TASK 7: DRAFT REPORT

Deep Water Ship Channel Closure Structure Alternatives Study

Prepared for:

WSAFCA
West Sacramento Area Flood Control Agency

Prepared by:

TETRA TECH

17885 Von Karman Ave., Suite 500
Irvine, CA 92614

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1. Study Purpose and Scope

1.1 Study Purpose

The purpose of this Closure Structure Alternatives Study (the Study) is to provide analysis of alternatives to reduce the flood risk posed by the breach created in the Yolo Bypass Levee when the Deep Water Ship Channel (DWSC) was constructed. Flood risk is increased due to the resulting reliance on more than 17 miles of navigation levee to manage water surface elevations in the DWSC by excluding Yolo Bypass flows. Alternatives considered include both temporary and permanent closure structures, with the permanent closure structures including both operable and non-operable structures/features.

1.2 Study Tasks

The following is a brief outline of the main study tasks:

- Identification of the study goals and objectives
- Identification of Problems, Opportunities, and Methodology for Analysis
- Identification of Alternatives
- Comparison of Alternatives - Initial Ranking
- Analysis of Alternatives
- Comparison of Alternatives – Secondary Ranking
- Completion of a Draft Report
- Stakeholder Outreach
- Completion of a Final Report and Executive Summary

As a “reconnaissance level” analysis, alternatives have been considered at a conceptual level of detail. Planning tools such as decision matrices and parametric cost estimates are used to assess how alternatives rank among categories such as financial impacts/tradeoffs, environmental costs, navigation impacts, risk management, and operation and maintenance costs, for example.

2. Study Area and Background

The City of West Sacramento (City) depends on levees for the safety of its residents. Approximately 50-miles of levees along the Sacramento River, Yolo Bypass, and Sacramento Bypass comprise the flood system protecting the City. Construction of the DWSC by the U.S. Army Corps of Engineers (USACE) created a breach in the Yolo Bypass levee along the western boundary of the City. The flood threat associated with this breach was addressed by the construction of “navigation” levees along the west bank of the DWSC and the north and south banks of the turning basin and harbor. These three levees comprise nearly 30 miles of the flood system protecting the City although they are not recognized as part of the Federally-authorized flood control system. Figure 1 is a vicinity map, and Figure 2 is a map of the system and local study area.

