting would be needed along the ridge south of the main dam abutment to cut off seepage.

The topography shown on Figure 2 within the reservoir and dam area includes two prominent high mounds extending up as high as elevation 330.0 feet. Geological mapping by DWR indicates the mounds are composed of sandstone and mudstone beds. Several shallow auger holes by DWR in the drainages located away from the mounds indicate the presence of medium plasticity clays to depths of 15 feet in the reservoir area. It is possible that the clay can be borrowed from within the reservoir to construct the core of the dam. The two mounds would be excavated down to match surrounding reservoir bottom to provide storage volume and the excavated material used to construct the shells of the dam. Any surplus excavated material from within the reservoir area can be used as borrow to construct the downstream shell of Golden Gate Dam.

Storage Allocations: As shown on Figure 3, the storage allocation for the alternative reservoir is divided into two components for this study. Approximately 1,250 acre-feet is allocated to daily pumped-storage operation. An additional 1,250 acre-feet is allocated to supplemental storage.

The pumped-storage allocation would permit power generation at a flow rate of 2,520 cfs for up to six on-peak hours each day. This is approximately one-half the generation flow rate assumed in the preliminary sizing of Holthouse reservoir. The lower flow rate for the alternative reservoir is selected from the area capacity curve on Figure 3 to limit the head variation on the pump-turbine units within the pumping-generating allocation range to approximately 10 feet. The

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supplemental storage is provided for operation flexibility and to provide the capacity to accommodate inflows that might be occurring from the canals and Sacramento River simultaneously with power generation releases in the spring or fall in wet years. Note that the pumped-storage allocation within the reservoir can be varied within the available reservoir storage limits depending on inflow and outflow conditions or other operational considerations. The pumped-storage allocation is shown near the bottom end of the storage on figure 3 to site the Sites PGP low enough in elevation to maintain the upstream end of the Inlet/Outlet Tunnel below the bottom of the planned active storage pool in Sites Reservoir and to provide for an Inlet/Outlet Tunnel slope of at least one percent to facilitate tunnel construction.

Inlet/Outlet Structure and Spillway: An emergency spillway is needed and an inlet and outlet structure for the Delevan and TRR Pipelines is needed to connect to the alternative reservoir. These facilities would be constructed in a concrete gravity dam section at the right (south-west) abutment of the dam, which should be in rock. The gated spillway and Inlet/outlet structure details would be similar to those already proposed for Holthouse Dam. The gated spillway would be designed to pass the emergency reservoir release through a short channel connected directly to Funks Creek and Funks Reservoir.

Delevan and TRR Pipeline Extension: The length of the Delevan and TRR Pipelines would increase by approximately one mile. The alignment for the pipeline extension around the south side of Funks Reservoir is shown on Figure 2. This alignment was selected to provide a pipeline profile that would permit return flow from the reservoir to the Glen-Colusa Irrigation District Canal and Sacramento River by gravity. The pipes would be bored and jacked under the TC Canal, and this operation could be scheduled to minimize operation impact to the canal.

New Funks Reservoir Pumping Plant: Funks Reservoir normally operates between elevations 204.0 feet and 206.0 feet. The water level in the alternative reservoir could be 30 to 50 feet higher. Because of this difference, it would be necessary to provide a new pumping plant and short section of pipeline to transfer the TC Canal flow entering Funks Reservoir up to the alternative reservoir. The plant would be sized to provide a pumping capacity of 2,000 cfs and a return flow capacity of 1,000 cfs (estimated TC Canal demand downstream of funks Reservoir. The plant would be similar to plant being provided at the TRR Reservoir. Release water would flow directly into Funks Reservoir. A new pipeline would be needed to connect the new pumping plant with the alternative reservoir.

Sites PGP: The Sites PGP generally remains in its current location. However, the elevation would be raised to be compatible with the higher water levels in the alternative reservoir. Raising the plant offers the potential benefits of reduced excavation in the ridge required for construction and reduced length of the Inlet/Outlet Tunnel to Sites Reservoir by 400 to 500 feet.

Pumping Energy: The total pumping energy for the project would increase to overcome the extra head loss associated with extending the TRR and Delevan Pipelines by approximately one mile. There would also be addition energy cost associated with head loss in the pipeline from the new Funks Reservoir pumping plant. Pumping head at the Sacramento and TRR plants would increase and pumping head is added at the new Funks Reservoir pumping plant, but the pumping head for the largest Sites PGP is reduced.

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4. Findings and Recommendation

It appears that the Option 2 alternative reservoir shown on Figure 2 could be a feasible option to replace the currently planned Holthouse Reservoir. Table 1 summarizes some of the main advantages and disadvantages for this option.

While a detailed cost comparison was not prepared for this study, a quick comparison of cost adders and deducts for the Project with the alternative reservoir suggests that the total project cost would not be significantly impacted. The alternative reservoir also addresses key concerns associated with building Holthouse Reservoir. For these reasons, it is recommended that the development of the alternative reservoir concept be further pursued by the Agency in the next design phase for the project. This would include foundation investigations in the proposed dam area to support conceptual foundation designs and define the need for foundation treatments to control seepage.

Table 1 Advantages and Disadvantages for Option 2 Alternative Reservoir

Advantages	Disadvantages
1. Reservoir could be constructed without impacting the operation of Funks Reservoir	1. Approximate one mile increase in lengths of the TRR and Delevan Pipelines.
2. TC Canal temporary bypass pipeline not needed if the currently proposed Holthouse Reservoir is not constructed+	2. Need for new Funks Reservoir pumping plant and associated pipeline. Need for larger inlet/outlet structure in the alternative reservoir for the added pipes from the Funks Reservoir Pumping Plant.
3. Property acquisition not needed for currently proposed Holthouse Reservoir area other than easements for pipeline extensions.	3. Reduced power generation flow for Sites PGP pumped-storage operation, but somewhat higher generating heads for the turbines in the TRR and Sacramento River Pumping Plants.
4. No relocation of WAPA lines and towers required.	4. Increased pumping energy cost to compensate for additional head loss in longer pipelines.
5. 6,000 to 8,000 feet of channel to connect Sites PGP to Funks Reservoir is eliminated. Sites PGP would be located on the bank of the alternative reservoir.	5. Some potential increase in Operation and Maintenance costs for the Project for added pumping plant and longer pipelines.
6. Excavation to build Sites PGs is reduced. Inlet/Outlet Tunnel to Sites Reservoir could be reduced in length by 400 to 500 feet.	
7. Easier access to the alternative reservoir site for geotechnical investigations.	
8. Decreasing the current environmental impact footprint for the Project by eliminating the proposed Holthouse Reservoir.	

REV	DATE	DESCRIPTION	SUB.	APPD

DESIGNED	APPROVAL RECOMMENDED	AECOM
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REVIEWED REG. CE. NO. 27855	DATE
APPROVAL RECOMMENDED REG. CE. NO.	
APPROVED REG. CE. NO. 40105	

Sites

AUTHORITY PROJECT ALTERNATIVE - D

FIGURE 1
OPTION 1

SPEC NO.

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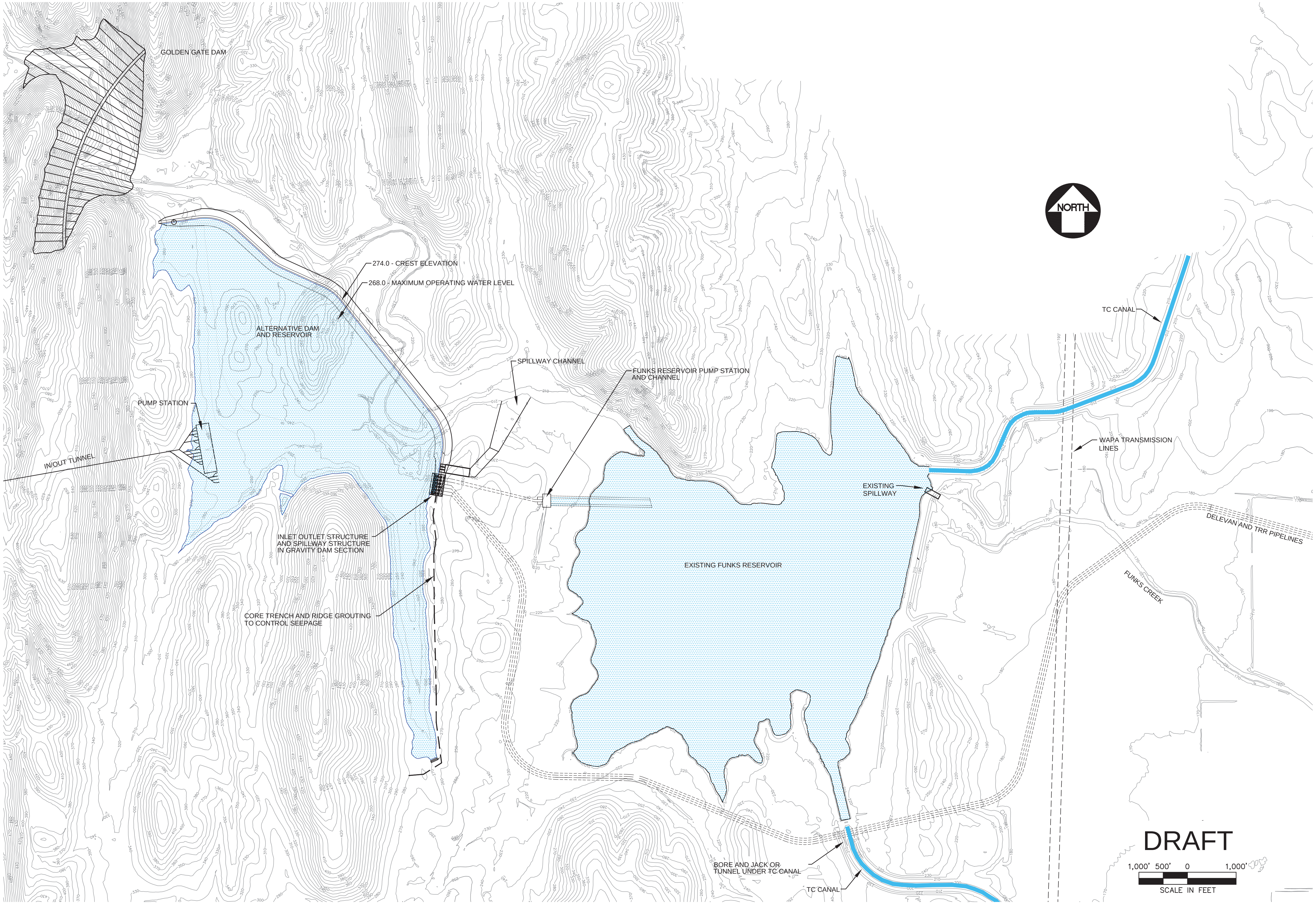

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REV	DATE	DESCRIPTION	SUB.	APPD

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Sites

AUTHORITY PROJECT ALTERNATIVE - D

FIGURE 2
OPTION 2

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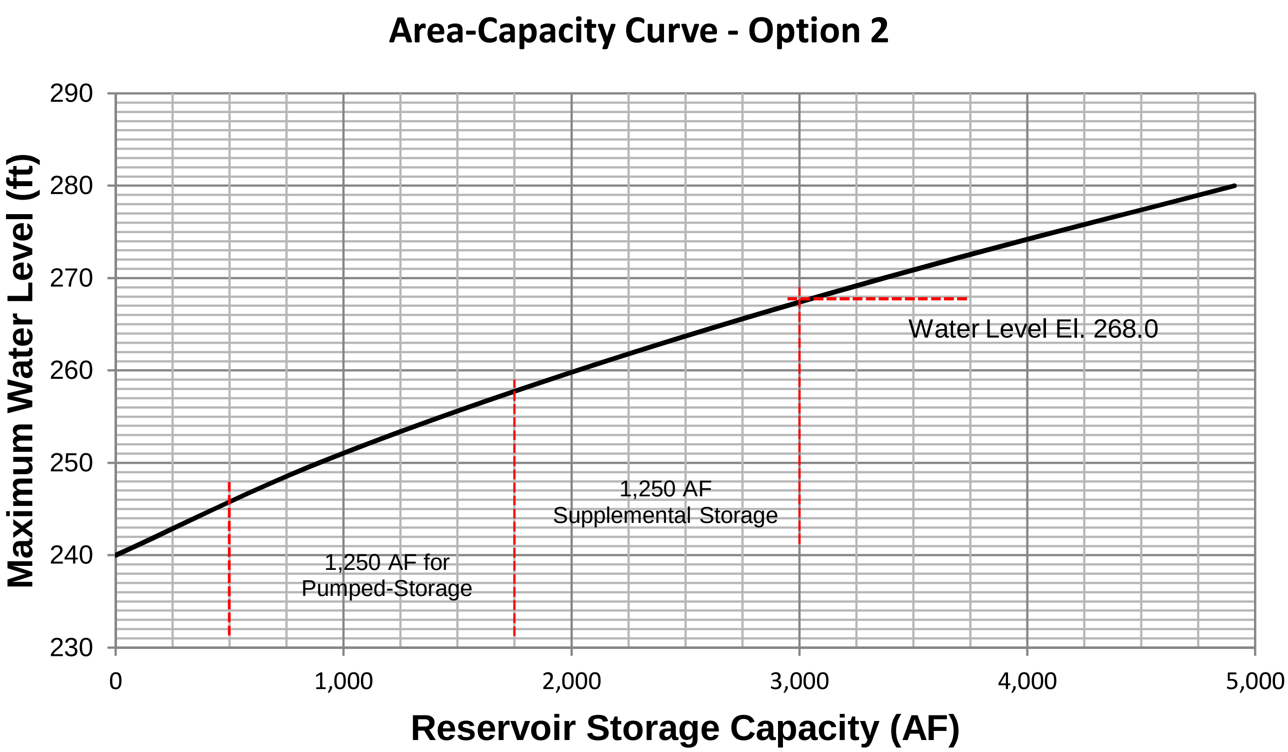

Area-Capacity Curve - Option 2
Maximum Water Level (ft)
290
280
270
260
250
240
230
0
1,000
2,000
3,000
4,000
5,000
Water Level El. 268.0
1,250 AF
Supplemental Storage
1,250 AF for
Pumped-Storage
Reservoir Storage Capacity (AF)

Figure 3

SITES RESERVOIR PROJECT

APPRAISAL LEVEL STUDY OF OPTIONS TO RELOCATE HOLTHOUSE RESERVOIR

WORKING DRAFT
SUBJECT TO CHANGE

Prepared by
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March 2019

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TABLES

FIGURES

ATTACHMENTS

ACRONYMS

Authority	Joint Powers Authority
cfs	cubic feet per second
DEC	Design, Engineering, and Construction Review
DSOD	California Division of Safety of Dams
DWR	California Department of Water Resources
fps	feet per second
GCID	Glenn Colusa Irrigation District
GWh	gigawatt-hours
JPA	Joint Powers Authority
kV	kiloVolt
LMP	Locational Marginal Pricing
MWh	megawatt hours
O&M	Operation and Maintenance
PGP	Pumping Generating Plant
Reclamation	U. S. Bureau of Reclamation
SPT	standard penetration test
TBM	tunnel boring machine
TC	Tehema-Colusa
TCCA	Tehema Colusa Canal Authority
TM	Technical Memorandum
TRR	Terminal Regulating Reservoir
WAPA	Western Area Power Association

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1 INTRODUCTION

In 2011, the Department of Water Resources (DWR) added Holthouse Reservoir to the Sites Reservoir Project to expand the size of the existing Funks Reservoir to provide extra storage, allowing the Sites Pumping Generating Plant (Sites PGP) to operate as a pumped-storage facility to enhance power generation benefits during the summer. Figure 1 shows the facilities that comprise the Sites Reservoir Project. Holthouse Reservoir, located on the existing Tehama-Colusa (TC) Canal, is the primary regulating reservoir used to manage all flows passing into and out of Sites Reservoir through the Sites PGP.

In this report, Holthouse Reservoir refers to the composite reservoir made up of the existing Funks Reservoir and the Holthouse Reservoir expansion, which would operate as a common storage pool. Water released through the Sites PGP for power generation during on-peak periods would be stored in Holthouse Reservoir. During off-peak periods, the stored water would be pumped back into Sites Reservoir. The volume of stored water pumped back on a daily basis would the water released for generation less daily releases made from Holthouse Reservoir to meet downstream irrigation needs and other commitments. Key assumptions for pumped-storage operation include the following:

a. On-peak power generation is assumed to occur over a six hour period each day.

b. Pumped-storage operation occurs primarily during summer months when no water diversions are being made from the canals or Sacramento River to Sites Reservoir.

c. Pumped-storage operation for power generation is a secondary project objective. The power generation flow is limited to a maximum of 5,100 cubic feet per second (cfs), which is the current highest estimated daily release rate needed to meet downstream irrigation and other demands without any enhancement for additional generating capability.

Adding Holthouse Reservoir to the project presents a number of challenges, including:

a. Real estate acquisition difficulties for the reservoir footprint area.

b. Need to relocate existing Western Area Power Association (WAPA) 500 kiloVolt (kV) and 230 kV transmission lines because nine existing towers fall within the planned reservoir footprint.

c. Significant risk associated with the cost estimate, design, and construction of the reservoir and dam due to the lack of any geotechnical data in the area. This is also a concern for the U. S. Bureau of Reclamation (Reclamation) that identified the lack of site specific data as a significant concern in their Design, Engineering, and Construction (DEC) Review Reports.

d. Requirement for a 12-foot-diameter temporary bypass siphon pipeline to connect segments of the TC Canal on the north and south sides of the existing Funks Reservoir. This siphon is needed to be able to maintain canal service to the south of Funks Reservoir for long periods when Funks Reservoir is dewatered. In addition, the Tehama Colusa Canal Authority (TCCA) loses the canal regulating capability provided by Funks Reservoir when the reservoir is dewatered, further complicating canal operations.

e. Sites Reservoir Project system operations and power generation are not well defined at this time. This will be more fully studied in future phases of the project. These studies could indicate that Holthouse Reservoir water levels would drop too low at times to supply the southern reach of the TC Canal by gravity from the reservoir. This could lead to a further enlargement of Holthouse Reservoir footprint in plan area as a future design impact, or require converting the temporary siphon bypass pipeline described above to a permanent project feature.

To address these challenges, the Sites Joint Powers Authority (JPA or Authority) requested that AECOM conduct a reconnaissance evaluation to determine if other reservoir sites could be identified as options to constructing Holthouse Reservoir. The evaluation identified an area on Funks Creek between the west end of Funks Reservoir and Golden Gate Dam with sufficient topographic relief to build a reservoir. AECOM prepared a Technical Memorandum[1] (TM) documenting the reconnaissance evaluation. Based on the TM, the Authority requested AECOM to prepare an appraisal level design and cost estimate for a reservoir in the area identified. This report documents the work, including engineering and design concepts, environmental evaluations, and cost estimate. The optional reservoir described in this report is named Fletcher Reservoir.

2 CURRENT HOLTHOUSE RESERVOIR CONCEPT

2.1 DESCRIPTION

Figure 2 provides a plan showing the concept for Holthouse Reservoir. A new zoned earthen dam similar to Funks Dam would be constructed across the Funks Creek floodplain east of Funks Reservoir. Water in the expanded reservoir would impound against the downstream slope of Funks Dam and the two reservoirs would interconnect through the existing Funks Reservoir spillway to form a common pool. The interconnecting spillway structure contains three large radial gates in individual bays. The spillway design capacity is approximately 21,000 cfs (based on original design plans), which is well in excess of what is needed to interconnect the reservoir pools for normal operation or to accommodate passing emergency releases from Sites Reservoir through Funks Reservoir and into Holthouse Reservoir (new spillway in Holthouse Dam passes emergency flows downstream to Funks Creek). The existing Funks Dam spillway gates could be removed after the expansion, or could remain in place in the full-up position. Likewise, Funks Dam could remain in place or could be removed as a borrow source to build the Holthouse Dam.

Four 12-foot diameter pipes connect to Holthouse Reservoir (refer to Figure 2). Two are for the Delevan Pipeline and two are for the Terminal Regulating Reservoir (TRR) Pipeline. The hydraulic inlet/outlet structures for these pipelines would be incorporated into a short concrete gravity dam section that would be built into an excavation into rock on the left (north) abutment of Holthouse Dam. This section would also include the flood control spillway, which is assumed to be a gated spillway similar to the one currently in service for Funks Dam. Figure 3 provides a plan of the inlet/outlet. Figure 4 provides an elevation of the concrete gravity section and typical cross section through one of the pipe connections.

The north abutment location was selected for the gravity dam section to provide for suitable rock foundation conditions for the inlet/outlet facilities and the spillway. Away from the abutment, in the Funks Creek floodplain, deep, soft soil conditions likely exist based on extrapolating available boring data at Funks Dam. Abutment rock conditions as well as foundation conditions under the earth dam will need be confirmed by geotechnical investigations at the site. The current lack of geotechnical data has been identified as a significant schedule and cost risk factor for the Sites project.

As shown in the Typical Pipe Entrance detail on Figure 4, each pipe inlet/outlet connection would include wheel gate slots to install a wheel gate to isolate each pipe from the reservoir if

[1] Technical Memorandum, Holthouse Reservoir Alternative, January 5, 2018.

needed. Downstream of the gate slots, an air vent and access shaft would be provided. The shaped inlet at the upstream end of each inlet/outlet is sized for a maximum inlet velocity of 2 feet per second (fps). The inlet will be surrounded by a separate bar rack structure sized for a maximum velocity of one foot per second through the bar openings to meet Reclamation standards.

The California Division of Safety of Dams (DSOD) emergency reservoir drawdown requirements will govern the sizing of the flood control works. The three gates shown on Figure 4 would be needed to pass the maximum Sites Reservoir emergency release (24,000 cfs). If portions of this emergency release are distributed to other locations around the reservoir (Sites Dam, northern saddle dams), the size of the spillway could be reduced.

DWR evaluated an option to the Holthouse Reservoir involving excavating around the perimeter of the existing Funks Reservoir to expand its active storage capacity. Expanding Funks Reservoir, however, was not adopted; apparently due to the large volume of surplus excavated material that would result because of the hilly topography around three sides of the reservoir.

3 FLETCHER RESERVOIR OPTIONS

Two potential reservoir options were identified in the AECOM 2018 TM. Figure 5 shows Reservoir Option 1 with a dam running along the south side of Funks Creek to minimize creek impacts. Figure 6 shows Reservoir Option 2 that considered building a shorter dam across Funks Creek. Both options would accommodate the Sites PGP without significant -relocation in plan.

Because of topographic constraints, Reservoir Option 1 cannot provide an acceptable amount of operational storage without being excessively deep with high, long dams. Reservoir Option 2 makes better use of the drainage ravine topography available on both sides of Funks Creek and, as described in Section 3.2, can provide an acceptable level of active storage with a more efficient dam configuration. Reservoir Option 2 is the Fletcher Reservoir configuration selected for evaluation in this report to Replace Holthouse Reservoir.

Reservoir Option 2 would inundate the downstream toe of Golden Gate Dam. There are dams in California with such inundation. This design aspect should be discussed early with DSOD if Fletcher Reservoir is adopted. Should this become a concern, a dike could be added at the upstream end of the reservoir to prevent inundation. The addition of such a dike would necessitate a pump-out system to remove seepage water that collects between the toe of Golden Gate Dam and the dike.

3.1 ADVANTAGES AND DISADVANTAGES

As identified in the AECOM 2018 TM, some of the advantages and disadvantages associated with selecting the Fletcher Reservoir option are briefly summarize below.

3.1.1 ADVANTAGES

a. Fletcher Reservoir eliminates significant impact to the operation of the existing Funks Reservoir and the TC Canal during and after construction of the Sites Reservoir Project.

b. The need for a temporary bypass siphon pipeline around Funks Reservoir to maintain canal flows during or after construction is eliminated.

c. Property acquisition for Fletcher Reservoir would be less challenging than for Holthouse Reservoir, and the real estate cost per acre would also be less.

d. The need to relocate the WAPA transmission lines is eliminated.

e. Over one mile of channel excavation to connect the Sites PGP with Holthouse Reservoir is eliminated. This channel generates a significant amount of surplus excavated material that would need to be spoiled on-site.

f. Ancillary benefits to the Sites PGP would include reduce excavation required for construction, reduction in the length of costly large diameter steel penstock piping, small reduction in the length of the Inlet/Outlet tunnel to Sites Reservoir, and reduced pumping heads for the largest pumping plant in the system.

g. Reduction in the impacts to Funks Creek and associated reduction in environmental mitigation costs.

3.1.2 DISADVANTAGES

a. Fletcher Reservoir requires a significant increase in construction lengths for the TRR Pipeline (four 12-foot diameter pipes in common trench).

b. The reservoir has a higher operating water levels then Funks Reservoir that would increase pumping heads for the TRR and Delevan Pumping Generating Plants.

c. A new Funks Reservoir Pumping Plant and two additional 12-foot diameter pipelines would be required to pump water for Funks Reservoir up into Fletcher Reservoir. (For the Holthouse Reservoir Option, water coming to the project from the TC Canal flows directly to the Sites PGP through Funks Reservoir without pumping.

d. The higher operating water level in Fletcher Reservoir decreases the power generation head for the Sites PGP, but increases the generating head for the TRR PGP and the Delevan PGP.

e. There would be impacts to the Operation and Maintenance (O&M) costs associated with Fletcher Reservoir, including the additional pumping energy required for the Funks Reservoir Pumping Plant that must be added to the project.

Where applicable, the costs for the various advantages and disadvantages listed above are reflected in the comparative cost estimates for the Holthouse Reservoir and Fletcher Reservoir options provided in this report.

3.2 PROPOSED FLETCHER RESERVOIR SIZING

Figure 7 provides a concept plan for the proposed Fletcher Reservoir. Figure 8 provides an elevation along the dam. This section provides a brief description of the criteria used to define the reservoir size and develop facility detail to support cost estimating. The reservoir concept presented is considered reasonable for comparing with Holthouse Reservoir and to support making a selection between the two. If Fletcher Reservoir is selected, it should be further evaluated in the next phase of the work to bring design details and cost estimates up to the feasibility level for inclusion in the Sites Reservoir Feasibility Report. Note that aspects of the design described in this report may be subject to modification as project designs are refined and geotechnical data becomes available in future phases of the project.

Available topography developed by DWR was used to prepare depth-capacity information for Fletcher Reservoir to select functional reservoir operating levels and set the crest elevation for Fletcher Dam. The criteria used to set the reservoir size is as follows:

a. Based on discussions with the Authority, the reservoir volume should provide space to store approximately 2,500 acre-feet of water associated with hydropower generation releases for six hours per day at a flow rate of 5,100 cfs.
b. Additional volume should be added to the power generation storage for operational flexibility. An additional 2,000 acre-feet is provided for this purpose.

Based on the sizing criteria above, the total active storage should be a minimum of 4,500 acre-feet. Figure 9 shows the reservoir depth-capacity curve developed from the available topography with the pumped-storage and operational storage volume components identified. The components are shown as discrete elements on the figure, but they can be set anywhere within the active storage zone between elevations 244.0 feet and elevation 264.0 feet. It is anticipated that future project operational studies will refine how Fletcher Reservoir active storage could best be managed for pumping and generating operations.

For comparison, the active storage in Fletcher Reservoir is about 500 acre-feet less than in Holthouse Reservoir and the operating water level range is larger. This should not be an issue. Unlike Holthouse Reservoir, Fletcher Reservoir is not functioning as the regulating reservoir for the TC Canal and the narrow operating range required for Holthouse Reservoir to be able to serve the TC canal to the south does not apply.

Note that elevation 244.0 feet was selected as the bottom of the operating storage for this study based on the shape of the storage curve. This would maintain the potential pumping and generating head change for a pumped-storage cycle to between 10 or 12 feet anywhere within the selected operating range.

3.2.1 RESIDUAL STORAGE

As shown on Figure 9, Fletcher Reservoir would have a residual storage of approximately 2,000 acre-feet below the bottom of the active storage zone at elevation 244.0 feet. The invert of the inlet/outlet structure for the Delevan, TRR, and Funks Reservoir Pipelines would be set at elevation 222.0 feet. This would make a significant portion of the residual storage available for release to the canals or Sacramento River (at reduced rates) through the pipelines, if needed.

3.2.2 SEDIMENT ACCUMULATION IN FLETCHER RESERVOIR

Being located immediately downstream of Golden Gate Dam, sediment accumulation in the bottom of Fletcher Reservoir should not be a concern.

3.2.3 EXCAVATIONS WITHIN THE RESERVOIR AREA

As seen on Figure 7, three prominent hills fall within the reservoir area. These hills, likely composed of soil and rock, would be excavated down to provide a portion of the storage volume. The estimated volume in the hills is approximately 2.1 million cubic yards. This material should be a suitable borrow source to construct the shells of Fletcher Dam and the Zone 4 downstream shell of Golden Gate Dam (which requires approximately 2.7 million cubic yards). A significant borrow source close to Fletcher Dam and on the same side of Golden Gate Dam where the material is needed enhances the constructability of the dams. The capacity curve on Figure 9 includes the volume resulting from the excavation of the hills. Note that only a portion of the cost of hill excavation is assigned to Fletcher Dam shell construction. The balance can be assigned to the cost estimate to construct the downstream shell of Golden Gate Dam.

3.3 FLETCHER DAM

Fletcher Dam is primarily an earthen embankment. However, a concrete gravity section is incorporated in the ridge on the right (south) side (refer to Figure 7 and Figure 8). The gravity section incorporates the six individual inlet/outlet connections, wheel gate closure shafts, and bar racks serving the large diameter Delevan, TRR, and Funks Reservoir pipelines.

For this study, the crest of Fletcher Dam is assumed at Elevation 274.0 feet; 10 feet above the maximum normal operating level at Elevation 264.0 feet (refer to Figure 9). This provides space for flood routing and residual freeboard. The spillway concept, design criteria, and estimated flood depth are discussed in Section 3.4.

3.3.1 EARTHEN EMBANKMENT

Embankment Description: The maximum height of the earthen embankment section would be approximately 70 feet measured above the bed of Funks Creek, excluding camber. The higher dam segment crossing the creek floodplain would be approximately 1,500 feet long. On the left (north) abutment the embankment would tie into a steep hill. The spillway would be incorporated into this abutment. On the right (south) abutment, embankment height reduces significantly and a low embankment, approximately 800 feet long and 14 feet above grade, would run along the ridge

For the current study, the typical cross section, internal embankment zoning and foundation treatment for Fletcher Dam is assumed to be the same as proposed for the high saddle dams located around the northern perimeter of Sites Reservoir. The typical high saddle dam section is shown on Figure 10. Exceptions are that the crest will be 20 feet wide and the freeboard above the maximum operating level will be 10 feet.

Geotechnical Considerations: Unlike Holthouse Reservoir, there are four auger borings in the proposed Fletcher Dam area as shown on Figure 11; two are under or very close to the dam footprint. Table 1 summarizes the boring data from available DWR logs.

Table 1 Available Boring Data

No.	Location	Description
GGO-AUG-1 Depth 11 feet El. 220.0 feet	Just under downstream shell, south of Funks Creek.	Bottom in intensely weathered sandstone with iron staining; moderately strong/hard; SPT at bottom recorded 81 blows for bottom 12 inches; no depth to water noted.
GGO-AUG-2 Depth 13.5 feet El. 230.0 feet	Just outside upstream Shell, South of Funks Creek.	Bottom in intensely weathered sandstone; no bedding; moderately strong/hard; SPT at bottom recorded 71 blows for bottom 12 inches; no depth to water noted.
GGO-AUG-3 Depth 36.3 feet El. 240.0 feet	West of dam, close to Funks Creek.	Sandy silty clay with gravel near base to 29 feet; gravelly silt to 35.4 feet. Mudstone below 35.4 feet, with iron staining; weak/soft; SPT at bottom recorded 89 blows for bottom 12 inches; depth to water 25.2 feet.
FR-AUG-7 Depth 28.5 feet El. 221.0 feet	East of dam toward Funks Reservoir	Silt, clay, sand and gravel layers 4 to 9 feet thick to 28.5 feet; sandstone from 28.0 to 28.5 feet; California Modified Blow Count of 150 for 6 inches in sandstone; no depth to water noted.

Notes:
SPT = Standard Penetration Test

From the information in Table 1, the following foundation assumptions were made for this study:

a. Based on the first two auger holes (AUG-1 and AUG-2) that are in close proximity to the dam, the depth below grade to the shell foundations for the dam would average approximately 12 feet across the floodplain away from Funks Creek. An additional 10 feet of required excavation was assumed to reach the core foundation across the floodplain. The shell excavations should remove soils subject to seismic liquefaction.
b. Based on the second two borings (AUG-3 and AUG-7), the depth below grade to the shell foundation for the dam in the vicinity of Funks Creek would average approximately 35 feet. An additional 10 feet of required excavation was assumed to reach the core foundation under the creek. Here again, the shell excavations would remove soils subject to seismic liquefaction.
c. Shallower excavation depths were assumed in the higher elevation areas on the left and right abutments of the dam.
d. Dewatering may not be a significant issue across the floodplain based on observed groundwater conditions noted in the auger holes.

A supplemental geotechnical investigation program is being planned for the Sites Project that will include drilling and geophysical investigations for the proposed Fletcher Dam area. The results will better define foundation conditions to support the future feasibility evaluation and preliminary design.

3.3.2 GRAVITY DAM

The gravity dam section is located in a cut section on the ridge on the south side of the earthen dam. A gravity section is proposed that would incorporate all of the formed and shaped facilities that are required for the inlet/outlet for the Delevan, TRR, and Funks Reservoir Pipelines. The gravity section would be founded on rock (Figure 8).

3.4 SPILLWAY

It is assumed for this study that the flood control spillway would be constructed on the left (north) abutment of the dam (refer to Figure 7). The criteria representing the maximum likely spillway design flow conditions that DSOD could require would be as follows:

a. For accidental over-pumping into the reservoir at the maximum rate. This could be up to 5,900 cfs.
b. For accidental releases from Sites Reservoir through the Sites PGP with the pipelines closed. This could be up to 5,100 cfs.
c. To pass the portion of the emergency Sites Reservoir drawdown that would be made through the Sites PGP assuming this flow passes over the spillway and into Funks Reservoir. This could be 10,000 cfs as further in Section 3.4.1.

3.4.1 EMERGENCY RELEASE FLOW

The initial peak release flow required from Sites Reservoir to meet DSOD emergency drawdown requirements would be 24,000 cfs. Managing and spreading out this release has been on ongoing goal for the Authority. It is not necessary to make the entire emergency release at one location. For this study, it is assumed that the release will be distributed between three locations. Six thousand cfs could be made through the diversion tunnel at Sites Dam to Stone Corral Creek. An additional six thousand cfs could be released through outlet works located at two of the highest saddle dams at the north end of Sites Reservoir. This would leave 12,000 cfs passing through the Sites PGP to be managed at Fletcher Reservoir. Of the 12,000 cfs, at least 2,000 cfs can be released directly back to the Sacramento River through the Delevan Pipeline. The remaining 10,000 cfs would pass uncontrolled over the spillway and would be the design basis for the spillway. Note that bypass valves in the new Funks Reservoir Pumping Plant would be provided to regulate irrigation releases back to Funks Reservoir and the TC Canal at a rate up to 2,000 cfs. For this study, it is assumed that these bypass valves would not be used to manage a portion of the emergency release, but these valves could be used if needed.

3.4.2 SPILLWAY DETAILS

For this study, the spillway would be a 300-foot long side channel spillway with crest set at elevation 264.0 feet and with a chute section and energy dissipating basin at the base of the chute. Figure 12 provides a profile for the spillway and a typical section through the Ogee crest side channel planned for the left (north) abutment of Fletcher Dam. Figure 13 shows the spillway rating curve developed for the 300-foot long crest.

The maximum water surface level in the reservoir when passing 10,000 cfs over the spillway would be at elevation 268.5 feet. This includes an allowance for head loss as water flows over the approach apron to the spillway crest. With the dam crest set at elevation 274.0 feet, approximately 5.5 feet of freeboard would remain to the waterside dam crest. The energy dissipation basin would be a standard basin discharging directly to Funks Reservoir designed to pass 10,000 cfs with the Funks Reservoir water surface at elevation 206.0 feet. Water discharged to Funks Reservoir from the spillway would pass downstream to Funks Creek through the existing radial gates in Funks Dam. These gates will not restrict the emergency release. They have a capacity up to approximately 21,000 cfs at elevation 206.0 feet based on the design spillway rating curve provided in the design plans for Funks Dam.

The design of the spillway and stilling basin generally follow the procedures recommended in the Reclamation's Design of Small Dams and other publications. The spillway sizing and water surface profile shown on Figure 12 were developed from preliminary hydraulic evaluations of the spillway assuming a critical depth control section located immediately downstream of the 300-foot crest section.

Other design considerations for the spillway would include:

a. Buttressed reinforced concrete walls for the higher spillway wall sections at and adjacent to the dam crest.
b. A spillway bridge at the intersection with the crest of the dam.
c. Anchor dowels for the chute floor.
d. Gravel and pipe drain system under the chute slabs.
e. Continuation of the foundation grouting for the core of the dam under the spillway across the full width to the north abutment.

3.5 SITES PUMPING GENERATING PLANT IMPACTS

With Fletcher Reservoir, the Sites PGP would relocate up in elevation and to the west in plan location due to the higher reservoir operating levels. This relocation would lead to cost savings when compared with the Holthouse Reservoir option that are valid to consider in preparing the cost comparisons for the two options. Cost reductions opportunities would include:

a. A possible 300 foot reduction in the total length of the large diameter Inlet/Outlet Tunnel connecting the Sites PGP with Sites Reservoir. The length removed would be in the more expensive downstream tunnel segment containing the steel liner.
b. Reduced excavations to construct the pumping plant site area, pumping plant, and the buried penstock piping that connect the pumping and generating units to the tunnel.
c. Reduced length for the larger diameter steel penstock piping, which is quite costly to fabricate and install. Some of these are 26 feet and 30 feet in diameter.

Note that the reductions listed above are based on comparisons in location for the Sites PGP as currently design with the single, large inlet/outlet tunnel. The dual tunnel option currently under consideration for the inlet/outlet tunnel should not affect the potential for cost reductions at the Sites PGP, and could provide additional savings because of further potential reductions in the size of the penstock piping. There could also be the potential for additional cost savings for the pumping generating plant equipment for the Fletcher Reservoir option. However, the facility design is not sufficiently advanced at this time to make reliable assessments of potential savings.

4 TRR PIPELINE EXTENSION OPTIONS FOR FLETCHER RESERVOIR

The TRR Pipeline is the only conveyance feature requiring pipeline extensions to connect to Fletcher Reservoir. The TRR Pipeline starts at the TRR PGP. The cost estimate for this pipeline segment includes four pipes in a common trench, two for the continuation of the Delevan Pipeline past TRR and two to convey the discharge from the TRR PGP to Holthouse or Fletcher Reservoirs.

Note that pumping and generating heads for the Delevan PGP and the TRR PGP are affected by the increased length of the TRR Pipeline and the higher operating water levels in Fletcher Reservoir compared to the Holthouse Reservoir option. Pumping and generating energy cost impacts to the O&M costs for the Sites Project are address in Section 4.3.

4.1 PIPELINE ALIGNMENT OPTIONS FOR FLETCHER RESERVOIR

As shown on Figure 14, there are two possible pipeline routes to extend the TRR Pipeline to the west to Fletcher Reservoir. Both options would start at a common point just west of the pipeline bore and jack location under the Glenn Colusa Irrigation District (GCID) Canal (refer to Figure 14). A southerly pipeline option would begin by following the current TRR Pipeline alignment to the vicinity of the inlet structure to Holthouse Reservoir. At that point it would diverge to the south, cross under the WAPA transmission lines, and continue around the south and west sides of Funks Reservoir to the Fletcher Reservoir Inlet Structure. A northerly pipeline option would proceed straight up the hill from the common start point toward the TC Canal, and then generally follow around the north side of Funks Reservoir to an intake/outlet facility location on the north bank of Fletcher Reservoir. Both optional alignments would require an additional bore and jack to install pipe under the TC Canal.