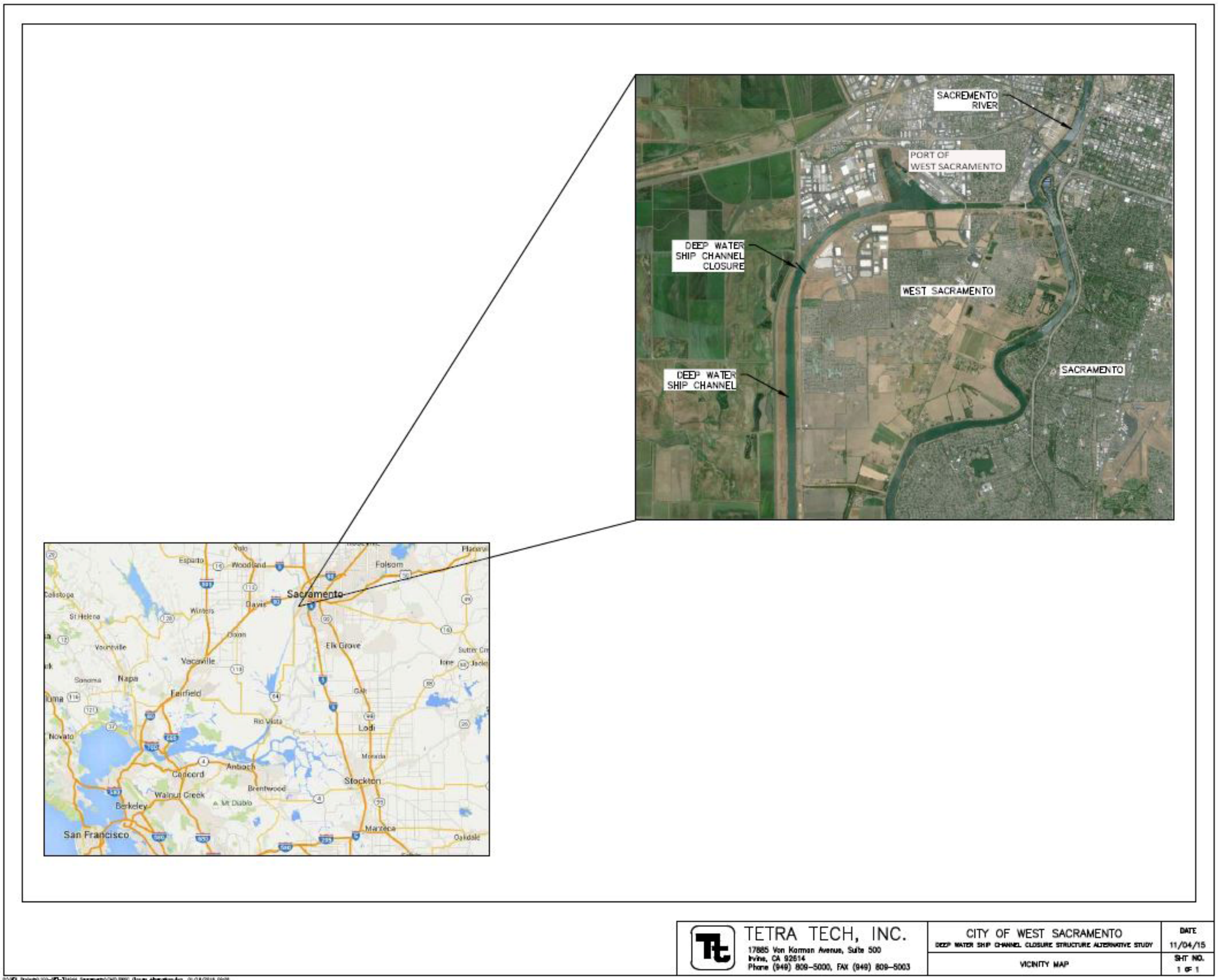

Figure 1. Vicinity Map

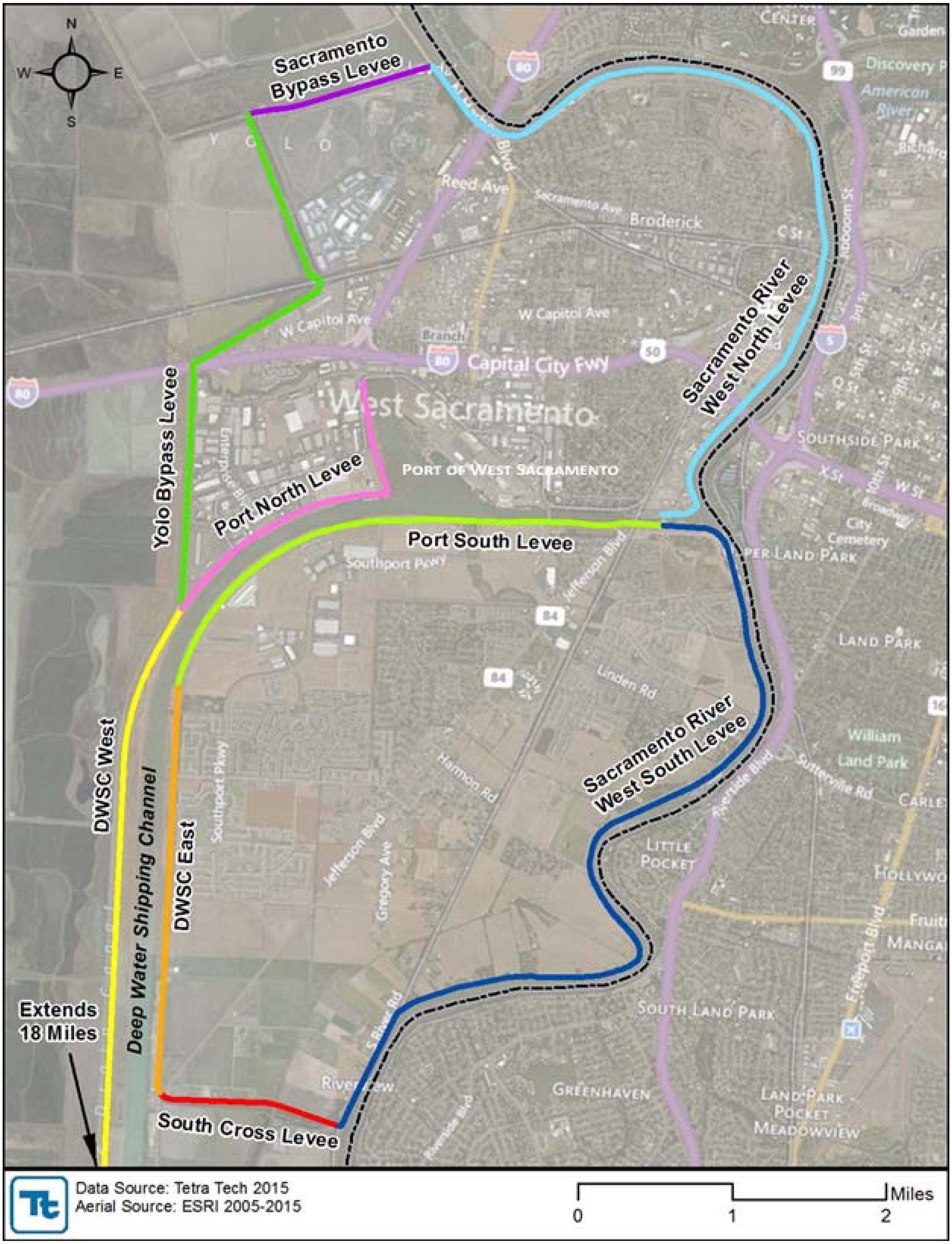

Figure 2. Study Area

The breach of the Yolo Bypass Levee by the DWSC in combination with the deficiencies identified in the Port North, Port South, and DWSC West levees pose significant risks to the City during a large flood event. The difference in stage between the Yolo Bypass and the DWSC during a 200-year event is approximately 10 feet. A breach in the DWSC West levee could result in severe flooding both north and south of the Port.

2.1 Flood Risk Management Study

USACE completed a Final General Reevaluation Report (GRR) and Final EIS/EIR that considered the feasibility of reducing flood risk (USACE, 2015a and 2015b). The GRR was completed to reevaluate the previously authorized project which was found to be inadequate to address the residual flood risk for the West Sacramento area (USACE 2015a). The cost of the recommended plan in the GRR is approximately $1.19 billion, with a projected cost of $1.63 billion over its 17-year implementation period.[1]

The GRR recommends a comprehensive plan of levee improvements to achieve WSAFCA's minimum goal of 200-year flood protection. Near the Port of West Sacramento (Port), this plan includes a total of approximately 26 miles of improvements to the Port North, Port South, and DWSC West levees (USACE, 2015a). Notably, the GRR recommended levee improvement plan does not actually protect the Port itself because it is on the water side of the levee improvements.

A permanent operable closure structure was evaluated as part of the alternatives evaluation in the GRR. The proposed structure was a sector gated structure with a 200 foot wide opening, a base elevation of -37.0 feet, and top of structure elevation of 34.0 feet. The proposed location was approximately 500 feet north of the South Basin Main Drain Pumping Plant. Cost of the structure (October 2014 price level) was approximately $519,429,000 (USACE, 2015a). The alternative containing the operable closure structure was eliminated due to cost inefficiencies.

2.2 Port Operations and Ship Requirements

The Port of West Sacramento was opened in 1963 following construction of the DWSC by USACE that was Congressionally-authorized by the Rivers and Harbors Act of 1946 and initiated in 1949. The Port includes a harbor, a turning basin, and a 1.5-mile-long shallow-draft barge canal with an 86-foot-wide and 600-foot-long navigation lock between the harbor and the Sacramento River. (USACE 2015a) It was constructed as a bulk cargo port to serve the agricultural and natural resource industries of Northern California. The Port's primary cargos were historically rice, wheat, woodchips, logs and fertilizer, and in 2007 cement was introduced. Annual cargo throughput prior to 1999 was approximately 1 million tons, but has dropped steadily to a baseline of approximately 320,000 tons since 2009, primarily rice exports. As of mid-2015, cement imports have increased consistent with the economic recovery and cement tonnage is expected to be approximately 240,000 tons in 2016.

[1] Following finalization of the GRR in December, 2015, the Chief of Engineers' Report was finalized in April, 2016.

Depending on the cargo and relative weight, the required depth due to a ship's draft can range from approximately 25 feet, for bulk rice shipments of 12-13,000 tons, to 30 feet for cement shipments of 30,000 tons. The current alternatives study therefore considers 30 feet as the minimum required channel depth, which is consistent with the current Federally-authorized depth for the navigation channel. The allowable height that would have to be accommodated if any closure structure extended vertically—such as with a lift gate—is the height of the lowest existing bridge, the Benicia Bridge, at 135 feet.[2]

Over the past six years, the annual vessel counts have ranged from 20-28 ships with an annual average of 24. The monthly average for any one month in the six year period ranged from 0.5 vessels in August to 2.7 vessels in May, November, and December, with an overall monthly average over the 72 month period of 2 vessels. The greatest number of vessels in the period was seven, during December 2013.[3] These counts exclude vessel traffic at the privately operated Yara terminal. Cemex also operates a private terminal on the ship channel and will likely add to these vessel counts in the future.

As described in the March 2013 Port of West Sacramento Business plan, the previous operating model of the Port had been financially unsustainable due to on-going operating deficits. Since the introduction of a landlord operating model in July 2013, the Port has eliminated its operating deficits and is growing positive cash flows through expansion and diversification of real estate lease revenues.

3. Study Goal and Objective

As mentioned above, the underlying goal of the study is to reduce the risk of flood damages to West Sacramento. The specific objective to meet this goal is to "*identify a range of alternatives for closing the gap between the Yolo Bypass Levee and Deep Water Ship Channel East Levee in order to reduce flood risks.*" The closures evaluated could either be temporary or permanent.

3.1 Considerations

While the objectives are simple statements of the intended purposes, they are informed by numerous considerations. The following considerations have been identified as important items in the development and analysis of alternatives.

- The primary goal of WSAFCA is to achieve at least a 200-year level of protection for the City as soon as possible, but no later than 2025 as required by Senate bill 5.
- Both 100 year and 200 year flood events will be evaluated in the analysis using the water surface elevation (WSE) of the Yolo Bypass as the design condition.

[2] Pers. Comm., Greg Fabun, Flood Protection Manager, City of West Sacramento, Dec 17, 2015; and meeting notes with City management, Oct 28, 2015

[3] Pers. Comm., Greg Fabun, Flood Protection Manager, City of West Sacramento, Dec 17, 2015

- Alternative plans should evaluate and consider the costs of ongoing levee operation and maintenance.
- Project implementation must consider the operation of the Port and impacts to channel maintenance. Timing of the implementation, both during construction and during operation, should be considered in alternative development and analysis.
- Economic viability will be evaluated through comparison of project costs and benefits, and include both construction and O&M costs.
- Alternatives will include the consideration of environmental impacts and required permitting for implementation. These will be described in general terms but more detailed analysis would be required prior to project implementation.

The objectives and considerations will be used to inform and guide the planning process which includes the identification of problems, opportunities and methods of analysis as well as the identification of alternatives.

4. Target Audience

There are several relevant target audiences of this study:

- WSAFCA (specifically, the City of West Sacramento, Reclamation District 900, and Reclamation District 537) and the Port of West Sacramento. Specific individuals representing these stakeholders—such as civil works/flood control managers, Port operations and business managers, environmental specialists, planners, etc.—will be identified through internal meetings. Information developed in this initial study will enable these decision makers to compare alternatives developed as part of this study and with operable closure structure alternatives presented in the USACE GRR.
- Stakeholders that will be involved in the implementation of any of the recommendations coming from this study include the following agencies that either have a regulatory role or would need to be involved in coordination prior to and/or during project implementation.
    - U.S. Army Corps of Engineers
    - U.S. Fish & Wildlife Service
    - National Marine Fisheries Service
    - U.S. Coast Guard
    - Central Valley Flood Protection Board
    - California Department of Water Resources
    - California Department of Fish & Wildlife
    - California State Water Resources Control Board
    - California Department of Boating and Waterways
    - Yocha Dehe Wintun Nation
    - California Delta Stewardship Council
- The general public, landowners, NGOs, and other interested parties.

5. Problems

The following flooding problems that are relevant to the current study are associated with existing conditions, and are discussed in the sections below:

- Flooding
    - Life Safety
    - Flood Damage
    - Environmental and Agricultural Resources
- Levee Construction Design, Methods, Materials, and Foundation
    - Erosion, Overtopping and Vegetation
    - Site Specific Levee Problems

5.1 Flooding

The City of West Sacramento is located at the confluence of the American and Sacramento Rivers, and adjacent to the Yolo Bypass (see Figure 2). It is within the floodplain of the Sacramento River. During large flood events, the City is an urban island that depends on the successful performance of nearly 52 miles of levees that help protect against the inflow of flood waters.

The region has a long history of flooding that prompted the 1917 authorization of the current flood control system which began with the Sacramento River Flood Control Project (SRFCP) levees and includes the Central Valley Project (CVP) and the 1956 completion of Folsom Dam. During the flood of record in 1986, an estimated 650,000 cfs flowed past the Sacramento metropolitan area in either the Sacramento River or Yolo Bypass. (USACE, 2015a)

The State standard for urban flood protection in California requires levees to have a top elevation equal to the mean 0.5% (1/200) Annual Chance of Exceedance (ACE) water surface profile, plus three feet of freeboard, plus an allowance for wave run-up, plus one foot to account for climate change. Portions of the levees do not meet this standard, as mentioned in the 2015 GRR, in which damages resulting from overtopping or failure of surrounding levees during a 0.5% ACE event as potentially flooding most of West Sacramento. Table 1 displays the floodplain area that was modeled. Figure 3 shows flood depths ranging from 0.1 to 30 feet associated with various ACE events (USACE, 2015a).

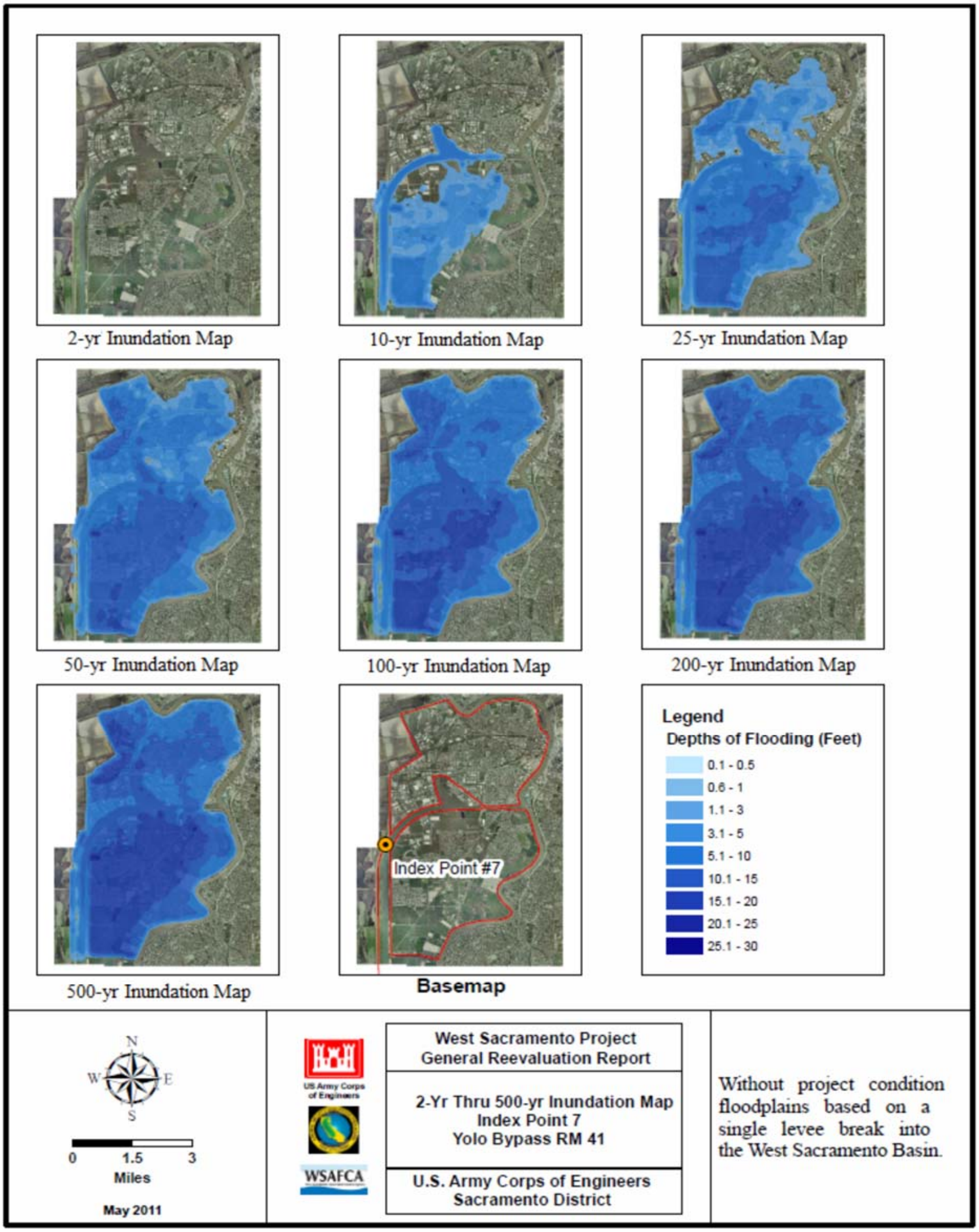

Figure 3. West Sacramento Area 2-year through 500-year floodplains, Index Point #7, from USACE 2015a

In addition, the GRR mentions the anticipated issuance in the near future of updated FEMA floodplain maps for West Sacramento that will show portions of the City within the 100-year floodplain. Due to this new mapping within the floodplain, development in the City will be constrained until a project is put in place that provides protection from the 100-year event.