With the Holthouse Reservoir option, summer releases back to the canals and to the Sacramento River are made by gravity without a need for pumping. This criterion would apply for the Fletcher Reservoir option. The north and south pipeline routes were selected so that the crown of the installed pipe is always a minimum of 10 feet below the hydraulic grade line for the controlling return flow case. The controlling case would be for the Delevan Pipeline assuming a potential need to deliver a total of 2,000 cfs back to the Sacramento River (1,000 cfs per pipe). This case would cover conveying to the river a portion of the emergency reservoir release for

Sites Reservoir or an enhanced environmental release back to the river. The normal maximum design flow in the Delevan Pipeline is typically 1,500 cfs (750 cfs per pipe).

For the southerly alignment shown on Figure 14, there are two short segments (less than 200 feet) where some addition hillside cutting or deeper trench excavation would be needed to provide for gravity flow. These areas are located just to the east and west of the bore and jack under the TC Canal.

For the northerly alignment, maintaining gravity flow will require bench cutting around the hill adjacent to the TC Canal near the canal terminus at Funks Reservoir. Figure 15 provides the bench cut location and concept used for this study.

In addition to the bench cut, a tunnel section is required near Fletcher Reservoir, due to topographic constraints. Figure 16 provides the tunnel concept. For this study, two lined 17-foot ID tunnels are used. Each tunnel would connect to two of the four TRR Pipelines. The tunnel size was selected so that the flow velocity in the tunnel would be comparable to the flow velocity in each of the two connecting pipelines. Based on current understanding of the geology of the area, either a tunnel boring machine (TBM) or roadheader could be used to advance the tunnels. The tunnel length may be too short for the TBM, so a roadheader was used for estimating purposes. Attachment A contains further background and details regarding the tunnel concept and cost. Note that the cost elements provided in Attachment A have been broken down and redistributed to fit within the estimating format for costs and markups used in Table 4.

Twin tunnels would likely be preferred for O&M flexibility. With two tunnels and four pipelines, there here should be a valve control structure at a convenient location just east of the downstream (east) tunnel portal to interconnect one Delevan Pipeline with one TRR pipeline. Using this interconnection, at least 50 percent flow can be maintained in the Delevan and TRR systems using one tunnel if the other tunnel is taken out of service for any reason.

4.2 OPTIONAL CONVEYANCE LENGTHS

Table 2 provides a comparison of the approximate conveyance lengths required for the Fletcher Reservoir option compared with Holthouse Reservoir from the common starting point. Lengths are single pipe or tunnel lengths, not total combined lengths.

Table 2 Conveyance Lengths for Pipeline Options

Conveyance	Holthouse Reservoir	Fletcher Reservoir Northerly Alignment	Fletcher Reservoir Southerly Alignment
Pipeline Length (feet)	11,720	15,300	23,000
Tunnel length (feet)		2,400	
Total (feet)	11,720	17,700	23,000
Increase (feet)	0 (Base Case)	5,980 (1.13 Miles)	11,300 (2.14 Miles)

Note: Pipeline lengths are measured from common starting point on west side of GCID Canal.
Lengths shown are single pipe or tunnel lengths.

4.3 PUMPING AND GENERATING HEAD IMPACTS

The increased pipe lengths shown in Table 2 and the higher operating water level in Fletcher Reservoir (approximately 60 feet) will impact pumping and generating heads for the Sites PGP, TRR PGP, and Delevan PGP. This will affect the energy costs included as part of the estimated O&M expenses for the Sites Reservoir Project. Also, new pumping costs would be incurred from the addition of the Funks Reservoir Pumping Plant needed to pump TC Canal water into Fletcher Reservoir. With the Holthouse Reservoir option, the TC Canal water flows directly to the Sites PGP through Funks Reservoir and the pumping plant is not needed.

To evaluate potential changes to pumping and generating revenues AECOM used the daily estimated diversion and release flow data developed by Hill-Jacobs for Sites Project Alternative D. System head curve data was developed for pumping and generating conditions for each pump generating plant, including pumping for the new Funks Reservoir Pumping Plant. The system head curves reflected increased conveyance lengths and higher static lifts associated with the Fletcher Reservoir options. The system head data was used to estimate winter pumping and summer generating energy for each day over the 82-year record and the results were averaged over the record period. The Holthouse option was also evaluated to serve as the base case for determining changes.

Table 3 provides the results of the energy evaluation for the average year in gigawatt-hours (GWh).

Table 3 Pumping and Generating Energy Evaluation

Item	Average Annual Energy (GWh)			Increase/Decrease (GWh)	
	Holthouse (Base Case)	Fletcher with Northerly Pipeline	Fletcher with Southerly Pipeline	Fletcher with Northerly Pipeline	Fletcher with Southerly Pipeline
Pumping Energy Required					
Delevan PGP	45.1	60.0	61.2	14.9	16.1
TRR PGP	11.5	19.0	19.5	7.6	8.0
Funks PGP	0.0	20.1	20.1	20.1	20.1
Sites PGP - Winter Pumping	179.3	140.7	140.7	(38.6)	(38.6)
Sites PGP - Summer Pump Back	45.6	36.1	36.1	(9.6)	(9.6)
Total Pumping	281.5	275.9	277.6	-	-
Net Pumping Change - Fletcher Options	-	-	-	(5.6)	(3.9)
Hydroelectric Energy Production					
Delevan PGP	23.3	40.6	39.8	17.3	16.5
TRR PGP	5.7	10.0	9.9	4.3	4.2
Sites PGP - Summer Generation	109.0	83.7	83.7	(25.3)	(25.3)
Total Generation	138.0	134.3	133.4	-	-
Net Generation Change - Fletcher Options	-	-	-	(3.7)	(4.6)

Notes:
GWh = gigawatt-hours
PGP = Pumping Generating Plant

Assumptions reflected in Table 3 include the following:

a. For TRR PGP and Delevan PGP, the winter pumping and the summer generation on release would occur 24 hours per day (no pumped-storage operations).
b. For the Sites PGP, winter pumping into Sites Reservoir would also occur 24 hours per day.
c. For the Sites PGP, summer operation would include daily pumped-storage operation for power generation and daily pump back of the generation water release that is not needed to meet daily irrigation requirements. Pumped storage operation is based on power generation at a flow of 5,100 cfs for six hours per day. For convenience, pump back of residual water on a daily basis is assumed to occur over a 12 hour period each day.

d. Unit efficiencies for the Sites PGP for pumping and generation were assumed to vary from 82 percent at lower levels to 88 percent at high levels depending on the reservoir elevation for the day being calculated. For all other pumping generating plants, the efficiency was assumed to be a constant 88 percent assuming that upstream and downstream water levels would be managed to maximize the efficiency of the pumping or generating operation.

e. Winter pumping is evaluated for the months December through March. Summer generation is evaluated for the months May through October.

f. Within the months evaluated, there are times (periods of days) where the pumped or released flows from the model are low and well below what could be accommodated using a reasonable spread of pumping and generating equipment. To avoid skewing the data for the average year for this study, the estimate of pumping and generation energy ignored days when the daily flows were less than 200 cfs for the Delevan PGP and 100 cfs for the TRR PGP.

5 ENVIRONMENTAL ASSESSMENT AND MITIGATION COSTS

AECOM prepared a TM to provide a comparison of the environmental impacts and feasibility-level mitigation cost estimates for the Holthouse Reservoir and the two possible Fletcher Reservoir options (Figure 2, Figure 5, and Figure 6) to support further evaluation of these options, in consideration with other factors. This analysis is limited to implementing mitigation measures and does not include best management practices already included in previously estimated project costs associated with the design, construction, and operations and maintenance activities. A copy of the TM is included as Attachment B to this study.

6 OPTION COST EVALUATION

An appraisal level cost was prepared for the Fletcher Reservoir option to compare against the cost for Holthouse Reservoir included in the Basis of Estimate Report for the Sites Reservoir Project. Table 4 provides the comparison. All costs presented in the table are estimated in October 2018 dollars. Subsequent sections provide additional discussion for some of the individual cost items.

The cost comparison in Table 4 uses Holthouse Reservoir as the base case, and provides pricing for the Fletcher Reservoir option with the northerly pipeline and tunnel alignment. The southerly alignment is not included because construction costs would be slightly higher and potential energy benefits lower. In addition, the northerly alignment avoids significant property acquisition issues and environmental impact issues associated with Funks Creek downstream from the existing Funks Dam.

6.1 RELOCATIONS AND TEMPORARY BYPASS SIPHON PIPELINE (ITEMS 1 AND 2)

Relocation of WAPA transmission lines and the need for a temporary bypass siphon pipeline are eliminated with both of the Fletcher Reservoir pipeline options and these costs are avoided.

6.2 TUNNELS (ITEM 7)

The cost estimate for the tunnels in Table 4 is developed from costs provided in Attachment A. These costs were broken down and redistributed to fit within the construction cost and markup format used in Table 4. The tunnel cost estimate does not include the use of any steel liners with the concrete lining.

Table 4 Appraisal Level Cost Comparison

Item	Facility	Holthouse Reservoir Direct Cost ($)	Fletcher Reservoir Northerly Pipe Alignment Direct Cost ($)
1	Relocate WAPA Lines	18,223,660	-
2	TC Canal Siphon Bypass	11,046,385	-
3	Holthouse Dam and Appurtenances	97,231,190	-
4	Channel Excavation, Holthouse to Sites PGP	34,647,305	-
5	Delevan	460,298,230	460,298,230
6	TRR Pipeline	247,672,950	278,303,585
7	Tunnel	-	95,500,000
8	TC Canal Bore and Jack	-	13,020,000
9	Fletcher Dam	-	43,400,000
10	Funks Pump Station and Pipeline	-	37,975,000
11	Fletcher Reservoir Spillway	-	16,275,000
12	Other Avoided Impacts For Fletcher Reservoir Option	-	-
12a	Pipeline Excavation and Backfill Premium for Reduced Pipeline Cover	3,255,000	-
12b	300' I/O Tunnel Reduction Due to Sites PGP Relocation to the West for Fletcher Reservoir	6,900,600	-
12c	Reduced Excavation for Sites PGP	6,510,000	-
12d	Reduced Length of Large Diameter Penstock Piping at Sites PGP	10,850,000	-
13	Allowance for Other Unallocated Costs		10,850,000
14	Embankment Foundation and Construction Cost Risk	40,000,000	8,000,000
	Total Direct Cost	**936,635,320**	**963,621,815**
15	Mobilization 5%	46,832,000	48,181,000
	Subtotal	983,467,320	1,011,803,000
16	Design Contingency 10%	98,347,000	101,180,000
	Contract Cost	1,081,814,320	1,112,983,000
17	Construction Contingency 15%	162,272,000	166,947,000
	Field Cost	1,244,086,320	1,279,930,000
18	Noncontract Cost 17%	211,495,000	217,588,000
	Construction Cost	**1,455,581,320**	**1,497,518,000**
19	Other Cost		
19a	Real Estate Affected by Option (With Markups)	9,920,000	470,000
19b	Environmental Mitigation Avoided Cost	3,011,000	2,679,000
19c	Differential Pumping Avoided Cost (PW for 100 Years)	7,440,000	-
	Total	**1,475,952,320**	**1,500,667,000**
		Differential Cost for Fletcher Reservoir	**24,714,680**

6.3 TC CANAL BORE AND JACK (ITEM 8)

An additional bore and jack will be required for the northerly TRR Pipeline route to pass the pipeline under the TC Canal (refer to Figure 14). The location for this bore and jack and controlled by topography and the need to avoid impacts to an existing check structure, bridge, and underdrain pipeline for the canal in the area.

6.4 FUNKS PUMP STATION AND PIPELINE (ITEM 10)

The Fletcher Reservoir option requires a new pump station and two short sections of 12-foot diameter pipeline to convey TC Canal water from Funks Reservoir into Fletcher Reservoir. This pump station and pipeline are not needed for the Holthouse Reservoir option because TC Canal water flows directly into Funks Reservoir and to the Sites PGP. For this study, it is assumed that the pump station would employ a series of 6 to 8 vertical turbine wet pit pumps in a reinforced concrete structure. There would be a separate electrical and control building, and a short channel section to open the pump station out into Funks Reservoir. Two energy dissipation valves would also be provided to return up to 1,000 cfs back to Funks Reservoir to meet summer demands. No hydroelectric generation capability is included with this facility.

6.5 UNALLOCATED COSTS (ITEM 13)

An allowance of $10.85 million was included in the Fletcher Reservoir cost to cover items not estimated in detail for this study, including the pipeline to tunnel connection structure and the valve structure to interconnect the Delevan and TRR Pipelines east of the tunnel portal.

6.6 EMBANKMENT FOUNDATION AND CONSTRUCTION RISK ALLOWANCE (ITEM 14)

A significant factor considered for the comparison of the Holthouse Reservoir and Fletcher Reservoir options is risk associated with constructing the dam foundations across Funks Creek and the floodplain. No foundation investigation data exists for Holthouse Dam, which introduces significant risk into the appraisal level design concept for the dam, required foundation excavation depths, the reliability of quantities for construction, and the suitability of the cost estimate. In contrast, Fletcher Reservoir is located to the west of Funks Reservoir in an up-slope area closer to the ridge that forms the eastern side of Sites Reservoir. Foundation conditions should be better at this site, which is also supported by limited data in the area available from auger borings in the area completed by DWR (refer to Table 1 in Section 3.3.1).

To monetize the construction risk, mitigation cost information provided in the Sites Reservoir Quantitative Risk Assessment Report[2] was used. From information in the Risk Register, the mid-range cost to mitigate the various construction cost risks associated with Holthouse Reservoir amount to approximately $40 million. This amount is included in Table 4. Fletcher Reservoir still includes a level of risk, but this risk is likely lower than for Holthouse Reservoir. For this study, a residual risk of $8 million, or 20% of the Holthouse Reservoir risk, has also been included for Fletcher Reservoir in Table 4.

6.7 AVOIDED COST FOR PUMPING ENERGY (ITEM 19c)

As shown in Table 3, the Fletcher Reservoir option with the northerly pipeline could reduce annual pumping energy by approximately 5.6 GWh (5,600 megawatt hours [MWh]). For 2018, the average hourly Locational Marginal Price (LMP) at NP 15 (essentially Northern California) is $39.09 per MWh. From December to March, the average hourly LMP could be a little less, but using an annual average is conservative.

For this study, the average hourly LMP is assumed to be $39.09. For a reduction of the annual pumping energy of 5,600 MWh, the annual cost reduction would be approximately $218,900. For a 100 year term at 2.75%, this savings would have a present value (2018 Dollars) of approximately $7.44 million. A $7.44 million cost reduction for the Fletcher Reservoir option for pumping energy has been included in Table 4 as a cost adder for the Holthouse Reservoir option.

6.8 POWER GENERATION COSTS

As indicated in Table 3, there could be a net reduction in annual power generation of approximately 3.7 GWh on average for the Fletcher Reservoir option. It is difficult to price this change to evaluate O&M impacts as it is made up of on-peak generation for the main Sites PGP and on-peak and off-peak run of release generation for the Delevan PGP and TRR PGP. There are ways to minimize or overcome the reduction, including optimizing the efficiency of the generating equipment to be purchased for all facilities, and generating through the Sites PGP beyond the 6 hour on-peak period each day, even though the generated energy would be of a

[2] AECOM, May 1, 2018. Sites Reservoir Project, Quantitative Risk Assessment Results.

lower value. Based on flow-duration data for Sites Reservoir releases, about 50 percent of the time, releases at 5,100 cfs would extend well beyond 6 hours each day without pump back just to meet the downstream daily irrigation demand. For these reasons, no penalty for lost generation revenue is included in the costs shown in Table 4.

6.9 OTHER COST ITEMS

The items listed in Table 4 represent the major costs that apply to an evaluation of the Holthouse Reservoir and Fletcher Reservoir options. There are other factors, including risks associated with facilities other than the dams, that are not included.

7 CONCLUSIONS AND PATH FORWARD

As can be seen from the comparison of costs provided in Table 4, Fletcher Reservoir is more expensive than Holthouse Reservoir by approximately $25 million. In terms of the total cost of the Sites Reservoir Project, this is not a significant increase (approximately 0.5 percent). Furthermore, there are significant landowner, environmental, and cultural considerations that haven't been fully characterized and monetized at this time. Fletcher Reservoir is probably the preferred option from a real estate/landowner perspective. It would also pose less impact to operation of the TC Canal. These considerations should not be ignored in making the selection between Holthouse Reservoir and Fletcher Reservoir. Future design phases of the project may develop design refinements and identify other opportunities and benefits for Fletcher Reservoir that have not been identified at this time. Given the cost difference between the options, a decision to take the comparison of the options to the feasibility level would be appropriate.

8 LIMITATIONS

AECOM represents that our services were conducted in a manner consistent with the standard of care ordinarily applied as the state of practice in the profession, within the limits prescribed by our client. No other warranties, either expressed or implied, are included or intended in this study.

Background information and other data (including topographic information) have been furnished to AECOM, which AECOM has used in preparing this study. AECOM has relied on this information as furnished, and is neither responsible for nor has confirmed the accuracy of this information.

The analyses and results presented in this study are for this current study only, and should not be extended, or used for any other purposes. The estimates supplied are for comparative purposes consistent with this appraisal level evaluation and are not intended for construction.