Table 1. Floodplain Area during a 0.5% (1/200) Annual Chance Exceedance Levee Failure or Overtopping

(source: USACE 2015a)

Economic Impact Area	Total Acres	Total Square Miles
North Basin	5,468	8.5
South Basin	6,822	10.7
TOTAL	12,290	19.2

5.1.1 Life Safety

The consequences of flooding due to a levee failure would be catastrophic, with nearly the entire population of approximately 50,000 at risk. Daylight loss of life is estimated at 124 individuals, and nighttime at 90 individuals. As described in the 2015 USACE GRR, even a levee breach during a 4% (1/25) ACE event would put the population at risk with flood depths potentially up to 10 feet. Moreover, the Sacramento Area Council of Governments in 2007 predicted that the population of West Sacramento would increase by 64% from 2007 to 2030, with a population of 73,500 in 2030.

5.1.2 Flood Damage

West Sacramento is urbanized with commercial, industrial, residential, and public buildings, and rural farm lands. The current flood risk poses a threat of extensive damage to this infrastructure as well as to the potential loss of life, injuries, illnesses, and other health and safety problems. Extensive damage to utilities, roadways, major interstate transportation corridors, and other infrastructure systems would also likely occur. The GRR states the following:

> *"Significant damages to structures would be expected, as well as loss of life, injuries, illnesses, and other health and safety concerns. Flooding in the West Sacramento area could trigger an uncontrolled release of hazardous and toxic contaminants into the waterways surrounding West Sacramento. Transportation through the area would be severely hampered by a major flood. Critical infrastructure could be rendered nonfunctional for an extended period of time after a flood. Impacts to critical infrastructure would have a significant impact on the ability of the community to react to and recover from a significant flood event. Emergency costs associated with evacuation, flood fighting, fire and police, and government disruptions would occur. Debris cleanup would be a substantial undertaking. Wildlife populations occupying these areas would be adversely affected by flooding. In summary, a flood in West Sacramento would cause massive damages."* [Note: While the predicted average increase of approximately 2-3% per year has not actually occurred since 2007, suffice to say an overall and significant increase

in population has been projected.]

Figure 4 shows the land use in the City of West Sacramento north of the DWSC. The population of 50,000 within the City that was mentioned above is housed within 19,903 units. Additionally, there are 734 commercial and industrial structures, 46 public structures, and 27 park facilities which would all be affected by a flood event. Table 2 summarizes the number of damageable structures within the 0.2% (1/500) ACE floodplain. Total value of property in that floodplain is estimated at $4.53 billion. Single-event damages for the 1% (1/100) ACE flood are anticipated to exceed $3.6 billion. (USACE 2015a).

Table 2. Number of Structures by Category in 0.2% Exceedance Probability Flood

(source: USACE 2015a)

Structure Count By Damage Category	
Category	**Count**
Commercial	365
Industrial	424
Public	98
Residential	12,951
TOTAL	**13,838**

Critical infrastructure is always a concern during flood and other emergency conditions. Figure 5 depicts many of the facilities listed below which are all within the area of potential flooding described above (USACE 2015a), and are shown for the northern portion of the City.

Essential Services

- Regional USPS mail processing center
- USACE Bryte Yard Facility
- The regional Department of Water Resources Flood Fight facility
- The California Highway Patrol Academy (a key facility in state emergencies)
- West Sacramento City Hall
- Police Stations
- Fire Stations
- Bryte Bend Water Treatment Plant

At Risk Population Facilities

- St Claires Home for the Elderly
- River Bend Nursing Facility

Transportation

- Union Pacific Main Railroad Line
- AMTRACK
- Interstate 80
- U.S. Highway 50
- The Port of West Sacramento

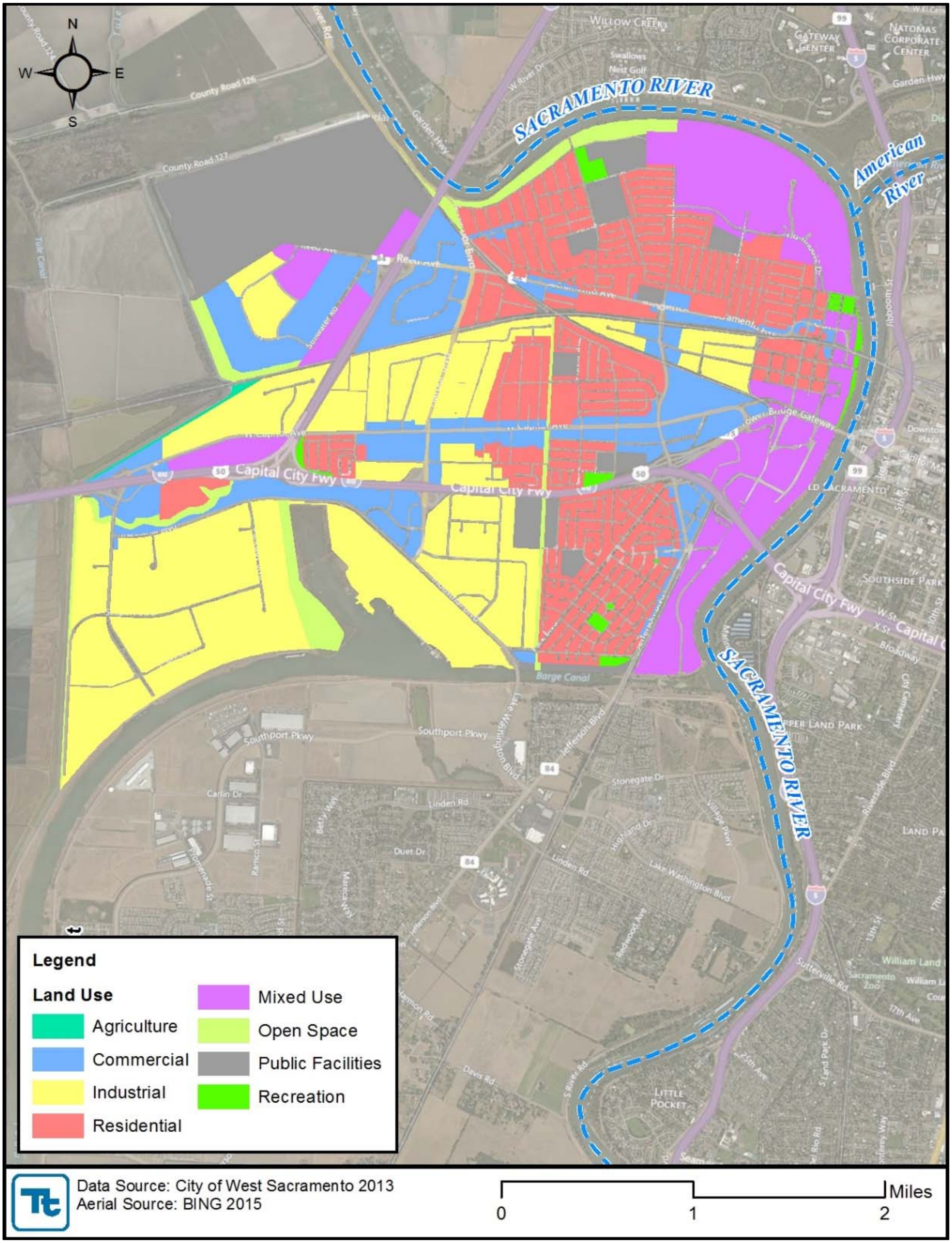

Figure 4. Land Use Map

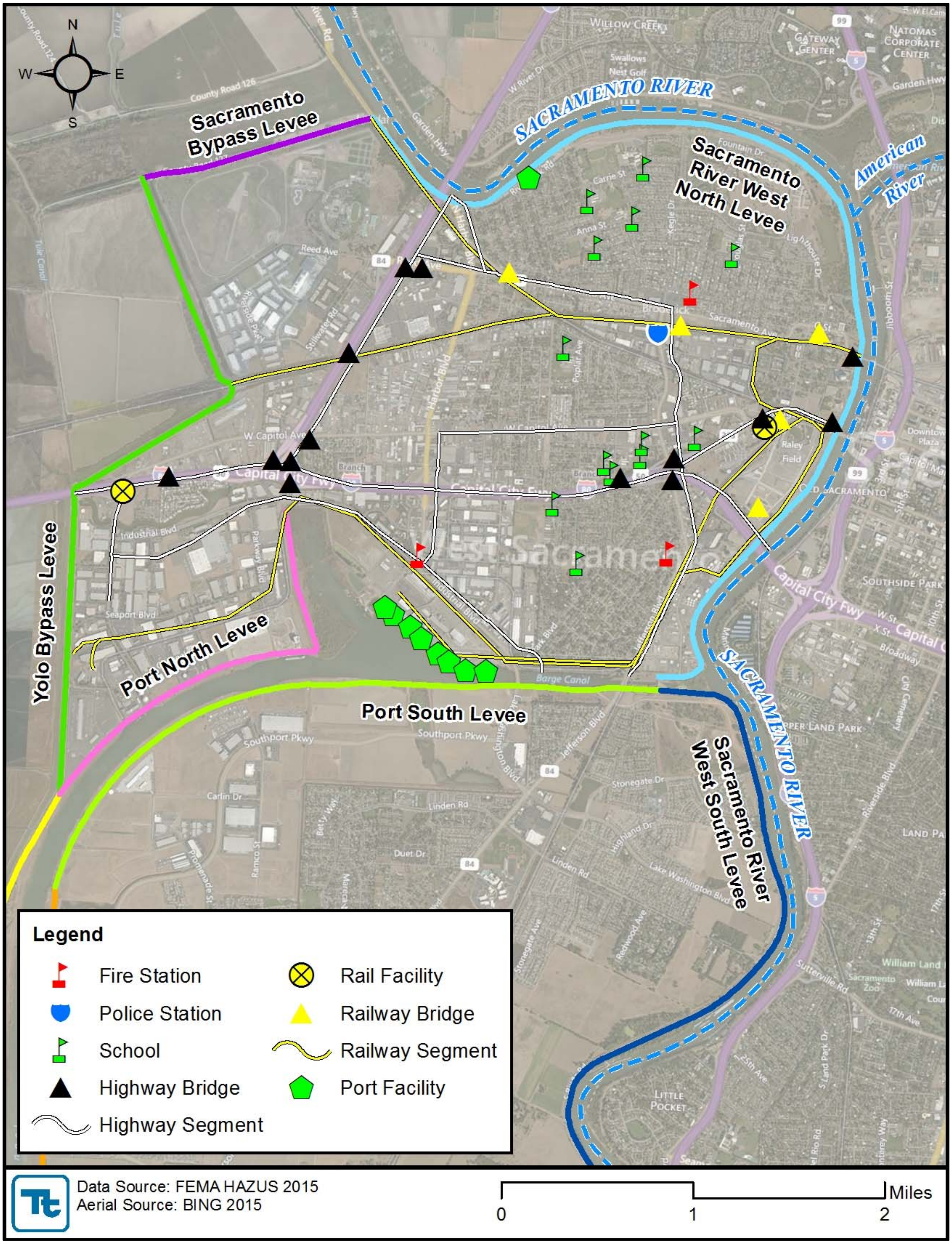

Figure 5. Critical Facilities Map

5.1.1 Impacts to Environmental and Agricultural Resources

Environmental and agricultural resources could also sustain major damage during a flood event. Of the land area within the City, 22.6% is either farmland or open space. If a catastrophic flood event occurred resulting in inundation of 10-15 feet, land damages alone are estimated to be $238 million. These values are based on the 1% (1/100) ACE event. (USACE 2015b)

A flood event could also cause severe public health hazards. Flooding in the city could release and spread stored hazardous materials creating hazardous conditions for the public and the environment, and potentially contaminating the Sacramento River and Delta surface waters as well as soil and groundwater. Flood damage to homes and other structures could render them dangerous due to structural damage as well as contamination. Additionally, the floodwaters and ponds left behind could provide a wide breeding ground for mosquitoes and other disease vectors. Effects to the water supply system could be particularly severe in a flood event, and could leave residents and businesses without a reliable water supply for a significant amount of time, as a single break in a water delivery pipe or main could contaminate the entire city's water supply.

5.2 Levee Conditions

Levee deficiencies pose a great threat even if peak flood flows do not occur. These deficiencies potentially stem from design limitations, construction methods, and materials. Both WSAFCA and USACE have identified severe deficiencies with the Port North, Port South, and DSWC levees that include perviousness, under seepage, foundational inconsistency, stability, and erosion. Deficient levee height is also a problem.

5.2.1 Material Deficiencies

In general, many of the levees in the study area were originally constructed with material dredged from the river and placed into a trench between two starter dikes.[4] Therefore the embankment is made up of pervious sands and gravels that transmit water during floods. In addition, the foundations upon which the levees were constructed is made up of the former river-bed including meanders and oxbows, which adds differential material in the foundation to the problems of perviousness and underseepage. Inadequate compaction along with assorted objects (such as dead trees and branches) have been found buried in the embankments. Slope failures have been observed during high river stages and where water seepage occurs. (USACE, 2015a).

5.2.2 Erosion and Vegetation

The Sacramento River channel is sediment-starved due to higher than "natural" velocities caused by confining levees and adjacent development that have created a narrow channel. Therefore there is a risk of erosion and undercutting by river flows.

[4] It is currently unknown whether this is true for the DWSC levees.

The GRR describes that at many areas of the study area there are both vegetation and encroachments on or near levees. The vegetation includes native vegetation, landscaping, gardens, and encroachments that include houses, utilities, outbuildings, swimming pools, etc. These are problematic due to their complicating effect on maintenance and flood fighting as well as their contributing effect on the instability of the levees themselves.