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FIGURES

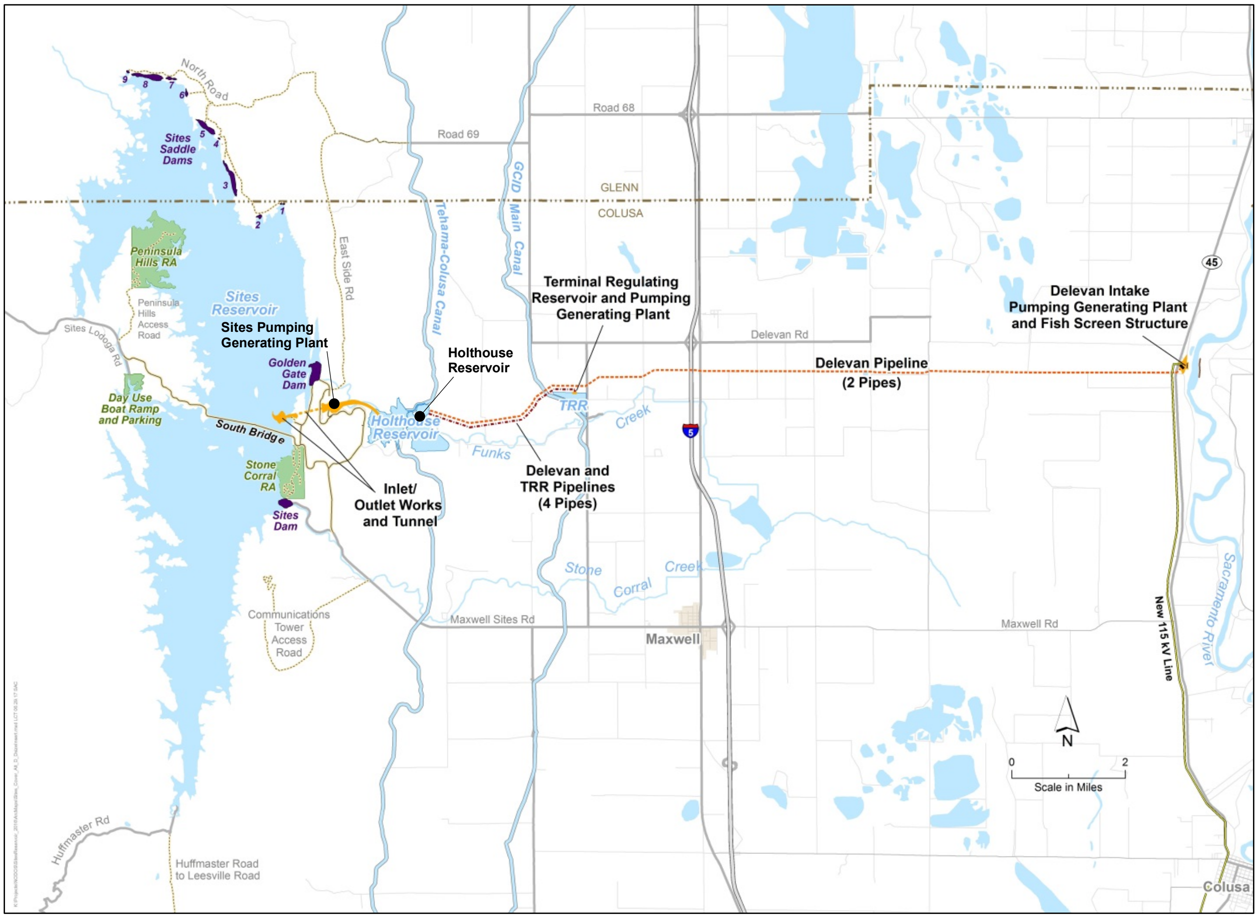


Figure 1 Sites Project Features

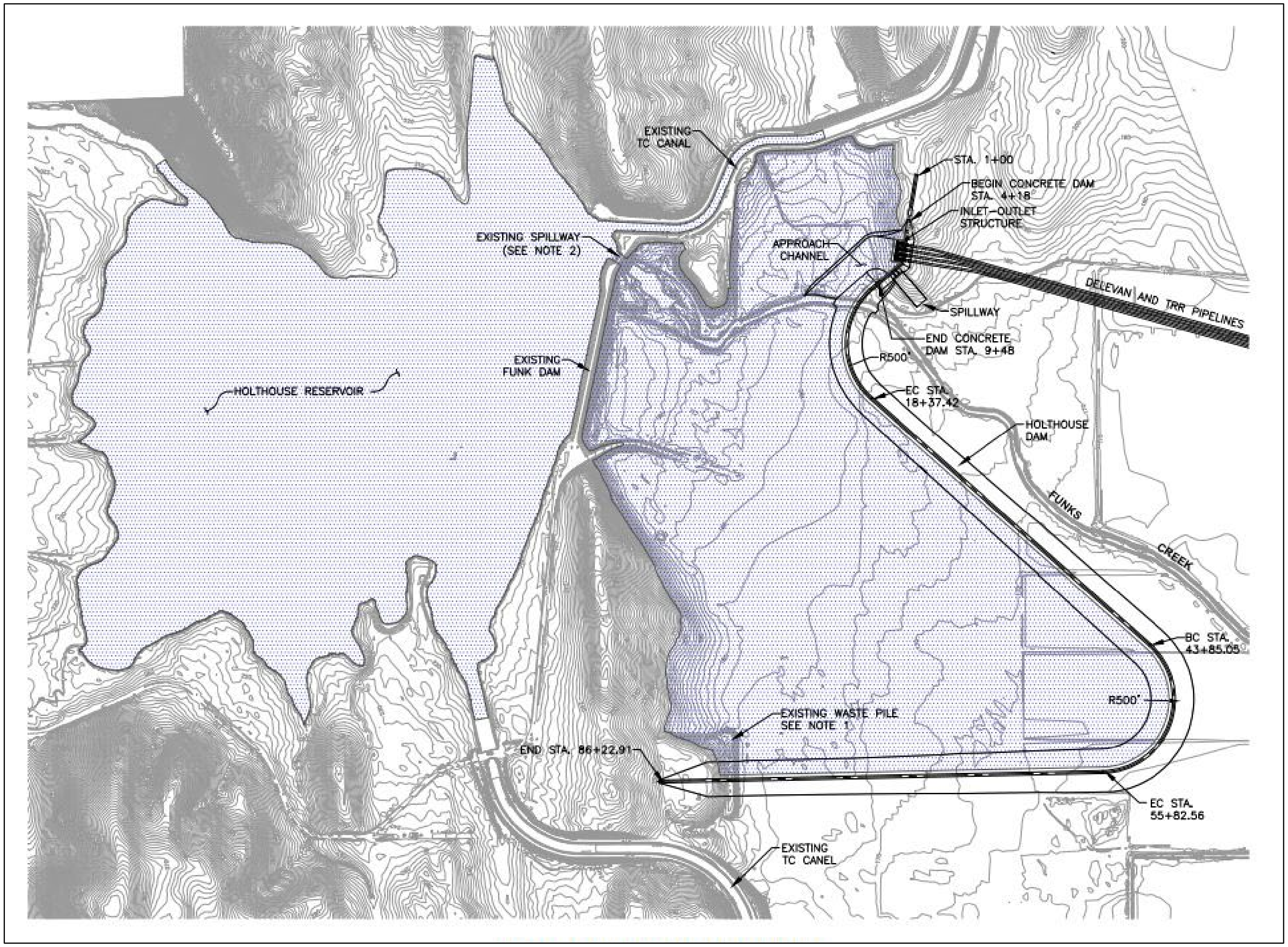


Figure 2 Holthouse Reservoir Plan

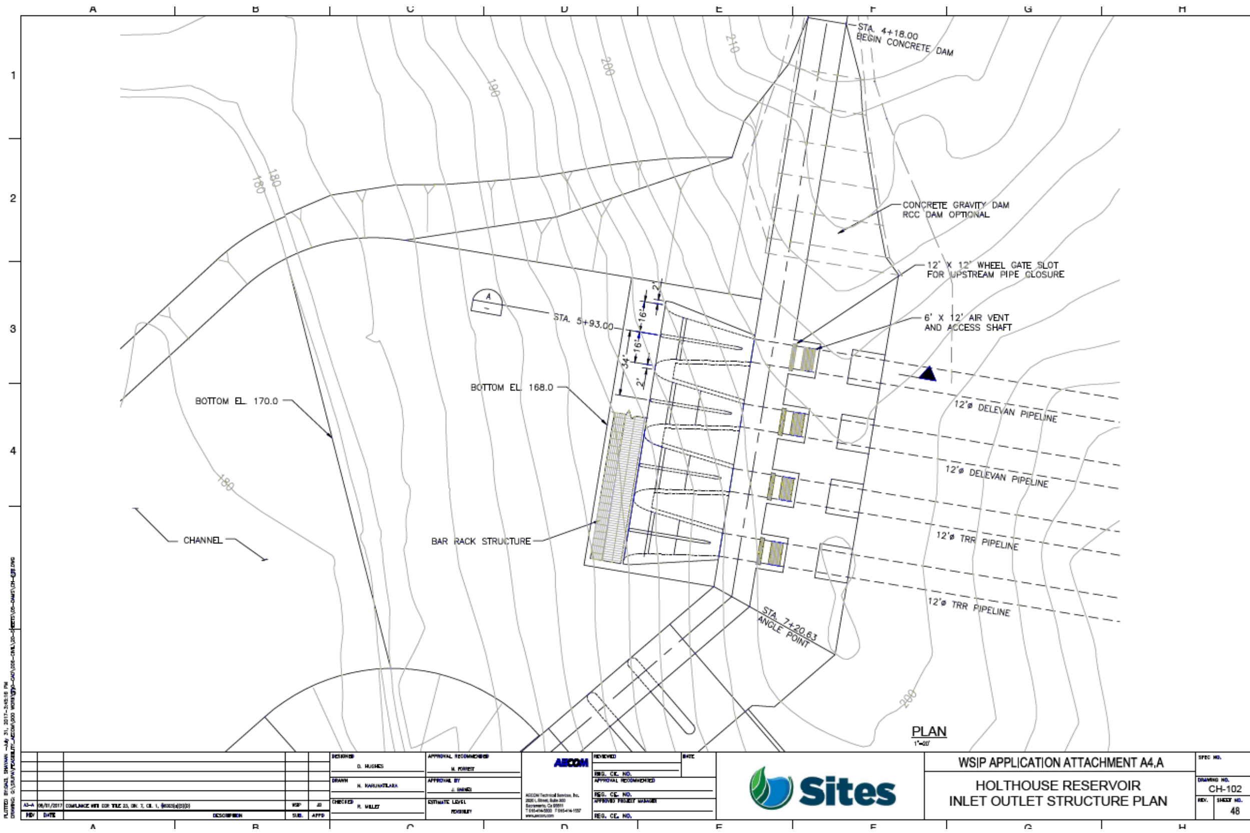


Figure 3 Holthouse Inlet/Outlet Plan

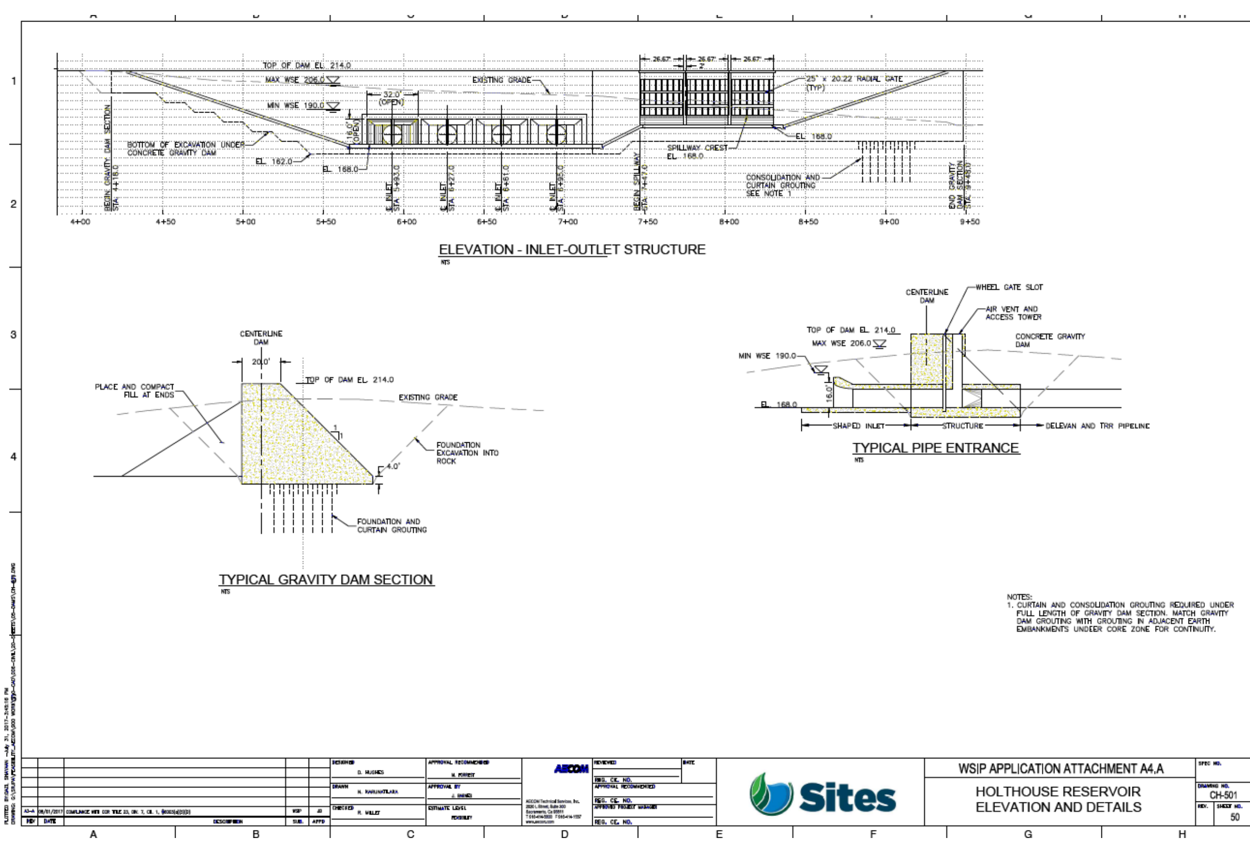


Figure 4 Holthouse Reservoir Inlet/Outlet Elevation and Sections

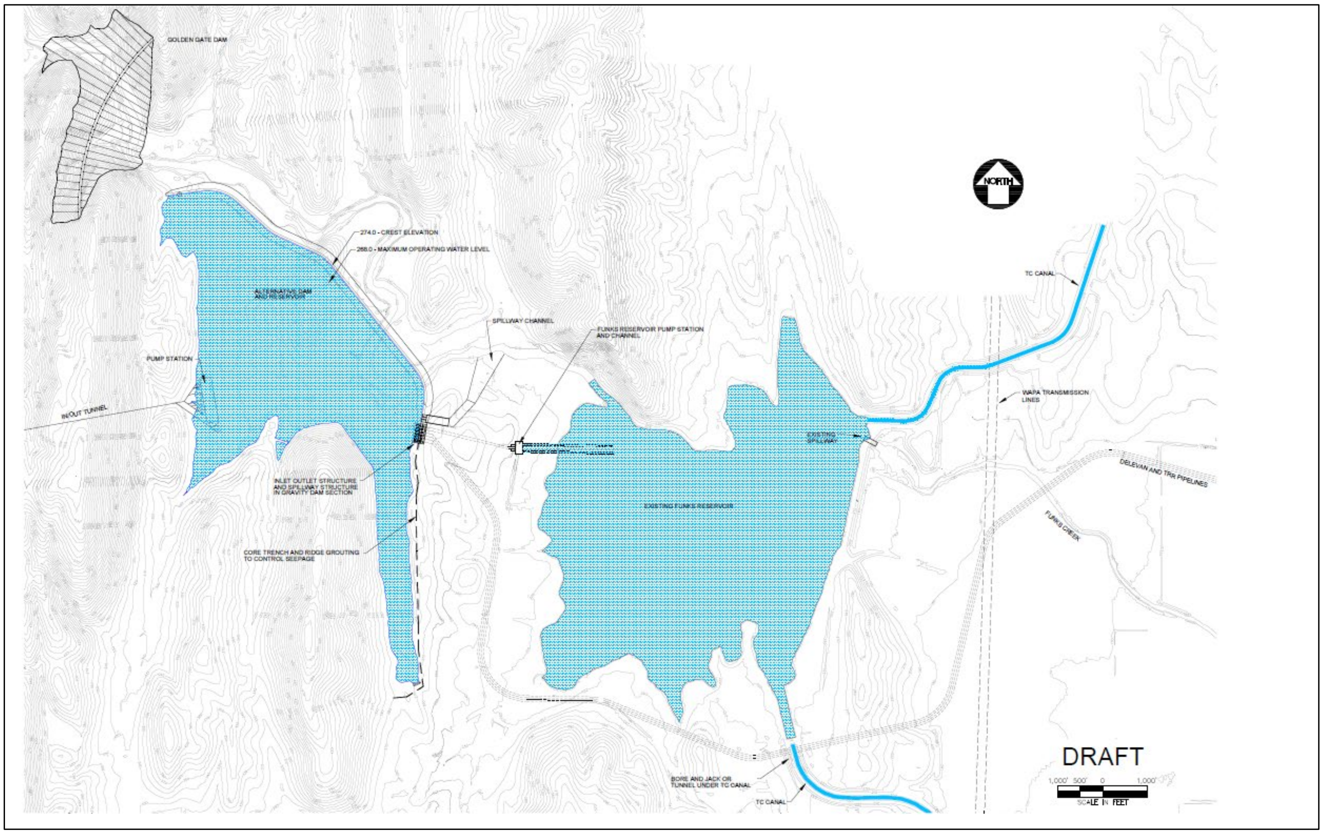


Figure 5 Fletcher Reservoir Option 1

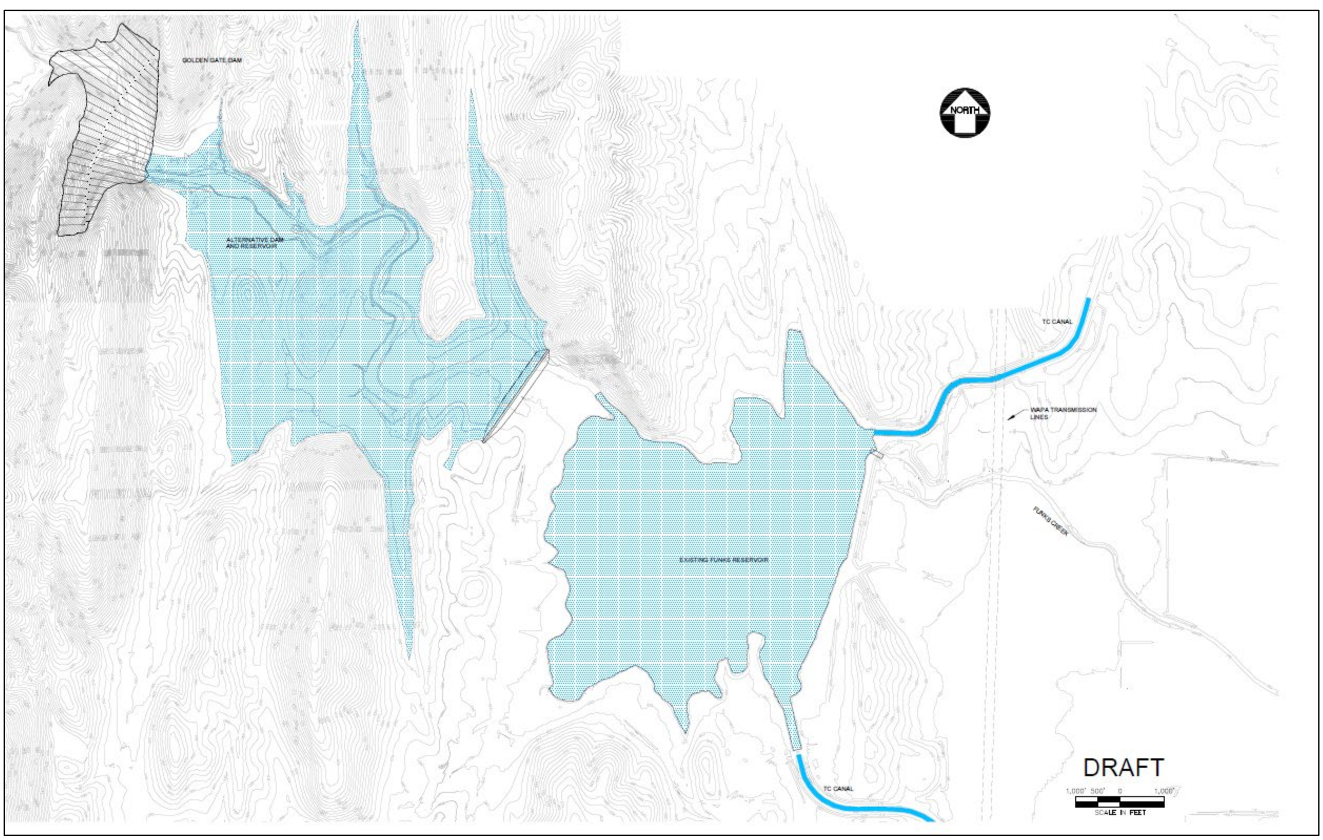


Figure 6 Fletcher Reservoir Option 2

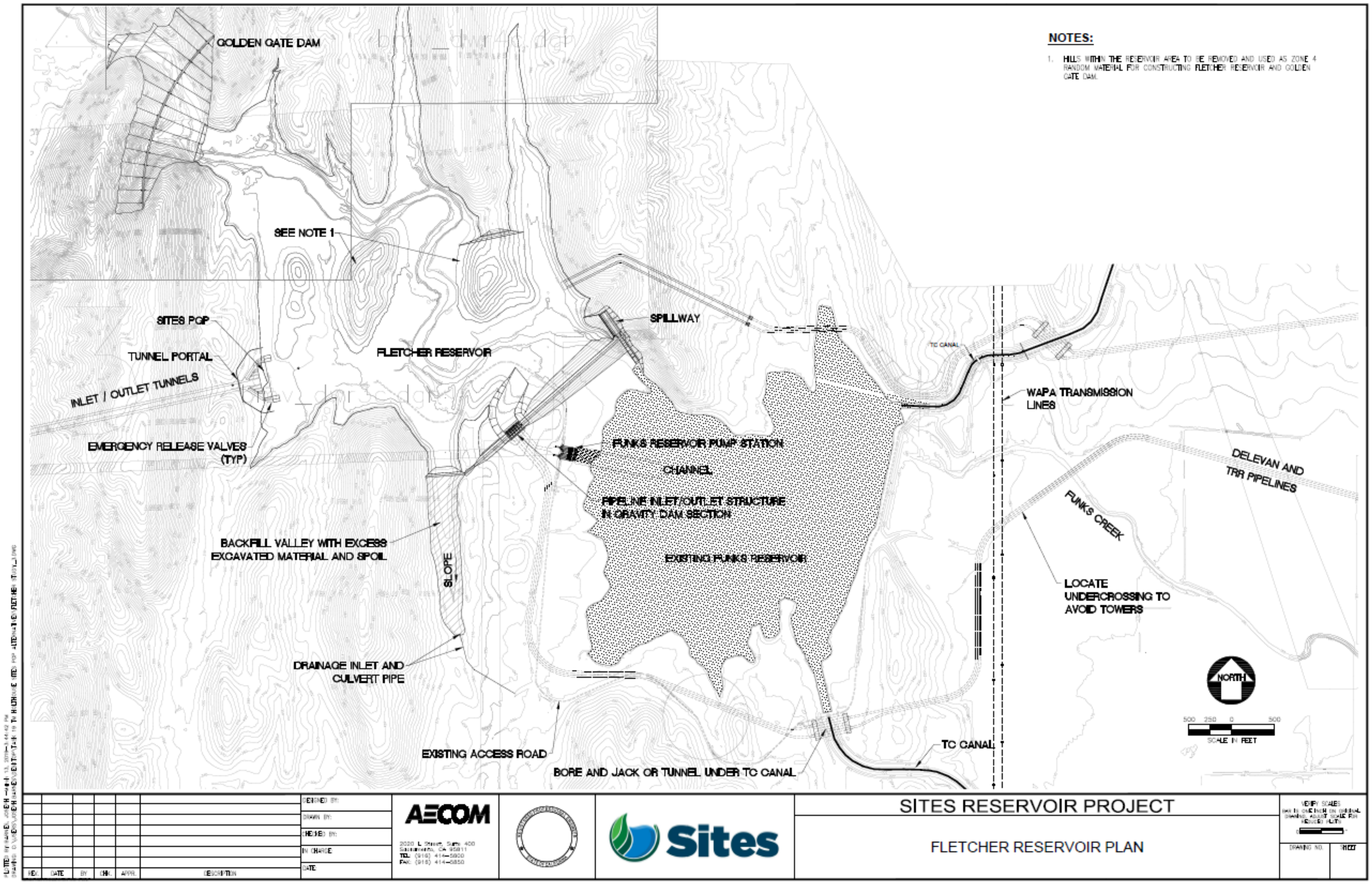


Figure 7 Fletcher Reservoir Plan

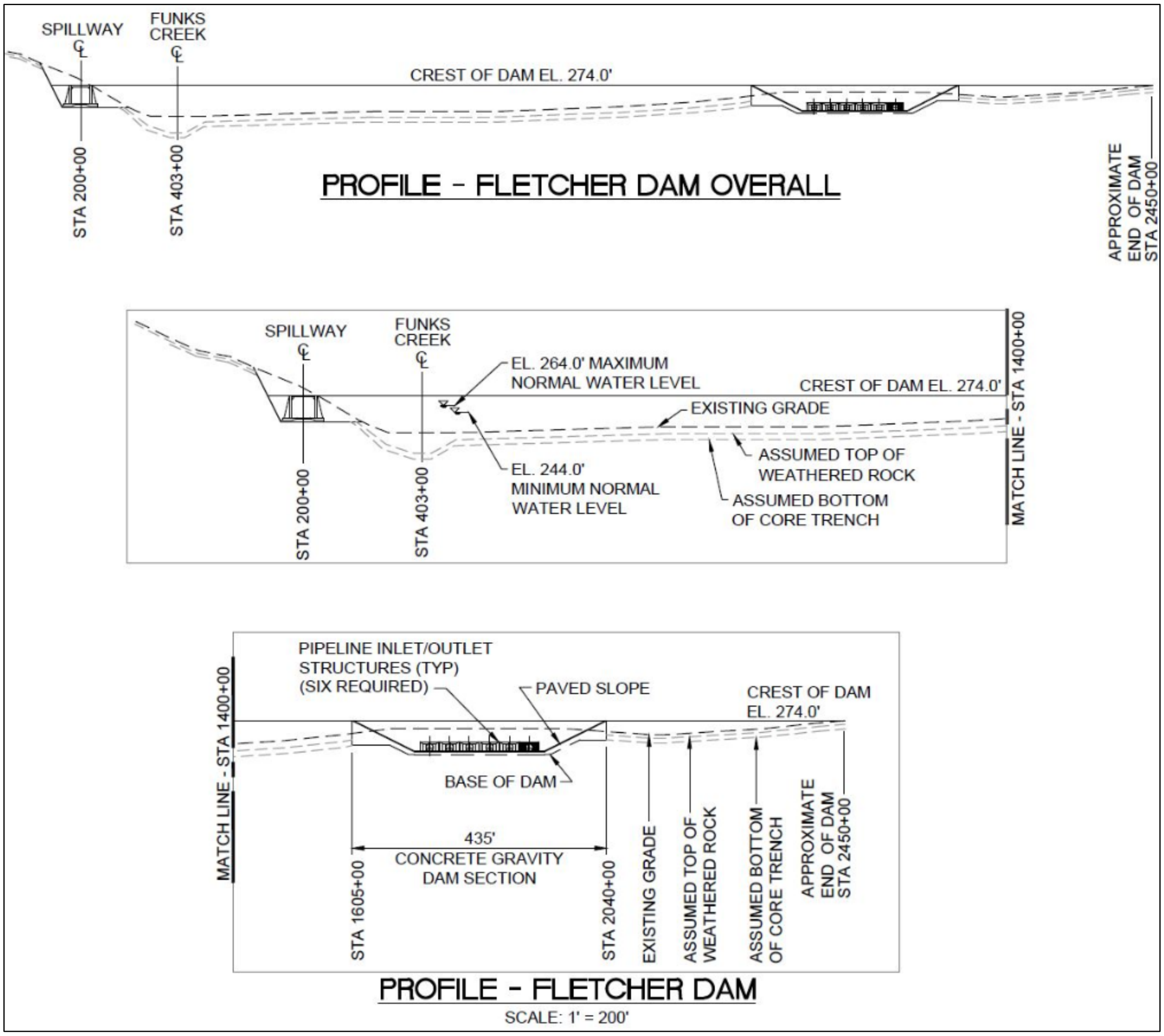


Figure 8 Embankment Elevation

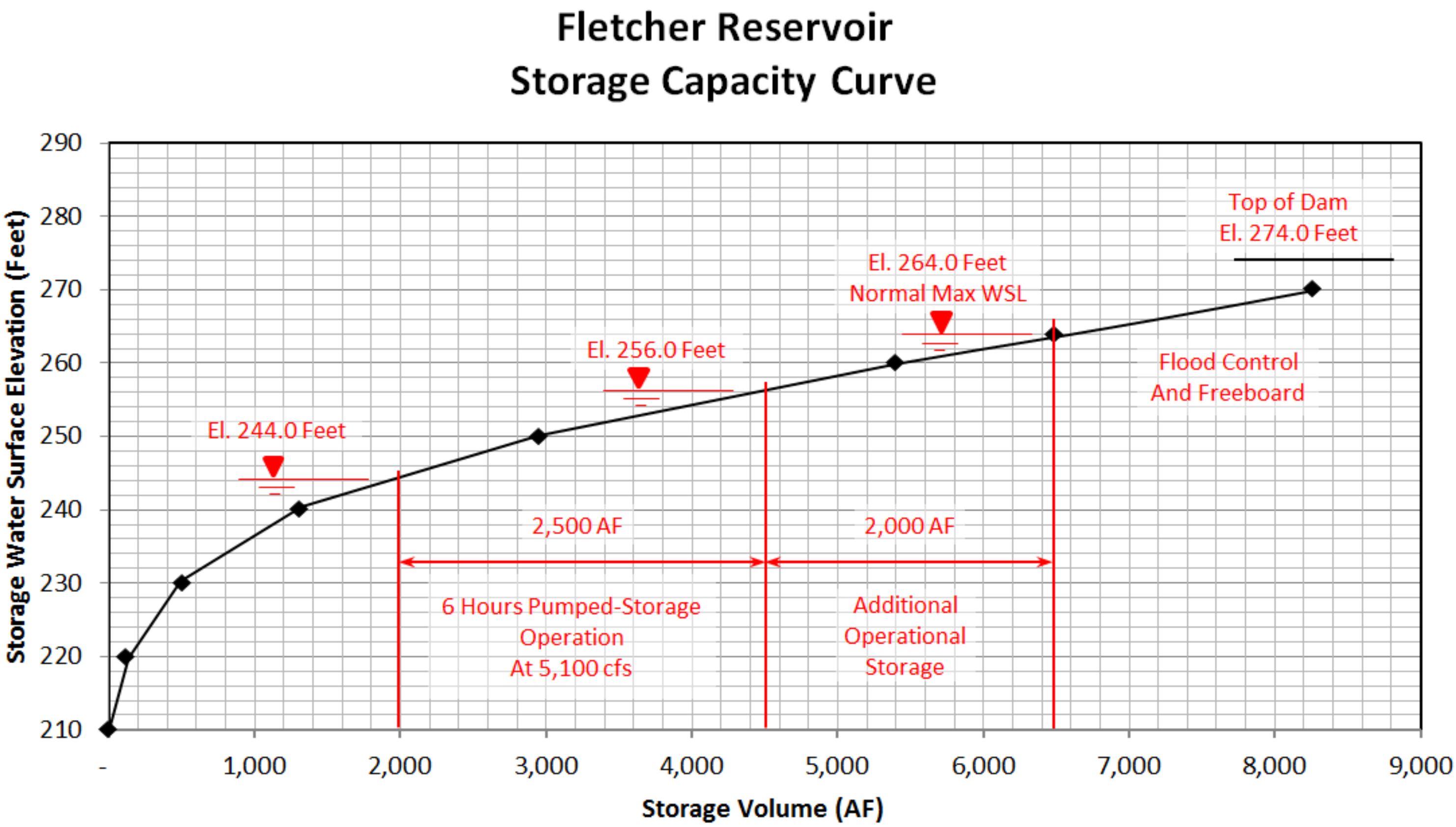


Figure 9 Reservoir Storage Curve

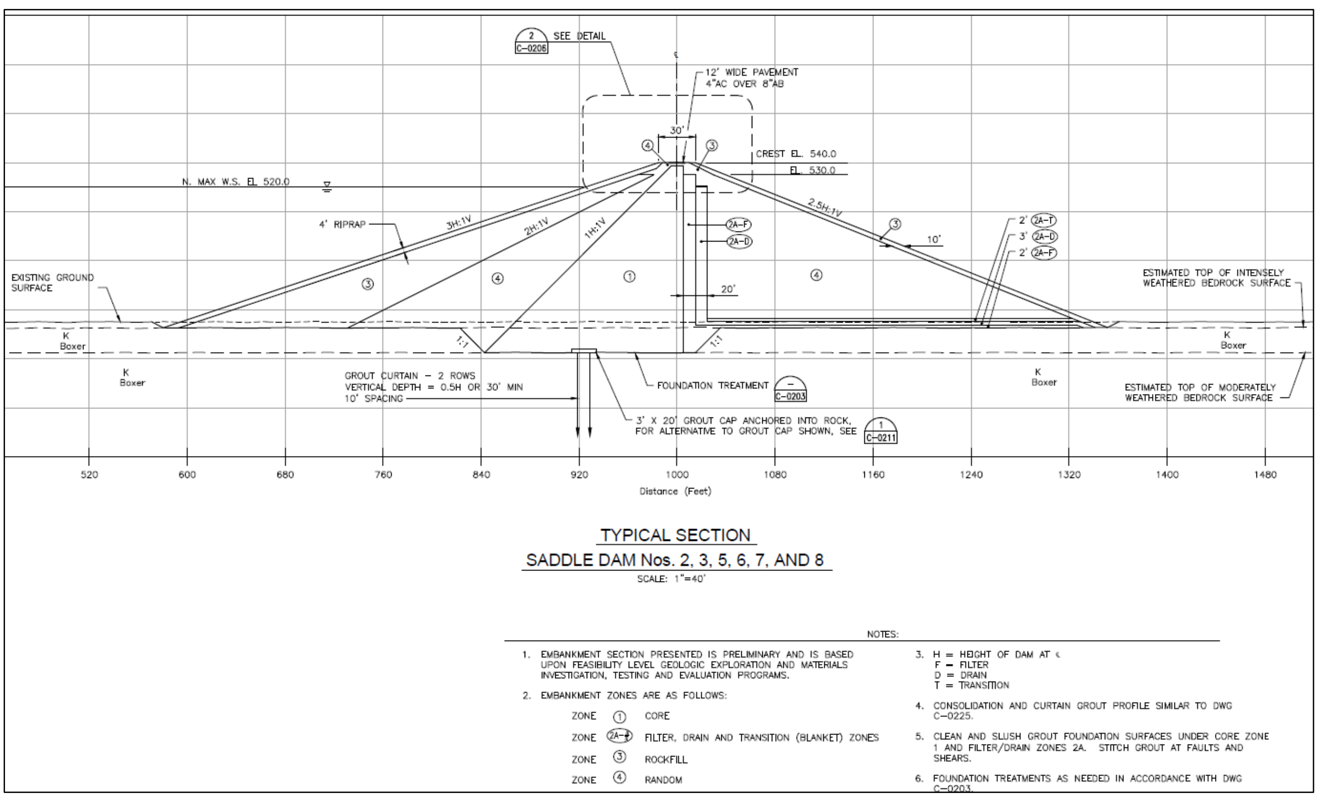


Figure 10 Dam Section

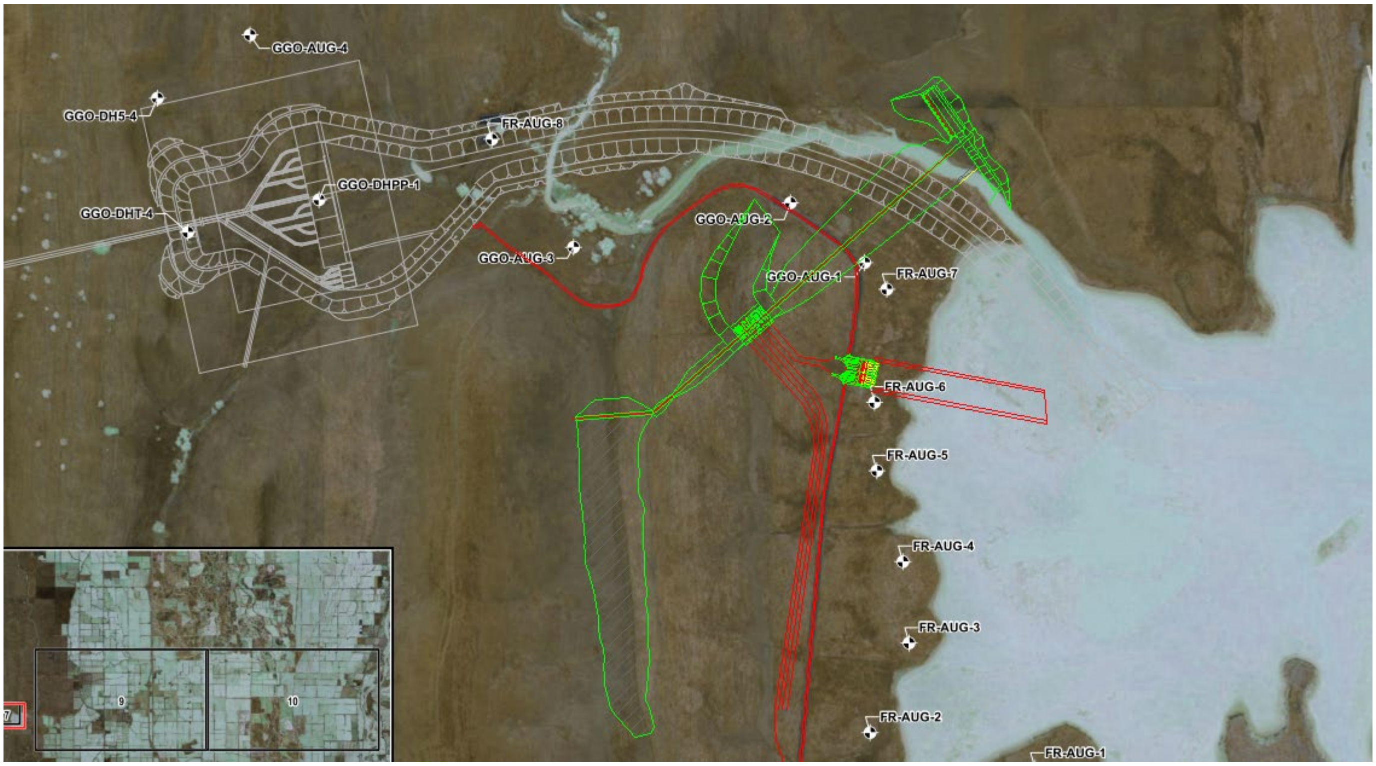


Figure 11 Existing Boring and Auger Hole Locations

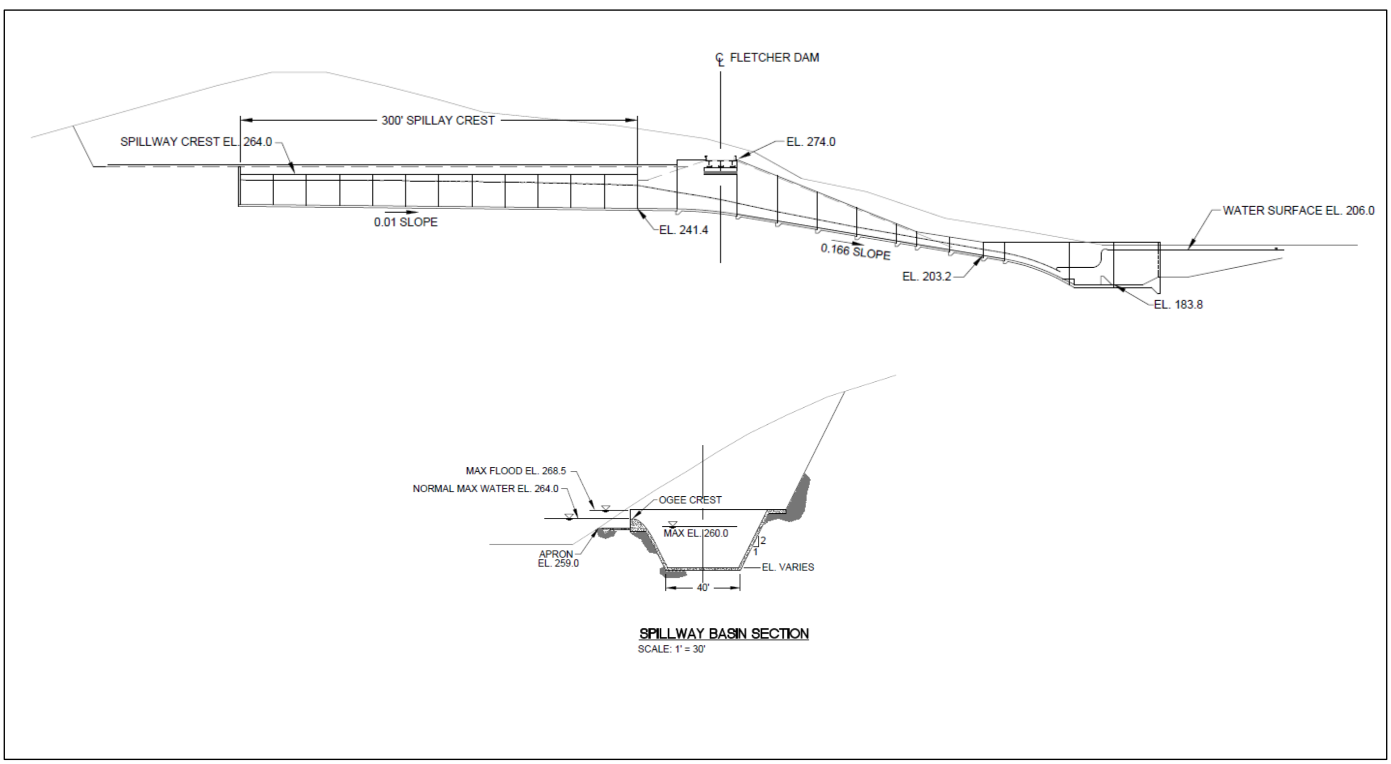


Figure 12 Spillway Profile and Section

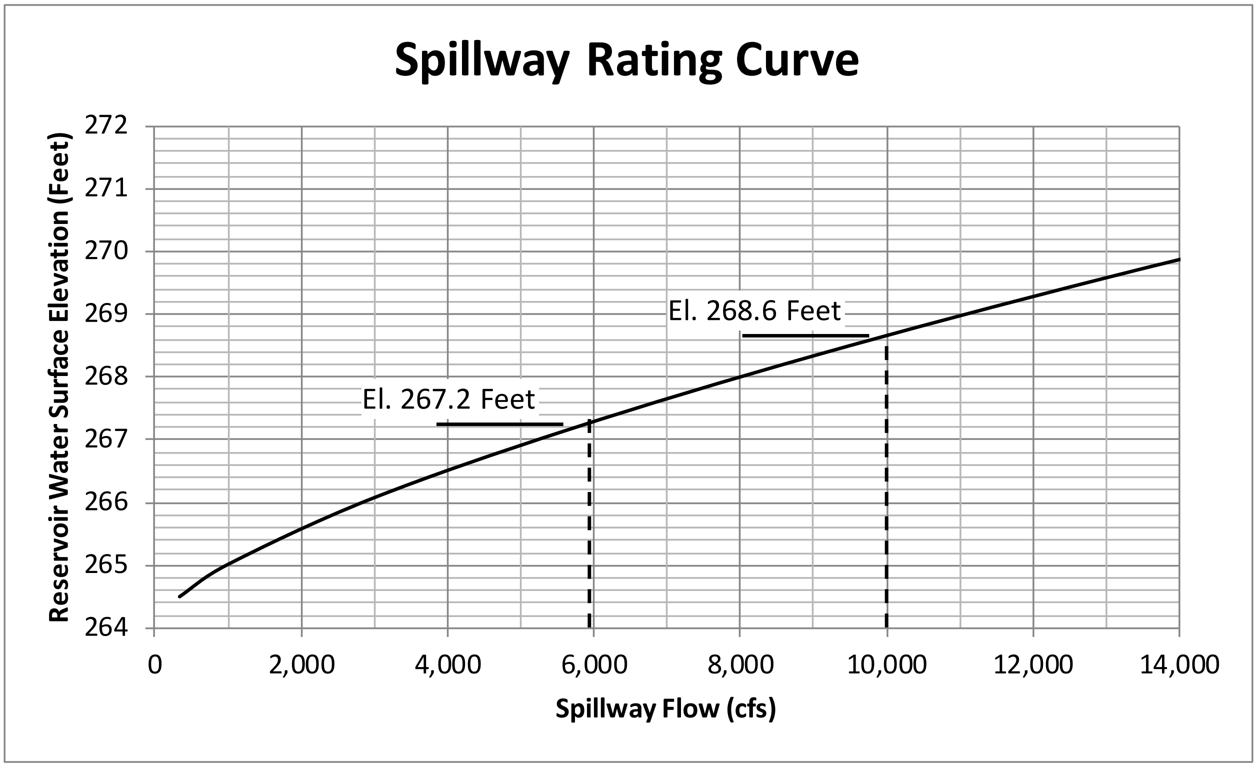


Figure 13 Spillway Rating Curve

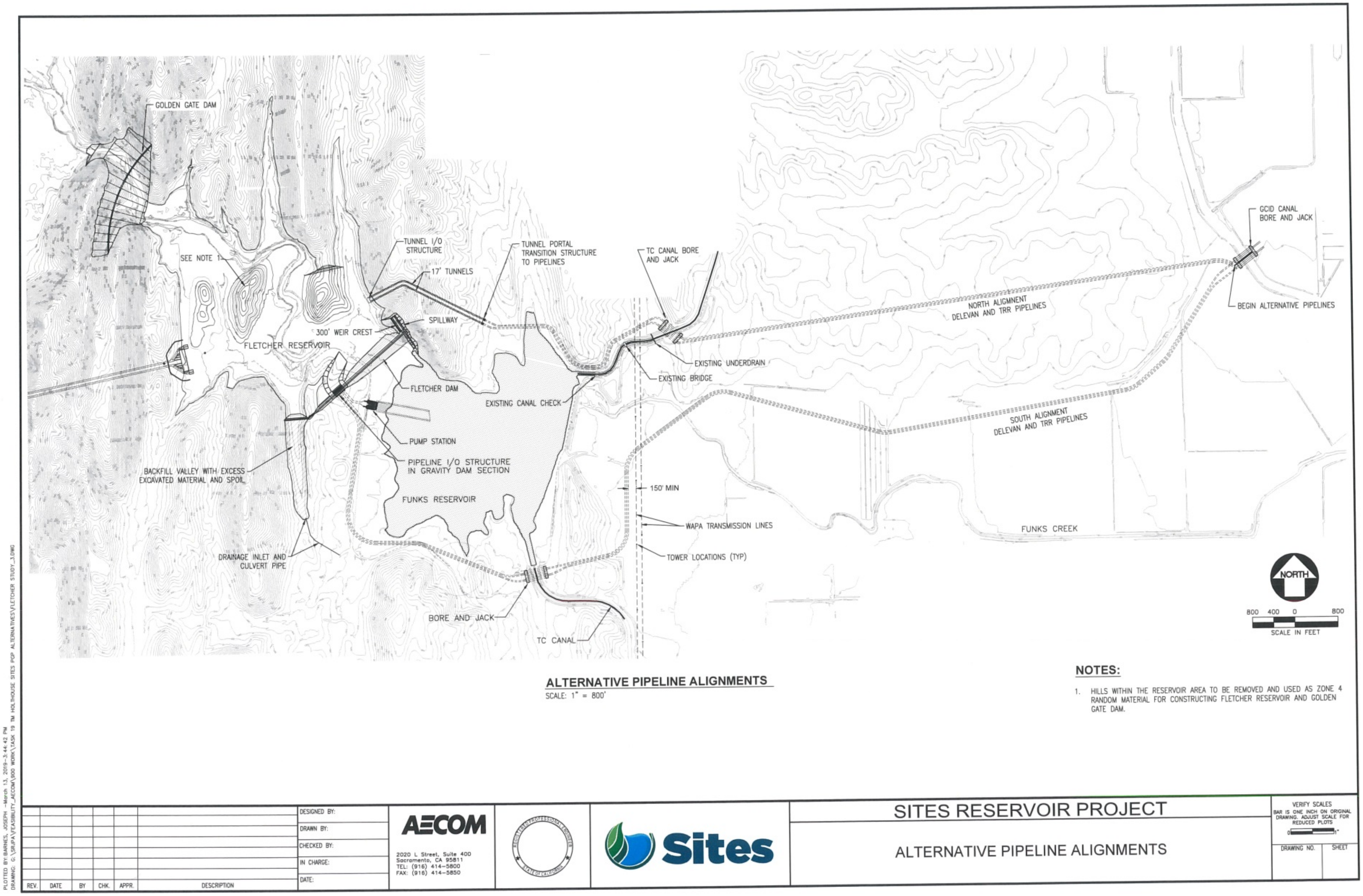


Figure 14 Pipeline Options

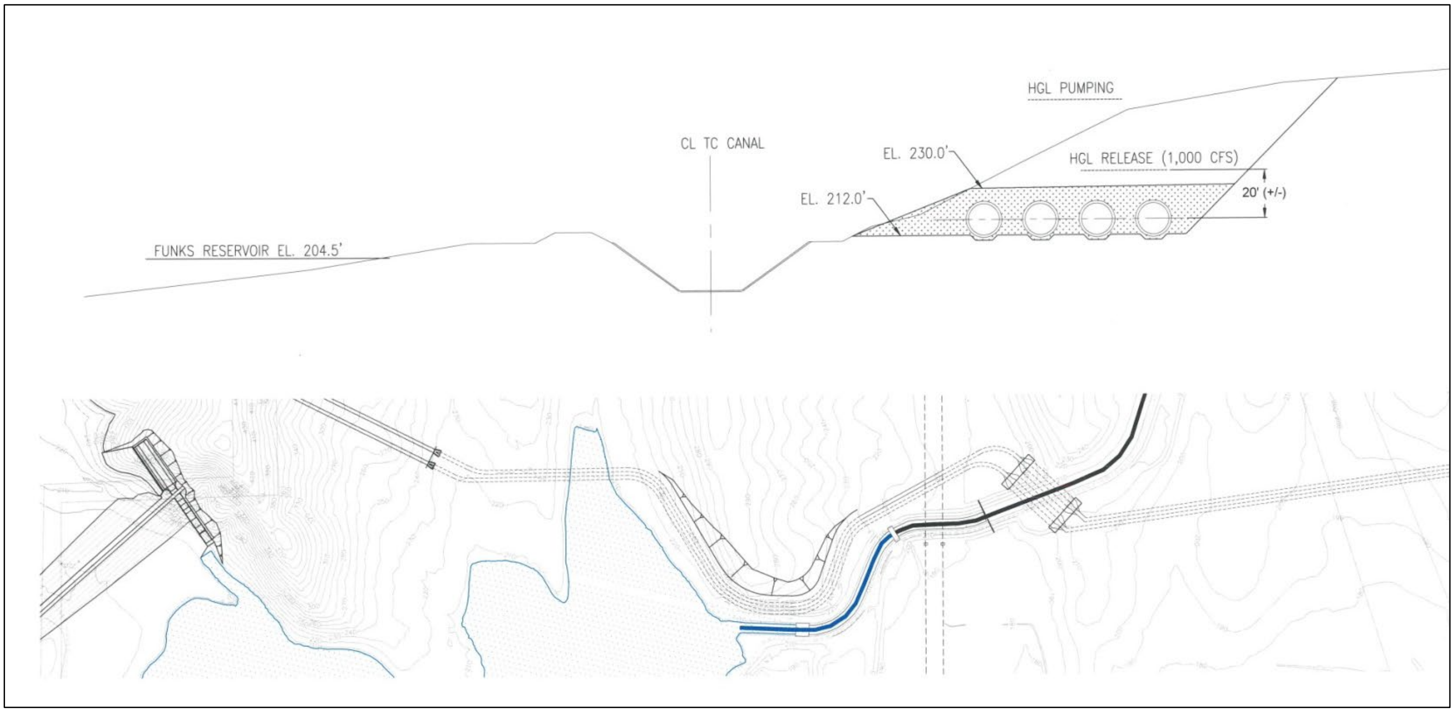
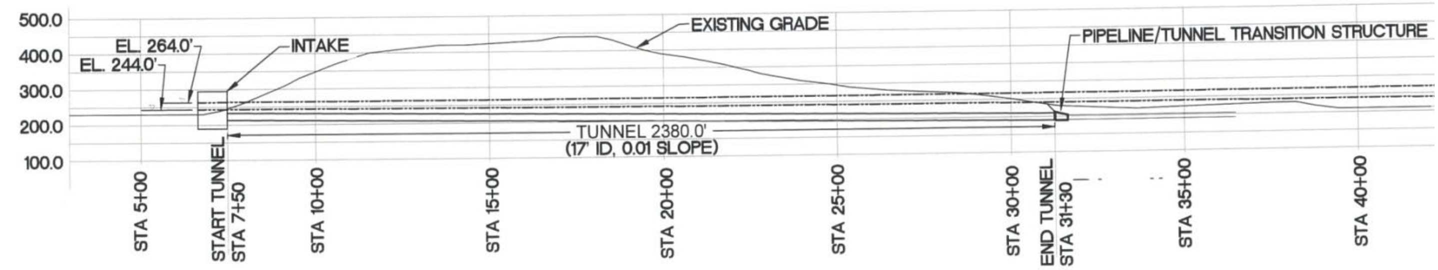
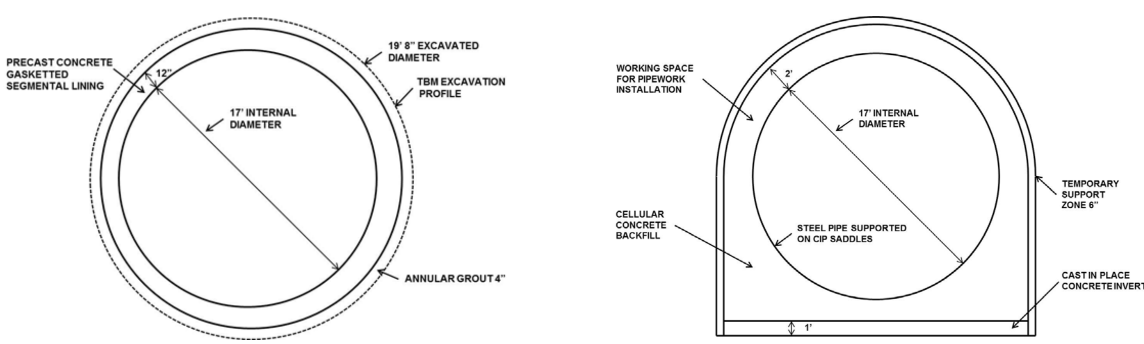


Figure 15 Bench Cut at TC Canal