5.2.3 Site Specific Levee Problems

Site specific levee problems where a significant probability of failure exists is identified and described in detail in the GRR. The magnitude of subsequent flood damage would of course depend upon the location of the levee breach, severity of the storm, and river flows at the time of a potential levee failure. Problem areas are briefly described below and are associated with "index points," shown in Figure 6 and consistent with the GRR (USACE 2015a).

The most relevant location to the current alternative analysis is Index Point 7 at the Deep Water Ship Channel West (DWSCw). This is the location where a closure alternative is being studied. Yet it is noteworthy that several locations within the SRFCP affecting West Sacramento could cause flooding within the City especially if a breach of the DWSC West Levee occurs concurrent with breaches in the Port North, Port South, and Yolo Bypass Levee during a large flood event.

The levees in the North Basin include the Sacramento River North (SRN), Yolo Bypass (YB), Port North (PN), and the Sacramento Bypass (SB) levees. The levees in the South Basin include the Sacramento River South (SRS), South Cross (SC), Deep Water Ship Channel East (DWSCe), DWSCw, and the Port South (PS) levees.

Of the nine levees listed, the following number of levees are considered to have the following deficiencies and probabilities of failure. The relevant index points are indicated.

Table 3. Levee Problems and Failure Probabilities in the Study Area
(source: USACE 2015a)

Levee [1]	Problem					Probability of Failure [2] (%)
	Seepage	Stability	Erosion	Overtopping	Vegetation	
SRN #1	X	X	X	X	X	95.6
SRN #2						99.4
YB #3	X	X				99.9
PN				X	X	n/a
SB #4	X	X	X			80.9
SRS #5	X	X	X		X	69.6
SRS #6						42.6
SC	X	X		X		n/a
DWSCe	X	X	X			n/a
DWSCw #7	X		X	X		99.2
PS #8	X			X	X	23.1

[1] Numbers indicate applicable Index Points per Figure 6

[2] Probabilities based on condition of water being at the top of the levee; this occurs at different flood frequencies depending on the location of the specific levees with respect to localized flood flows.

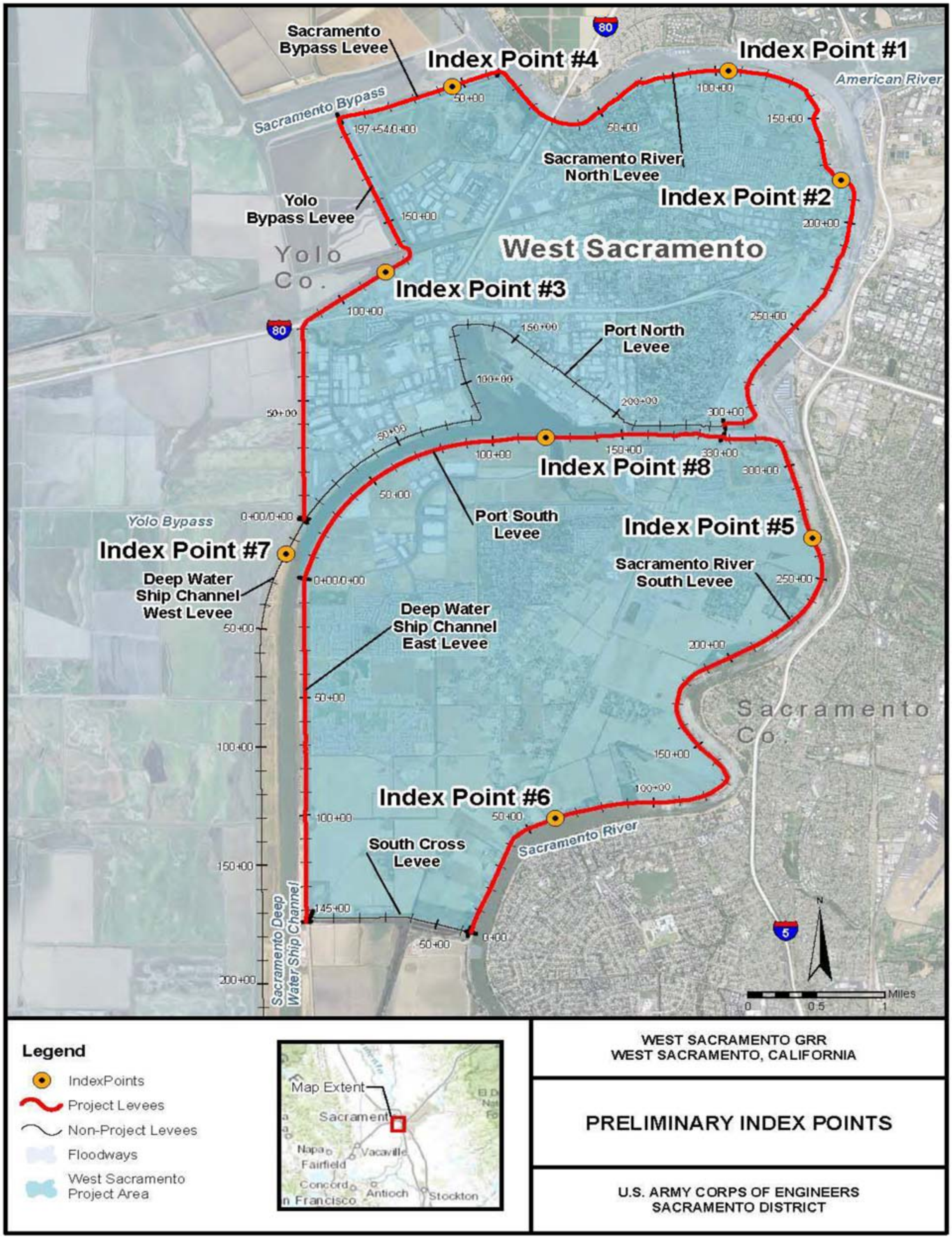

Figure 6. Levee Index Points

5.2.1 Deep Water Ship Channel West Levee

The difference in stage between the Yolo Bypass and the DWSC during a 200-year event is approximately 10-feet, and a breach in the DWSC West levee would result in severe flooding both north and south of the Port. This flooding scenario was illustrated in the GRR and is shown in Figure 3 based on a single levee breach in the DWSC Levee near its point of intersection with the Yolo Bypass Levee (Index Point #7). The figure depicts a suite of flood frequencies ranging from the 50% (1/2) ACE to the 0.2% (1/500) ACE. As shown in the 10-yr inundation map, the flood water from Yolo Bypass enters the DWSC and backs up to the Port of West Sacramento, then overtops the Port South Levee and DWSC East Levee. Port North levee is overtopped during a 25-year event. These floodplains indicate extensive flooding over a majority of the City starting with the 2% (1/50) ACE flood event.

6. Opportunities

An obvious opportunity to reduce the flood risk in the City of West Sacramento is to improve the structural integrity and/or height of levees within the study area. That is the primary recommendation of the USACE GRR. However, the current alternatives analysis is intended to identify a standalone alternative to the DWSC gate closure structure that was studied within the GRR but that was eliminated from consideration due to cost considerations. As such, the closure structure is independent of the need to improve the DWSC west levee downstream of the structure, and/or improve the Port North levee, Port South levee, and the DWSC East levee north of where a closure structure would be located.

Since the DWSC was constructed by breaching the Yolo Bypass Levee, the flood risk is from floodwaters entering the study area through the levee gap created by the DWSC. The opportunity therefore exists to develop a closure structure for the levee gap that provides a more cost-effective solution compared to the structure studied in the GRR, and potentially more cost-effective than the components of the GRR Recommended Plan for fixing 22 miles of levees.

The benefits of the closure structure go beyond reducing threats to life and structural flood inundation damages. They also include the avoided costs of business impacts, loss of employment, clean up, health effects, and traffic and rail disruption. Further, many of these avoided costs would not only affect the Port and the businesses and residents of the City, but would also provide regional and Statewide benefits.

7. Formulation of Alternatives

In the course of this analysis it became apparent that two major sets of alternatives should be considered:

(1) Temporary structures that would provide interim risk reduction but that would need to be removed after the flood threat subsides. A temporary structure may be considered advantageous while the overall GRR recommended plan is designed and funded; and

(2) Permanent structures that would either provide maritime vessel passage or not provide passage. These would include operable gate structures that are alternatives to the sector gate recommended in the USACE GRR, and non-operable, reconstruction of the levee.

   a. Permanent structures were considered for their compatibility with a vehicle bridge to provide access across the DWSC and/or public access as, for example, an extension of Enterprise Blvd.

   b. Permanent structures were considered for two operating conditions: always closed unless navigation is required, or always open unless a flood threat is imminent.

The assessment of the two major sets of alternatives differs. For example, the expectation for the implementation time to open and close a closure structure is relatively short for the permanent solutions—on the order of hours or minutes—while a much longer time—days or even weeks depending on the availability of construction equipment and material—is to be expected for an interim solution.

Specific alternatives considered as part of each set of solutions are given below.

7.1 Permanent Structures

This set of solutions includes permanent operable (PO) gates and permanent closures (PC). Cost efficiencies could be attained through the use of modified construction methods, resized navigation openings, or alternative gate structures. The permanent closures considered in this study include:

1. USACE Sector Gate (PO)
2. Sector Gate with Diversion (PO)
3. Resized Sector Gate (PO)
4. Steel Barge Gate (PO)
5. Lift Gate (PO)
6. Operating Bulkhead Gate (PO)
7. Navigation Barrier Gate (PO)
8. Rolling Gate (PO)
9. Pneumatically-Actuated Steel Plate Gate (PO)
10. Rock Berm or Earthen Levee (PC)
11. Sunken Barges (PC)

Each of the operable solutions has the potential variation of leaving the structure in either the normally open or normally closed position. A normally open position supports navigation more easily in that no action is needed to allow maritime traffic to pass. A normally closed position more effectively supports flood risk management in that no action is needed to provide flood protection. A normally closed gate may also provide vehicular transportation benefits to those alternatives that could support a roadway.

The following sections describe each of the permanent solutions considered.

Attachment 1 displays details including photographs and renderings that further explain how these alternatives function.

7.1.1 USACE Sector Gate

A sector gate consists of two hinged gates in the shape of part of a circle (or sector) that swing inward towards the channel and act as a barrier to flow. This alternative is the same sector gate alternative presented by the USACE in the GRR. The sector gate recommended in the GRR has a 200 foot wide opening, a base elevation of -37.0 feet, and top of structure elevation of 34.0 feet for a total gate height of 71 feet. The structure would consist of conventionally reinforced concrete and post tensioned concrete supported on a pipe pile foundation. The concrete structure would use float-in construction. The concrete shell would be built similar to barge type construction in a graving site adjacent to the project site. The float-in design eliminates the need for cofferdams, structure site dewatering systems, and a structure site bypass.

The sector gate recommended in the GRR did not include a roadway. Due to the non-linear alignment of the radial gates, a roadway on top of the gates is limited with the arrangement shown in the GRR. A maintenance road can be accommodated. A two-lane road can also be accommodated albeit with limited vehicular speed, some larger vehicle limitations, and some modifications to the monolith and its alignment with the tie in T-wall. The modification to the shape of the monolith together with the modified alignment of the tie in T-wall maintains the flood barrier but also allows the roadway across the sector gate to transition more smoothly to the roadway across the T-walls.

7.1.2 Sector Gate with Diversion

This alternative is a modification of the USACE sector gate alternative only in that the method of construction is changed. Rather than using a float-in construction this alternative is intended to include diversion of the water in the DWSC with on-site construction. All other elements are the same as the USACE sector gate. This alternative was considered only to determine if a more cost effective sector gate is feasible. An initial assessment showed that the cost difference was not significant for this level of feasibility and this option was not evaluated further. However, if the sector gate option is selected, this variation should be considered.

7.1.3 Resized Sector Gate

This alternative is similar to the USACE sector gate but the height and width are minimized by constraining the channel. In order to realize savings from the smaller gate size, the width would need to be reduced to a point where not all current traffic that travels the DWSC to the Port would be accommodated. This effectively eliminates current maritime use. Other alternatives that also eliminate maritime use have a significantly lower cost. Based on this initial assessment, no further evaluation of this alternative was made.

7.1.4 Steel Barge Gate

The steel barge gate consists of a floatable barge that is operated by swinging the gate open and closed, and resting it atop landing supports in the open/closed position. The barge gate would seat onto a slab/cutoff wall that can resist uplift. However, the steel barge gate cannot be opened when the difference in the water level on both sides of the gate is significant.

A roadway can be added across the barge for vehicular traffic. The width of the barge gate would need to be increased to accommodate construction of a road. This alternative is able to integrate the road with the gate and realize significant savings from the dual construction.

7.1.5 Lift Gate

A lift gate consists of a large plate that is lowered into position to form a barrier that acts as a barrier to flow. A lift gate requires an overhead structure for lifting the plate as well as a concrete foundation. The lift gate needs to be able to be lifted above the elevation needed for clearance of the maritime traffic. The total height of the gate is 71 feet (see section 7.1.1) and maritime traffic requires a 130 feet clearance above a normal water elevation of 5 feet giving a top of structure elevation of 211 feet. The foundation at the invert of the DWSC is at an elevation of -37 feet giving a full structure height of approximately 250 feet.

Lift gate fabrication is more straightforward and typically less expensive than a sector gate given that there are no curved members. However, a lift gate is going to be a more expensive option than the sector gate for this specific set of circumstances:

- Lift gates become more inefficient to design as they become wider (200 feet wide at DWSC) compared to a sector gate because the lift gates span from one side of the channel to the other, acting like a beam.
- The lateral load due to the hydrostatic (water) forces on the proposed gates is very large. One advantage that lift gates typically have over sector gates is that they have smaller foundations. Considering the estimated number of piles required to resist the lateral load, the foundation for the lift gate would be just as large as the sector gate foundation.
- The proposed clear height for the lift gate is very high. The seismic force resistance system for the lift gate towers will be similar to high rise building and will be expensive to implement. Seismic loads on the lift gate towers will be high considering the likely foundation conditions in the river and the importance of the structure.
- The lift gate may have settlement issues. The closure structure will be located in an area likely to have soft ground conditions. Both gate foundations will be subject to settlement. However, because the gate is attached to two towers located 200 feet apart, the gate may bind in its tracks if there is differential settlement. The sector gate with a traditional concrete monolith is tied together so differential settlement is less likely.