Tunnel -Profile



TBM Tunnel **Roadhedder Tunnel**

Figure 16 Tunnel Concept

ATTACHMENT A

TUNNELING BACKGROUND INFORMATION

ATTACHMENT A
WATER TRANSFER TUNNELS TO FLETCHER RESERVOIR

1. INTRODUCTION

This tunnel concept accommodates the four 12 foot ID buried water transmission pipelines (Delevan and TRR) that convey water to Fletcher Reservoir from the Sacramento River and TRR pumping plants. This section describes tunnel options adjacent to Fletcher Reservoir where tunneling is required through the ridge to be able to provide return flow to the canals and Sacramento River by gravity. This will require the construction of two 2,400 foot tunnels (Figure 1). It is recommended that a minimum of two tunnels be used to provide for operational redundancy and allow for shutdown for routine inspection and any necessary maintenance. Hydraulic calculations are discussed elsewhere in the report relative to siting the pipeline to maintain gravity return flows in summer.

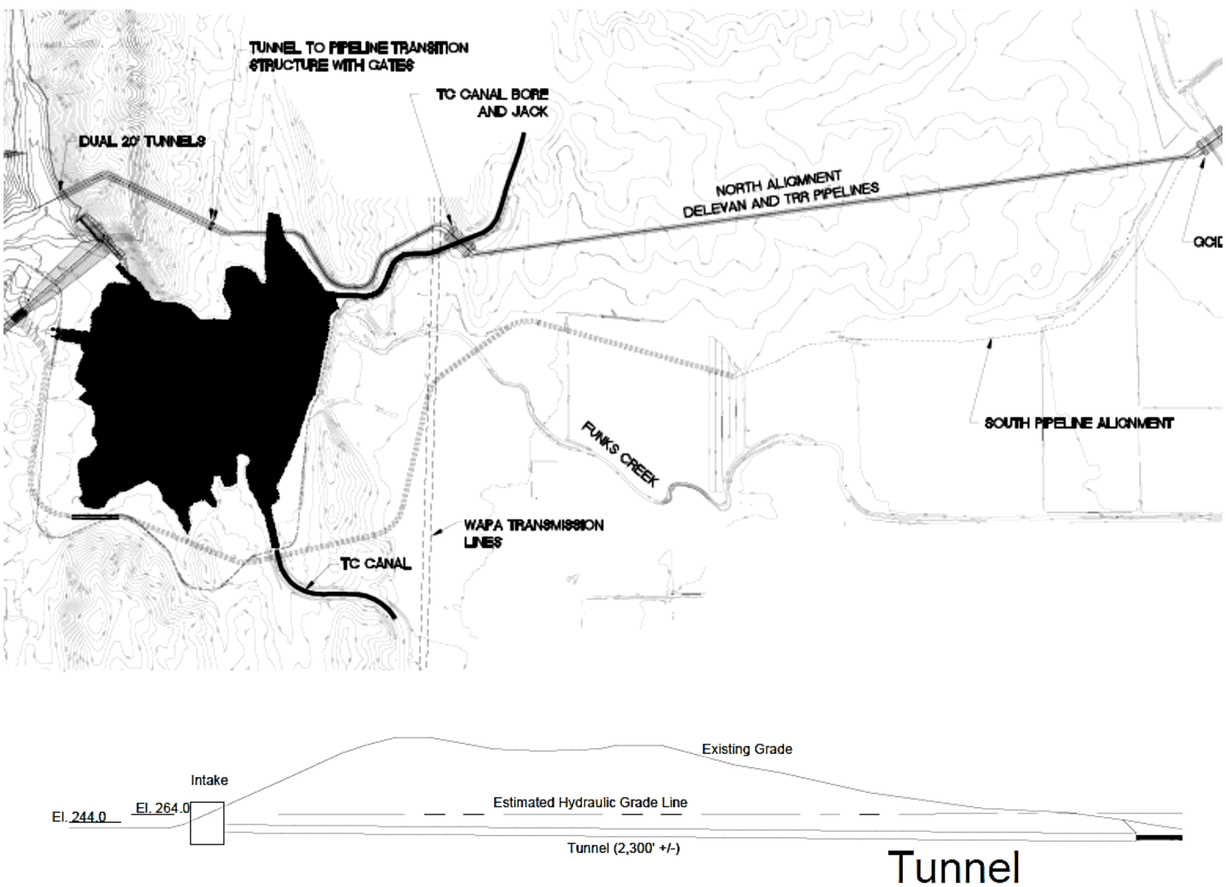
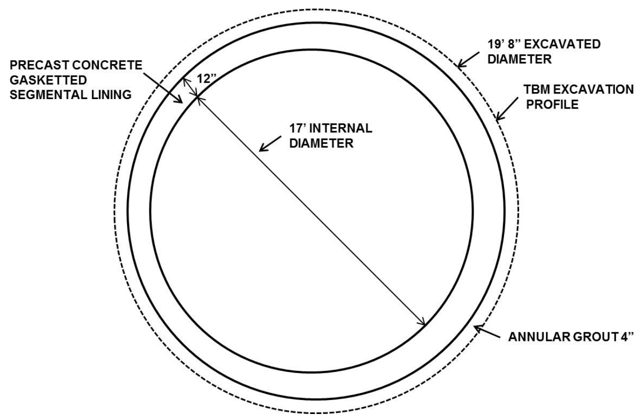


Figure 1: Plan and Longitudinal Section

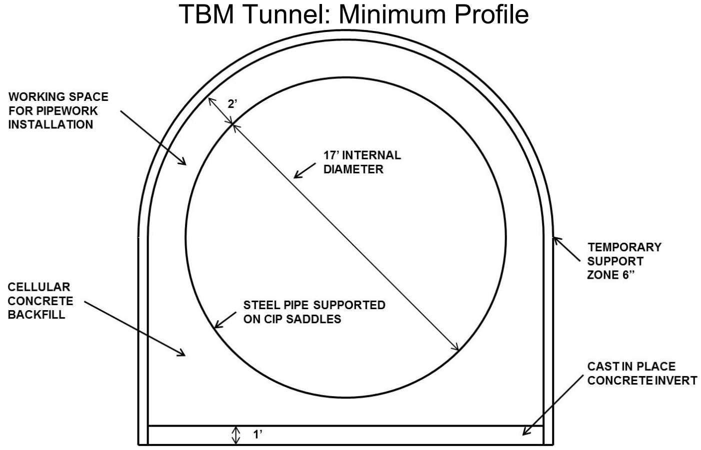
2. PROPOSED TUNNEL CONFIGURATION

To keep tunnel flow velocities approximately the same as the flow velocities in the pipelines, and for operational redundancy, twin 17-foot ID tunnels are required. The excavated profile required to achieve this ID will depend on method of excavation and type of final lining provided.

Indicative cross sections are shown in Figure 2 below for both TBM and roadheader construction.



TBM Tunnel: Minimum Profile



Roadheader Tunnel Profile

Figure 2: Indicative Tunnel Cross Sections

For TBM construction it has been assumed that a shielded TBM will be used erecting a one pass precast concrete segmental lining that will be fitted with EPDM sealing gaskets to provide for water-tightness. EPDM gaskets have been proven to have an effective service life of more than 100 years by accelerated ageing tests and are capable of resisting internal hydrostatic pressure of up to 8.5 bars (284 feet of water pressure). The highest operating head in the tunnel for the pumping conditions would be approximately 35.0 feet and it is assumed that the rock will be sufficiently competent to resist the low internal pressure without excessive deflection of the segmental lining that could impair the gaskets function. This will be confirmed by a geotechnical investigation program currently in planning. If that assumption is incorrect, a grout in place steel liner in zones of shallow cover and weak rock could be required.

3. GEOTECHNICAL DATA

Only limited data is available as summarized in Table 1 below.

Table 1. Available Boring Data

No.	Location	Description
GGO-AUG-1 Depth 11 feet El. 220.0 feet	Just under downstream shell, south of Funks Creek.	Bottom in intensely weathered sandstone with iron staining; moderately strong/hard; SPT at bottom recorded 81 blows for bottom 12 inches; no depth to water noted.
GGO-AUG-2 Depth 13.5 feet El. 230.0 feet	Just outside upstream Shell, South of Funks Creek.	Bottom in intensely weathered sandstone; no bedding; moderately strong/hard; SPT at bottom recorded 71 blows for bottom 12 inches; no depth to water noted.
GGO-AUG-3 Depth 36.3 feet El. 240.0 feet	West of dam, close to Funks Creek.	Sandy silty clay with gravel near base to 29 feet; gravelly silt to 35.4 feet. Mudstone below 35.4 feet, with iron staining; weak/soft; SPT at bottom recorded 89 blows for bottom 12 inches; depth to water 25.2 feet.
FR-AUG-7 Depth 28.5 feet El. 221.0 feet	East of dam toward Funks Reservoir	Silt, clay, sand and gravel layers 4 to 9 feet thick to 28.5 feet; sandstone from 28.0 to 28.5 feet; California Modified Blow Count of 150 for 6 inches in sandstone; no depth to water noted.

Based on the above data it is assumed that:

- rock surface is at 30 to 40 feet below existing ground level over the entire route;
- the rock will comprise interbedded sandstone and mudstone of varying degrees of weathering; and
- The tunnels can be classified as non-gassy.

No groundwater data is available at this time. However, it will be assumed that:

- occasional inflows requiring pre-excavation grouting will be encountered; and
- these inflows will not be sufficient to cause tunnel instability.

Similarly, no structural geological data is available and it is assumed that:

- the tunnels will be excavated through Sandstone and Mudstone formations;
- occasional fracture zones will be encountered that will be no greater than 18 feet wide measured normal to the tunnel alignment; and
- the tunnel alignment does not cross active fault zones.

4. SUITABLE TUNNELING METHODS

The tunnels will be excavated through predominantly highly weathered to fresh sedimentary rocks. There is no testing data available and typically the suite of tests identified below would need to be carried out prior to selecting the suitable tunneling method(s). It is assumed that this data will be collected in geotechnical investigations being planned to support the preliminary and final engineering for the Sites Project.

- Unconfined Compressive Strength (UCS) tests
- Bulk Density tests
- Specific Gravity of Solids
- Point Load tests
- Determination of Water Absorption
- Petrographic Analysis
- Cerchar Abrasiveness tests
- Splitting Tensile Strength of Intact Rock Core Specimens

Current indications are that both roadheaders and tunnel boring machines (TBM) would be suitable to excavate the tunnels in these strata.

Roadheader excavation is considered to be economic in rock strengths with UCS of up to 14,000 psi if the rock mass is favorably jointed and 11,000 psi in ‘massive’ rock with few joint sets. Regional data suggests that the UCS of the sandstone and mudstone is unlikely to exceed 7,000 psi except on rare occasions when UCS of up 15,000 psi may be encountered. Such strengths are likely to be localized with the majority of the rock UCS being no greater than 3,500 psi. In these circumstances it may be necessary to supplement roadheader excavation with limited drill and blast excavation.

TBM excavation would be suitable for range of rock strengths envisioned for the project. The cutter head would be set up to cut rock strengths ranging from extremely weak (0-150psi) to very strong (14,500-30,000psi). This would require a mix of cutting tools comprising scrapers and disc cutters. In addition, the cutter head would require wear plates consisting of vanadium steel or other specialty alloys, to resist abrasion as it rotates against the face. Various types of TBMs are available but they can be split in to two principal types, open and shielded.

The open type is most suitable for stable rock that requires little or no temporary support during excavation (Figure 3). They are provided with a slatted shield extending located behind the cutter head to provide secure access to install rock bolts and straps in the shoulders to crown of the tunnel if required. The TBM extends hydraulically operated ‘grippers’ against the tunnel side wall to generate the reaction to secure the TBM during excavation. Open type TBMs can be equipped with drilling and grouting equipment to either stabilize poor ground or stem groundwater inflows prior to excavation.

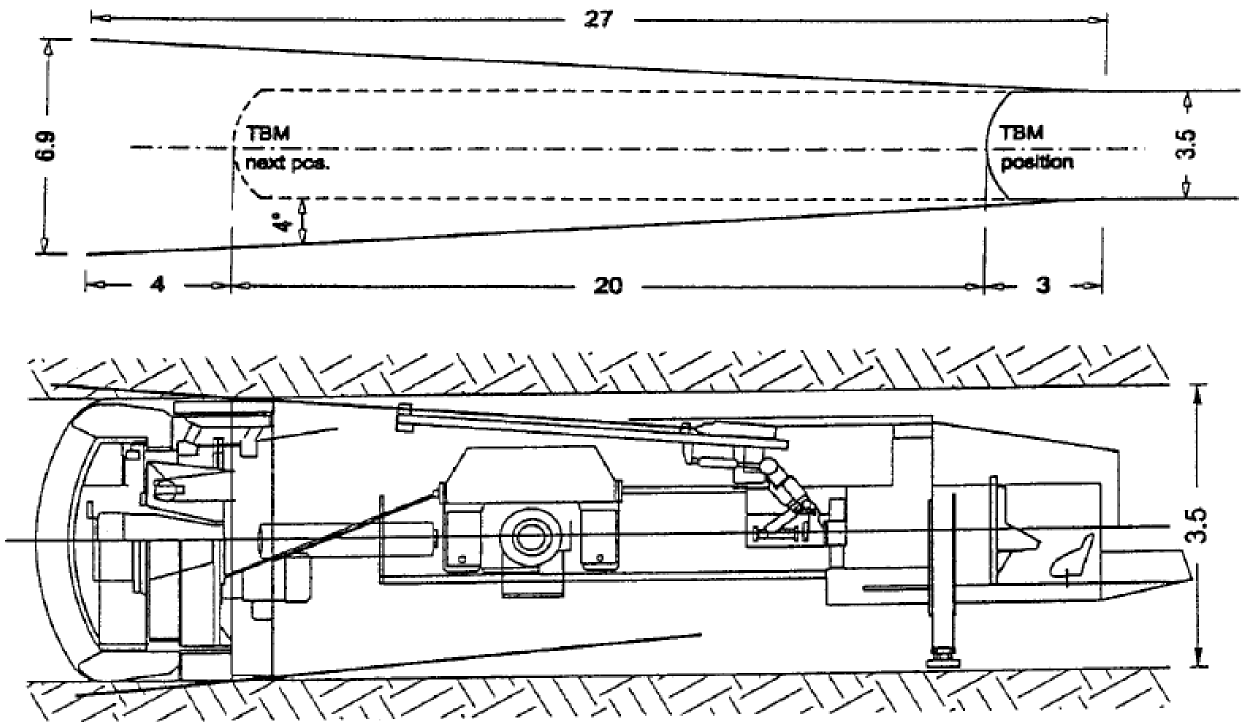


Figure 3: Open-type TBM.

Shielded TBMs encase the TBM machinery within a circular steel shell that provides security against collapse during excavation through poor quality rock masses (Figure 4). A preformed lining is erected behind the TBM as it progresses to support the tunnel and provide reaction force during cutter head operation and to advance the TBM using thrust rams. Drilling and grouting equipment can also be mounted on shielded TBMs. The telescoping double shield TBM is hybrid of the two types comprising a shielded TBM equipped with both side wall grippers and thrust rams allowing the TBM to progress more rapidly in stable conditions by removing the erection of the pre-formed lining.

Another sub-set of shielded TBMs is the closed face TBM. These TBMs incorporate a pressure bulkhead. This allows the cutter head and muck chamber to be pressurized to prevent inundation by groundwater and provide support to a potentially unstable tunnel face. There are two types closed face TBM: earth pressure balance (EPB) and slurry. The former can be used in both open and pressurized mode but the latter must be operated as pressurized at all times. Both types of closed face TBMs have been operated successfully in full face hard rock, mixed face, and full face soil. However, due to the relatively short production runs they are unlikely to offer any substantial commercial, or schedule benefits.

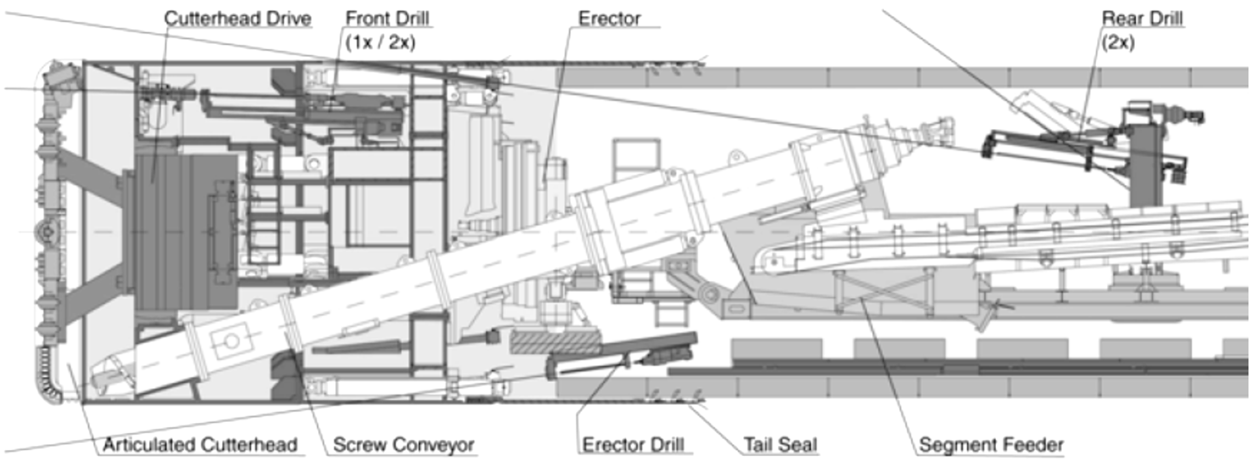
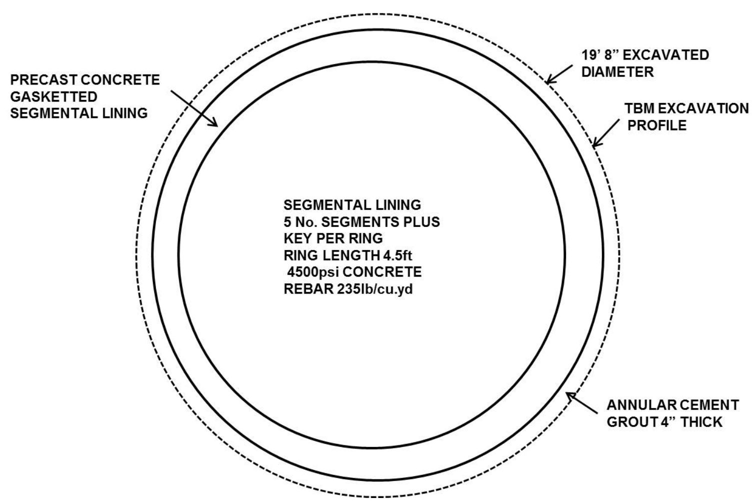


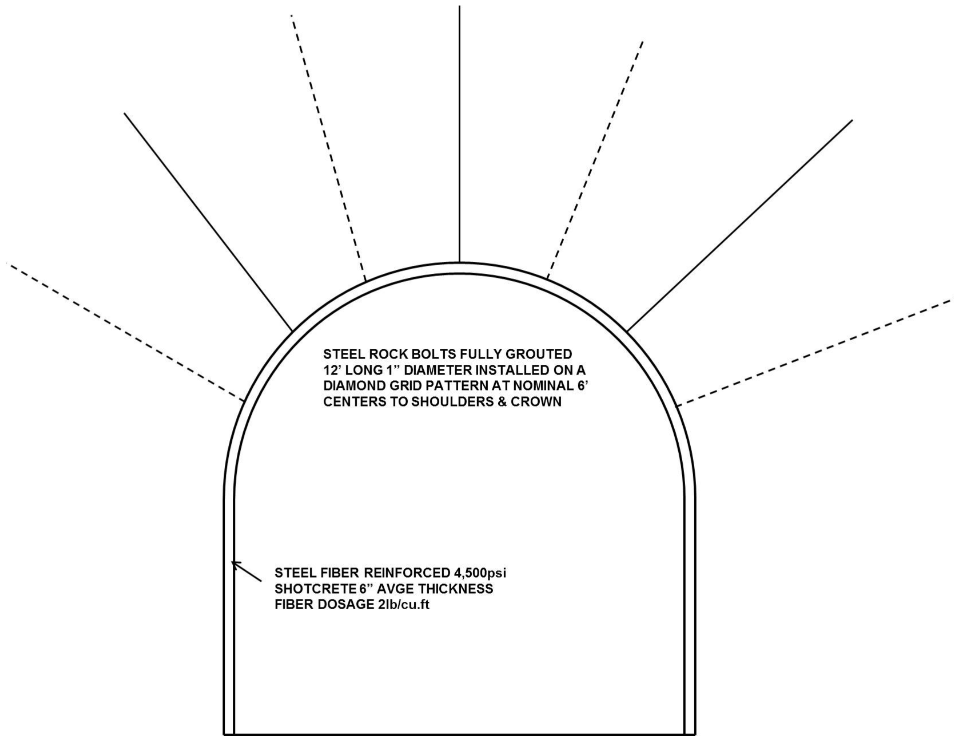
Figure 4. Shielded-type TBM

5. TUNNEL SUPPORT

The tunnel will require support during excavation. For the TBM tunnel, the one pass lining system will perform this function, but for the roadheader option sequential excavation and placing of support will be required to secure the opening as the tunnel advances. There is insufficient data to make an accurate estimate of the types and extent of temporary support required. For the purpose of comparative estimating, an indicative temporary support system is shown on Figure 5. Bolting patterns would accommodate formation bedding.



TBM Tunnel



Roadheader Tunnel

Figure 5: Indicative Temporary Support

6. PORTAL STRUCTURES

The ‘rule of thumb’ was to provide a minimum cover of 2.5 times the span, or diameter, of the tunnel to allow for ground arching. This often requires either deep open cuts or a significant retaining structure to be built to achieve this criterion. Current practice is to start tunneling at the highest elevation compatible with the stability of the permanent tunnel works. Ground cover in the range 15 to 20 feet is quite common. Initial stability is achieved using preplaced support for open face excavation and containment structures for closed face TBMs.

Preplaced support often includes pipe piles, or other longitudinal elements grouted into ‘horizontal’ drill holes around part, or all, of the tunnel periphery. A closed face TBM maintains excavation stability by applying a support pressure to the tunnel face. However, the pressure required is not uniform with the pressure required at the invert higher than that at the crown. Therefore, the applied pressure and the face pressure are usually ’balanced’ at the TBM axis. In the shallow cover situation, the ratio of the overpressure to the insitu pressure at the crown can approach unity, or less. This results in an overpressure at the tunnel crown that can rupture the overlying ground leading to rapid decompression and collapse at the tunnel face. To counter this tendency, the ground can be strengthened by ground treatment, a containment slab constructed at ground surface, the launch site is ‘overfilled’ to artificially increase ground cover, or all are used in various combinations.

7. INITIAL CONCLUSIONS

The construction of the tunnels is feasible and based on limited information both roadheader and TBM excavation appears to be suitable excavation options.

If roadheader, or open face TBM, construction is preferred, the vertical alignment should be selected to provide sufficient rock cover to allow the development of a full rock arch above the tunnel to minimize temporary support requirements. The estimate below assumes that steel ribs would only be required for the first 300 feet of excavation at each portal location.

The total length to be tunneled, 5,000 feet is short, and probably not sufficient to cover the additional mobilization costs required for TBM excavation. Therefore the initial cost estimate has been prepared based upon roadheader excavation. The adoption of roadheader excavation would allow multiple faces working to be adopted if the schedule requires this.

8.0. INITIAL CONCEPTUAL-LEVEL CONSTRUCTION COST ESTIMATE

An initial conceptual-level construction cost estimate of the two 2,400 foot tunnels to convey water to Fletcher Reservoir was performed for an appraisal of potential tunnel costs. The cost estimate (in 2018 dollars) shown in Table 2 is based on a recent tunnel cost estimate for a project in northern California of similar diameter to the Fletcher tunnels.

Table 2. Initial Conceptual Cost Estimate (2018 dollars)

Cost Groups			**Estimated Cost ($)**
Preliminaries			
	Access Roads		
	Offices & Work Shops		
	Fencing		
	Utilities		
	Site Formation		
	Plant Mobilization		
		Sub Total	20,745,000
Portals / Shafts			
	Excavation		
	Soil Nails		
	Rock Dowels		
	Shotcrete		
	Backfill		
		Sub Total	7,265,000
Excavation			
		Sub Total	51,012,000
Temporary Support			
	Steel Arches		
	Rock Dowels		
	Shotcrete		
	Mud Slab		
	Waterproofing		
	Drain Pipe		
		Sub Total	12,285,000
Cast in Place Liner			
		Sub Total	33,163,000
		TOTAL	**124,470,000**
Steel Pipe (if required)			
		Sub Total	16,094,000
		TOTAL	**140,564,000**

The average cost per linear foot of tunnel excluding Preliminaries, Portals, and Steel pipe is $19,292.

ATTACHMENT B

TECHNICAL MEMORANDUM
ENVIRONMENTAL ASSESSMENT

Memorandum

Date:	February 22, 2019
Prepared for:	Sites Project Authority
Project:	Sites Reservoir Project
Prepared by:	Kelly Bayer, Matthew Bettelheim
Subject:	**Environmental Screening for Holthouse and Funks Reservoir Alternatives Comparison**

1.0 INTRODUCTION

In the WSIP project description, Holthouse Reservoir serves as the primary collection point for all water entering and leaving the Sites Reservoir project from the canals and the pipeline from the Sacramento River. The construction of the proposed Holthouse Dam and Reservoir would expand the capacity of Funks Reservoir, allowing the Sites Pumping-Generating Plant to operate as a pumped-storage project. However, there are concerns associated with constructing and operating Holthouse Reservoir at its currently proposed location including land owner impacts, operational impacts to Funks Reservoir and the Tehema-Colusa Canal, and utility relocation requirements. To address these concerns, a conceptual screening study was conducted to determine if there are on-site locations (i.e., areas that fall within the project boundaries defined in the current environmental documentation) where a new storage reservoir could be constructed in the vicinity of the Sites Pumping-Generating Plant. This study identified two options for a new reservoir (Fletcher Reservoir) west of Funks Reservoir: 1) construct a dam following along the south side of Funks Creek to take advantage of a natural drainage that flows into Funks Creek (Fletcher Reservoir Alternative 1), and 2) construct a dam across Funks Creek at a location just west of Funks Reservoir (Fletcher Reservoir Alternative 2) (AECOM, 2018).

The purpose of this Technical Memorandum (TM) is to provide a comparison of the environmental impacts and feasibility-level mitigation cost estimates for the Holthouse Reservoir and two Fletcher Reservoir alternatives to support further evaluation of these alternatives, in consideration with other factors. This analysis is limited to implementing mitigation measures and does not include best management practices already included in previously estimated project costs associated with the design, construction, and operations and maintenance activities. In addition, certain environmental impacts and mitigation requirements would result from all three alternatives and would not serve as differentiators among the alternatives; therefore, these impacts and their associated mitigation costs were not considered in this comparative assessment. This evaluation focused on three environmental resource areas considered mostly likely to be substantial differentiators among the alternatives in terms of mitigation costs: natural vegetation communities, cultural resources, and land use/agriculture.

2.0 METHODS

The identification of natural vegetation communities, cultural resources, and land use/agriculture was informed by a desktop review of the study area and previous environmental studies and analysis performed for the Sites Reservoir Project, including the Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) (Sites Project Authority and Reclamation, 2017) and Draft Environmental Assessment for the Maxwell Water Intertie Project (ICF, 2018). A site reconnaissance was conducted by an AECOM biologist to confirm the natural vegetation community/habitat types that could be impacted by the alternatives. For this assessment, consideration of land use/agriculture impacts was limited to compatibility with the general plan land use or zoning designations, and conversion of California Resources Agency Farmland Mapping and Monitoring Program Important Farmland and Williamson Act[1] contract lands to non-agricultural use.

The total estimated costs associated with impacts on natural vegetation communities and agricultural lands were developed by first calculating the land mitigation requirements using applicable mitigation ratios and estimated land impacts presented on a per acre basis. A more detailed habitat assessment and land evaluation would be needed to identify more precise impacts. Agency coordination would also be required to determine land types necessary to meet mitigation requirements. The range of mitigation ratios used for cost estimating were derived from mitigation ratios used in previously implemented projects, including the CALFED Programmatic EIR/EIS, Shasta Lake Water Resources Investigation EIR/EIS, and Los Vaqueros Expansion Investigation EIR/EIS, as well as mitigation ratio ranges identified in the Sites Reservoir Project Draft EIR/EIS. Unit costs were derived from mitigation cost estimates previously developed for the project (AECOM 2016).

Cost estimates for cultural resource impacts are based on known site conditions and experience on similar projects.

3.0 ENVIRONMENTAL IMPACTS

The following discussion is focused on identified impacts with associated mitigation costs; however, it is not an exhaustive analysis off all impacts with mitigation costs for these resources topics. This evaluation concentrated on those impacts that are anticipated to be more substantial differentiators among the alternatives in terms of mitigation costs. As noted below, for some impacts there is not sufficient information available at this time to estimate potential mitigation costs.

3.1 NATURAL VEGETATION COMMUNITIES

Several land cover types are present in the study area for the three reservoir alternatives, and include natural communities such as annual grassland, riparian woodland, riverine, alkali wetland, and seasonal wetland. Other land cover types present (e.g., agriculture) are associated with human activities. While the acreage of some land cover types (riverine, annual grassland, lacustrine) was estimated as part of this early assessment, the acreage of the these and other land cover types (seasonal wetland, alkali wetland, riparian woodland) would require a formal wetland delineation, habitat mapping, and/or tree survey to more accurately document their presence and acreage. This comparative assessment focused on the known primary land cover types in the study area. These primary land cover types are described below followed by discussion of the estimated impacts of each alternative on these land cover types.

Annual Grassland. Annual grassland is defined as areas where grasses and forbs occur as extensive stands without an overstory. The grassland community is typically dominated by introduced (non-native) annual grass species, such as brome (*Bromus* spp.) wild oats (*Avena* spp.), barleys (*Hordeum* spp.), and ryegrass (*Festuca* spp.), with a small minority (less than 15 percent relative cover) of native perennial species Annual grassland provides foraging habitat for species such as golden eagle

[1] The Williamson Act, also known as the California Land Conservation Act of 1965, enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments which are much lower than normal because they are based upon farming and open space uses as opposed to full market value.

(*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), and white-tailed kite (*Elanus leucurus*), and nesting habitat for species such as western burrowing owl (*Athene cunicularia*), western meadowlark (*Sturnella neglecta*) and savannah sparrow (*Passerculus sandwichensis*).

Riparian Woodland. Riparian woodland and shrubs occur along Funks Creek. The portion of Funks Creek immediately upstream of Funks Reservoir supports a narrow corridor of riparian and other associated trees, and very small patches of wetland vegetation within its bed (Sites Project Authority and Reclamation, 2017). The densely vegetated portion of Funks Creek adjacent to the Funks Reservoir dam supports riparian vegetation, including willows (*Salix* spp.), cottonwoods (*Populus* spp.), black walnut (*Juglans nigra*) and valley oak (*Quercus lobata*) trees for approximately 0.2 mile, at which point these trees become sparser farther downstream from the reservoir (ICF, 2018). Overstory riparian trees may be used for nesting and roosting by numerous raptors, including red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), and special-status species such as white-tailed kite and Swainson's hawk (*Buteo swainsoni*). Riparian woodland provides suitable nesting habitat for a variety of non-raptor bird species, including green heron (*Butorides virescens*), yellow-rumped warbler (*Dendroica coronata*), and white-breasted nuthatch (*Sitta carolinensis*), and important cover and foraging habitat for resident, migratory, and wintering birds. Cliff swallow nests have been observed on the Funk Reservoir Dam and connection to Funks Creek (ICF, 2018). Riparian communities also provide habitat for the western pond turtle (*Actinemys marmorata*). Elderberry shrubs, which provide habitat for the federally-listed as threatened valley elderberry longhorn beetle (VELB), may be present within the riparian corridor along Funks Creek or within agricultural lands or grasslands.

Riverine. Funks Creek originates at approximately 850 feet elevation in blue oak savanna in the foothills west of Antelope Valley. It flows southeast as an intermittent natural stream, where it is joined by Grapevine Creek. As it flows through the foothills and Antelope Valley, its banks are generally eroded to near-vertical slopes, the gravel bed is highly disturbed and compacted by cattle, and it is bordered by annual grassland vegetation. Little to no riparian vegetation occurs throughout much of this reach, although occasional cottonwoods, willows, or non-native species occur along the banks. As Funks Creek cuts through the Golden Gate gap and enters the west side of the Sacramento Valley, the stream channel becomes wider, although flows are still intermittent. The banks and channel have occasional groupings of riparian trees and shrubs. Occasional wetlands occur, mainly small patches of emergent wetland or stock ponds. Approximately one mile downstream of the Golden Gate gap, Funks Creek is impounded by Funks Reservoir. This reservoir is fed mainly from waters of the Tehama-Colusa Canal. Downstream of the reservoir, Funks Creek is bordered by agricultural lands, and much of this reach is channelized before emptying into Stone Corral Creek. The banks are bordered by levee roads and sparsely vegetated with non-native weedy species. Occasional native or non-native riparian trees and shrubs occur along the bank, as well as small patches of emergent wetland vegetation. This portion of Funks Creek likely has some flow year round due to leakage from the dam at Funks Reservoir. A large wetland area, fed by waters from agricultural canals and Funks Creek, occurs upstream of the confluence of Funks Creek and Stone Corral Creek (Sites Project Authority and US Bureau of Reclamation 2017).

Funks Creek is characterized by a deeply incised channel that is largely devoid of riparian cover as a result of heavy cattle use. On the valley floor, Funks Creek flows through irrigated pasture, rice fields, and row crop agriculture. During summer, much of the streambed is dry, except for occasional pools or when receiving agricultural drainage or runoff. In addition, water quality is reported to be poor and high in dissolved minerals (Sites Project Authority and US Bureau of Reclamation 2017). Funks Creek provides aquatic habitat for giant garter snake (*Thamnophis gigas*). Although the nearest recorded occurrence of California red-legged frog (*Rana draytonii*) is greater than 50 miles away from, the US Fish and Wildlife Service has indicated that California red-legged frogs (federally-listed as threatened) may be potentially present in the creek and associated suitable uplands (ICF, 2018).

Lacustrine. Although Funks Reservoir is heavily managed and the nearest recorded occurrence of California red-legged frog is greater than 50 miles away from the action area, the US Fish and Wildlife Service has indicated that California red-legged frogs (federally-listed as threatened) may be potentially present in the reservoir and associated suitable uplands (ICF, 2018)

3.1.1 Holthouse Reservoir

The approximate 365-acre area proposed for the Holthouse Reservoir Complex is composed mostly of agricultural fields and annual grassland. The annual grassland within the footprint of the Holthouse Reservoir facilities is highly disturbed consists almost entirely of non-native weedy grasses and forbs, and is not a wetland or vernal pool landscape (Sites Project Authority and Reclamation, 2017). Because of the extent of farming within this area, the amount of annual grassland within this area that may require mitigation could not be estimated for this high-level screening.

The Holthouse Reservoir would impact the Funks Creek Channel. The construction of the dam, spillway, and stilling basin, and the consequent inundation of Holthouse Reservoir, would result in the permanent removal of an approximate 4,000-foot reach of Funks Creek immediately downstream of the existing Funks Reservoir. One of the largest potential impacts to aquatic habitat would be the inundation of the riparian area supported by Funks Creek downstream of the existing dam outlet, where Funks Creek averages more than 80 feet wide. The remaining length of the Funks Creek channel supports a narrow strip of mature riparian trees that would be lost to construction of these facilities (Sites Project Authority and Reclamation, 2017). The total length of Funks Creek channel loss under the Holthouse Reservoir Alternative is 7,000 feet.

A 13-acre alkaline and saline wetland complex lies immediately southeast of the Holthouse Reservoir Complex, located within a 40-acre area that supports an upland (grassland) matrix. The source of water for the wetland complex appears to be seeps located at its southern edge, as well as runoff from both the nearby orchard to the east and the adjacent agricultural land to the north. After inundation the weight of the water behind Holthouse Dam would have the potential to leak fresh water into adjacent groundwater tables to the east, converting the existing alkaline wetlands, flats, swales, and vernal pools to a freshwater marsh plant community. Such conversion from rare alkaline meadow/wetland to freshwater seasonal wetland would most likely cause disappearance of all of the special-status plant species that now occur around the saltgrass-dominated plant community and alkaline wetland swales (Sites Project Authority and Reclamation, 2017). While this potential indirect impact was identified in the project Draft EIR/EIS, further study would be required to determine the extent of this impact and there is not sufficient information available at this time to estimate mitigation costs that may be associated with this impact.

3.1.2 Fletcher Reservoir Alternative 1

The approximate 210-acre footprint proposed for Fletcher Reservoir Alternative 1 is composed mostly of annual grassland. Annual grassland within the footprint of the Fletcher Reservoir Alternative 1 consists almost entirely of non-native weedy grasses and forbs (Sites Project Authority and Reclamation, 2017).

Fletcher Reservoir Alternative 1 would impact the Funks Creek Channel, resulting in the net loss of approximately 1,100 feet of Funks Creek immediately upstream of the existing Funks Reservoir.[2] The upstream length of the Funks Creek channel supports a narrow strip of mature riparian trees that would be lost to construction of these facilities (Sites Project Authority and Reclamation, 2017).

3.1.3 Fletcher Reservoir Alternative 2

The approximate 310-acre footprint proposed for Fletcher Reservoir Alternative 2 is composed mostly of annual grassland. Annual grassland within the footprint of the Fletcher Reservoir Alternative 2 consists almost entirely of non-native weedy grasses and forbs (Sites Project Authority and Reclamation, 2017).

Fletcher Reservoir Alternative 2 would impact the Funks Creek Channel, resulting in the permanent removal of an approximate 8,000-foot reach of Funks Creek immediately upstream of the existing Funks Reservoir. The upstream length of the Funks Creek channel supports a narrow strip of mature riparian trees that would be lost to construction of these facilities (Sites Project Authority and Reclamation, 2017).

3.1.4 Habitat Impacts Alternatives Comparison

The approximate area of natural vegetation communities that would be impacted by each alternative is summarized in Table 1. Estimated mitigation costs are presented by alternative in Tables 2 through 4.

Table 1. Impacts to Habitat Communities by Alternative

Alternative	Riverine (acres)	Lacustrine (acres)	Seasonal Wetland * (acres)	Alkali Wetland * (acres)	Riparian Woodland * (acres)	Annual Grassland (acres)
Holthouse Reservoir	8.0	0	Unknown	Unknown	Unknown	210*
Fletcher Reservoir 1 (set back from Funks Creek)	2.5	0	Unknown	Unknown	Unknown	210
Fletcher Reservoir 2 (dam across Funks Creek)	9.2	0	Unknown	Unknown	Unknown	310

*Actual acreage calculations would require a formal wetland delineation, habitat mapping, and/or tree survey to document this land cover type's presence and acreage. Channel to Funks and pumping plant would still impact 210 acres.

Table 2: Holthouse Reservoir Alternative Habitat Mitigation Costs

Vegetation Community	Acreage	Mitigation Ratio	Unit Cost/Acre	Cost
Wetlands/Waters				
Riverine	8.0	3	$20,000	$482,160
Lacustrine	0	--	--	$0
Seasonal Wetland*	Unknown	--	--	Unknown
Alkali Wetland*	Unknown	--	--	Unknown
Upland				
Riparian Woodland*	Unknown	--	--	Unknown
Annual Grassland	210*	1	$1,500	$315,000

*Actual acreage calculations would require a formal wetland delineation, habitat mapping, and/or tree survey to document this land cover type's presence and acreage.

[2] Approximately 2,200 feet of existing meander length would be eliminated during construction; however, approximately 1,100 feet of meander bypass would be reconstructed along the dam toe.

Table 3: Fletcher Reservoir Alternative 1 Habitat Mitigation Costs

Vegetation Community	Acreage	Mitigation Ratio	Unit Cost/Acre	Cost
Wetlands/Waters				
Riverine	2.5	3	$20,000	$151,536
Lacustrine	0	--	--	$0
Seasonal Wetland*	Unknown	--	--	Unknown
Alkali Wetland*	Unknown	--	--	Unknown
Upland				
Riparian Woodland*	Unknown	--	--	Unknown
Annual Grassland	210	1	$1,500	$315,000.0

*Actual acreage calculations would require a formal wetland delineation, habitat mapping, and/or tree survey to document this land cover type's presence and acreage.

Table 4: Fletcher Reservoir Alternative 2 Habitat Mitigation Costs

Vegetation Community	Acreage	Mitigation Ratio	Unit Cost/Acre	Cost
Wetlands/Waters				
Riverine	9.2	3	$20,000	$551,040
Lacustrine	0	--	--	$0
Seasonal Wetland*	Unknown	--	--	Unknown
Alkali Wetland*	Unknown	--	--	Unknown
Upland				
Riparian Woodland*	Unknown			
Annual Grassland	310	1	$1,500	$465,000.0

*Actual acreage calculations would require a formal wetland delineation, habitat mapping, and/or tree survey to document this land cover type's presence and acreage.

3.2 CULTURAL RESOURCES

The cultural resources inventory completed for the Sites Reservoir Project covered 35,774 acres; 144 archaeological sites were recorded on California Department of Parks and Recreation (DPR) forms (Form 523) during these surveys (Sites Project Authority and Reclamation, 2017).

The record search completed for the cultural resources inventory did not identify any previously recorded resources within the proposed Holthouse Dam and Reservoir footprint (Sites Project Authority and Reclamation, 2017); however, lands to the west of Funks Reservoir would still be impacted by the connecting channel and pumping plant (see following description for Fletcher impacts). Portions (348 acres) of the Holthouse Dam and Reservoir have been surveyed; however, other portions of the Holthouse Reservoir Complex would require survey for archaeological resources prior to project construction. One prehistoric isolate, a chert flake, was recorded on the north shore of Funks Reservoir, but no archaeological sites have been found to date; no historic-era archaeological resources have been found to date (Sites Project Authority and Reclamation, 2017). The built environment resources within the proposed Holthouse Reservoir Complex are the Tehama-Colusa Canal, Funks Dam, and the WAPA Maxwell-Olinda 500-kV overhead transmission line, all of which would be decommissioned within the Holthouse Reservoir footprint. The Tehama-Colusa Canal and Funks Dam are not yet 50 years old, but are considered contributing elements of the National Register of Historic Places (NRHP)-eligible Central Valley Project (CVP), and should be recorded as elements of the CVP because it will be important to have a record of their locations regardless of the alternative selected. Initial construction of the WAPA transmission line occurred over 50 years ago; however, the substations at either end of the circuit were not built until 1986. Therefore, the resource does not meet the age criterion for NRHP/California Register of Historical Resources eligibility. Although portions of the Holthouse Reservoir Complex still require survey, the presence of resources that would require mitigation is not expected due to the prior disturbance of these areas for active farming involving tilling and row crop production. There are no identified known cultural resources with associated mitigation costs specific to the Holthouse Reservoir Option.

The Fletcher Reservoir/Holthouse Channel options area was included in previous archaeological surveys completed for the project. One prehistoric cultural site is present within the footprint of both alternatives; no historic-era archeological resources have been identified. The ranch house present within this area is not considered an historic structure. The estimated the mitigation cost for either Fletcher Reservoir alternative is $243,000.

3.3 LAND USE/AGRICULTURE

All three alternatives would conflict with Colusa County agricultural zoning designations and General Plan land uses. Mitigation measure Land-2 in the Draft EIR/EIS requires working with Colusa County to modify or amend General Plan and/or zoning ordinances to bring lands into consistency with the proposed project land uses (Sites Project Authority and Reclamation, 2017). Therefore, there is no unit cost/acre for this impact.

All three alternatives would impact Farmland Mapping and Monitoring Program designated Farmland of Local Importance. The footprints of all three reservoir alternatives are designated as Farmland of Local Importance (Sites Project Authority and Reclamation, 2017). Conversion of Farmland of Local Importance to a non-agricultural use is not a significant impact evaluation criterion for the purpose of the California Environmental Quality Act and National Environmental Policy Act; therefore, there is no associated mitigation.

The Holthouse Reservoir Complex and associated construction disturbance area around these facilities would be located on eight parcels of land that have a Williamson Act contract with Colusa County (Sites Project Authority and Reclamation, 2017). Both Fletcher Reservoir alternatives would also be located on parcels of land that have a Williamson Act contract with Colusa County (California Department of Conservation, 2013). Estimated fees associated with the cancellation of Williamson Act contracts for each alternative are presented in Table 4.

Table 4: Williamson Act Contract Cancellation Costs by Alternative

Alternative	Acreage	Unit Cost/Acre	Cost
Holthouse Reservoir	240	$3,006	$721,440
Fletcher Reservoir #1 (set back from Funks Creek)	210	$3,006	$631,260
Fletcher Reservoir #2 (dam across Funks Creek)	310	$3,006	$931,860

4.0 ALTERNATIVE MITIGATION COST COMPARISON

Total estimated environmental mitigation costs for each alternative based in the individual estimates above for natural vegetation communities, cultural resources, and land use/agriculture plus allowances and contingencies are presented in Table 5. Escalation of construction costs to a Notice to Proceed date has not been included in the estimate. This was done to avoid confusion and double counting, because escalation is a factor included in the benefit-cost feasibility analysis of the project following several possible design and construction scheduling options.

	Holthouse Reservoir	Fletcher Reservoir #1 (set back from Funks Creek)	Fletcher Reservoir #2 (dam across Funks Creek)
Vegetation Communities*	$1,498,200	$466,536	$1,016,040
Cultural Resources	$243,000	$243,000	$243,000
Land Use/Agriculture	$721,440	$631,260	$931,860
Subtotal	**$2,462,640**	**$1,340,796**	**$2,190,900**
Mobilization (2%)	$49,253	$26,816	$43,818
Subtotal with Mobilization	$2,511,893	$1,367,612	$2,234,718
Contract Cost Allowances (13%)	$326,546	$177,789	$290,513
Contract Cost	**$2,838,439**	**$1,545,401**	**$2,525,231**
Contingencies (2%)	$56,769	$30,908	$50,504
Field Cost	$2,895,208	$1,576,309	$2,575,735
Non-Contract Cost (4%)	$115,808	$63,052.38	$103,029.44
Construction Cost	**$3,011,016**	**$1,639,362**	**$2,678,765**
Escalation to NTP	-	-	-

* As noted in Section 3.1, there may be additional mitigation costs associated with vegetation community impacts.

In terms of environmental mitigation costs, Holthouse Reservoir is the most expensive based on the findings of this assessment, primarily because it affects lands on both the east and west side of the existing Funks Reservoir. However as noted above, there are unknown mitigation costs associated with habitat impacts for all three alternatives. Specific to the Holthouse Reservoir Alternative, potential annual grassland mitigation costs could not be fully estimated; these estimate costs are represented for the other alternatives. In addition, there could be mitigation costs associated with potential indirect impacts to alkaline meadow/wetland from the Holthouse Reservoir, as identified in the Draft EIR/EIS. The primary difference in mitigation costs between the two Fletcher Reservoir alternatives is the larger overall footprint and greater impacts to Funks Creek Channel from Fletcher Reservoir Alternative 2. All three alternatives are anticipated to have mitigation costs associated with cancellation of Williamson Act contracts. Known cultural resource mitigation costs were identified for the Fletcher Reservoir alternatives whereas as none were identified for the Holthouse Reservoir Alternative; however the cultural resource mitigation costs are considerably less than those estimated for vegetation communities and land use/agriculture.

5.0 REFERENCES

AECOM. 2016. Sites Reservoir Feasibility Study Technical Memorandum: Mitigation Measure Evaluation and Cost Estimate. October.

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