The proposed lift gate is large, and providing an integrated roadway for either regular vehicular traffic or for maintenance vehicles can readily be accommodated with a bridge on top of the structure, considering that the gate leaf itself is straight.

7.1.6 Operating Bulkhead Gate

The operating bulkhead gate is similar to the lift gate except than when open, it is stored in the horizontal, lifted arrangement to reduce the effects of wind and seismic loads (compared to a traditional lift gate). Because of the horizontal storage, the total height can be reduced to approximately 180 feet to allow for maritime traffic clearance. The foundation requirement is still very large leading to a high capital cost that overshadows relatively smaller savings resulting from the horizontal storage.

The operational method of this gate would require a separate roadway bridge, parallel to the operating bulkhead gate that would also have to be lifted to clear the shipping traffic. This alternative does not provide any advantage as compared to the lift gate; therefore, no further evaluation of this alternative was made.

7.1.7 Navigable Barrier Gate

The gates operate by rotating a plate from a horizontal position along the channel bottom into a vertical position to create the barrier. The plate is hollow and fills with water when it is submerged and stored along the channel bottom. When operated, it empties as it emerges from the river.

Due to the method of operation, a navigable barrier gate cannot support an integrated roadway. It also does not support construction of a maintenance road.

7.1.8 Rolling Gate

When in the open position, this gate is stored in a recessed “slot” in the lock wall built into the bank of the channel. The gate operates by being mechanically rolled into position to create a barrier to flow. Similar to the lift gate, a large foundation is required resulting in a total capital cost higher than a sector gate. If the gate is kept in the normally open position, the dry storage results in longer life span. This longer life span is not realized if the gate is left in the normally closed position. The rolling gate cannot be opened when the water level is not the same on both sides of the gate.

A rolling gate can support an integrated roadway for either regular vehicular traffic or maintenance. The straight alignment of the gate is compatible with a roadway.

7.1.9 Pneumatically-Actuated Steep Plate Gate

For this type of gate, the steel plates in the structure are hinged at the bottom and raised by inflating a bladder. The structure is permanently mounted at the channel bottom and fixed to a reinforced concrete foundation using clamp plates and anchor bolts. The plates lie flat until the bladder is inflated by pumping air inside the rubber body until the design height or pressure is reached. Due to the method of operation, a steel plate gate cannot support an integrated roadway. A separate structure would be required to support a roadway for either regular vehicular traffic or maintenance.

While gates of this type have been used throughout the world, the manufacturer has never built one at the required 70-foot height.[5] To avoid potential risk, no further evaluation of this alternative was made.

7.1.10 Rock Berm or Earthen Levee

This alternative includes a rock berm that is placed across the channel to effect a water barrier. Sheetpile cut off walls would be included in the berm for the permanent design to prevent through seepage and under seepage. Small tainter gates or sluice gates could be incorporated into allow for flushing of water upstream and downstream of the berm.

This alternative is not operable and precludes maritime traffic. A roadway for vehicular traffic and maintenance can be incorporated into the rock berm and significant savings from the dual construction would be realized.

A variation of this alternative is to construct using earth rather than rocks. The footprint of this alternative is larger than the rock berm because the placed soil material must be of sufficient width to prevent through-seepage and under seepage. If the earthen levee is chosen for implementation, the design should meet the same level of protection currently provided by the adjacent levees upstream and downstream. To increase the level of protection of only the closure levee would be unnecessarily cost inefficient since the adjacent, tie-in levees would drive the overall level of protection. Any additional level of protection should therefore be accomplished consistently across the DWSCe levee, the Yolo Bypass levee, and proposed closure levee.

The evaluation of either the rock berm or earthen levee is the same so they are considered as a single alternative in this initial assessment.

7.1.11 Sunken Barges

For the permanent structure category, this alternative would use multiple barges that are floated into position, then scuttled, in order to close off the channel. Several barges would be required to create the barrier. Positioning the barges to create an effective barrier would be difficult. Moreover, limiting leakage to create an effective permanent barrier would also be difficult. Because of this, no further evaluation of this alternative was made.

7.2 Temporary Structures

Two of the permanent structures, above, could also be used on a temporary basis primarily in the event of emergencies when flooding becomes imminent. These structures would preclude navigation for a period of time until the ship channel could be reopened. These temporary, non-operable closures (TC) generally involve significant effort and construction equipment to remove.

[5] The largest existing installation to-date is on the Nanming River in China, at 200 feet by 25 feet (pers. comm., Henry Obermeyer, February 2016).

Note that further evaluation could occur to address the potential of the following options related to variable closure of the ship channel as a function of flood risk. Once identified, it could become formalized in an Emergency Action Plan.

- Viability of having a cost effective rock berm closure that is removed following every flood season. This would effectively create a seasonal port. While the navigation patterns currently indicate no clear cut seasonal distribution of maritime traffic, the possibility for the concept could be evaluated.
- The frequency of closure considering not only the available warning time but also the levee performance that may not depend on an overtopping water surface condition.
- Identification of the triggers to institute an emergency closure as related to the evacuation plan. For example, one trigger could be when the WSE reaches the 25-year frequency level, and the next trigger could be if the bypass begins to fail.
- Risk related to an assumption of variable West Levee failure could be identified. That is, what frequencies of flooding could be sustained with little damage to allow a temporary closure to remain open.

7.2.1 Rock Berm

Similar to the alternative described in Section 7.1.10, a rock berm would be placed across the channel to create a barrier. Once the flood event has passed, the rocks are removed.

Because of this structure's intent being temporary:

- No sheet pile is incorporated to prevent seepage (as exists in the permanent version of the Rock Berm).
- No roadway would be incorporated for vehicular traffic.

The temporary rock berm would take at least a week to construct. Because of the lack of timely emergency response, no further evaluation of this alternative was made.

7.2.2 Sunken Barges

Multiple barges would be stationed at the port and floated into position, then scuttled, in order to close off the channel. Several barges would be required to create the barrier. It's unlikely that the Port can easily store these barges on a permanent basis without impacting its operations. In addition, positioning the barges to create an effective barrier and limit leakage would be difficult. Because of the operational difficulties, no further evaluation of this alternative was made.

8. Alternatives Considered Further

A description of each alternative was provided in Section 7. The following alternatives which passed the initial screening evaluation, are being considered:

1. USACE Sector Gate (PO)
2. Steel Barge Gate (PO)
3. Lift Gate (PO)
4. Rolling Gate (PO)
5. Rock Berm or Earthen Levee (PC)

For the operable gates, two versions of each alternative is considered where possible: the gate normally left open and normally left closed.

Attachment 1 includes further details on these alternatives.

9. Ranking Considerations

The tasks that represent this Closure Structure Alternatives Study including the identification, comparison, and analysis of alternatives, are intended to offer a "reconnaissance-level" phase analysis utilizing a "proof of concept" approach. As such, the initial rankings will consider the following criteria and considerations in a nominal ranking that avoids detailed quantification. In order to best convey the relative rankings for each criterion, a visual matrix has been used that helps immediately identify advantages and disadvantages of each alternative within each criterion. Colors (green, yellow, and red) are used to quickly convey best and worst choice alternatives. In addition to the colors used, the matrix will also convey the relative weighting of importance of each criterion by varying their respective row heights.[6] Narrative explanations will accompany the alternatives, below, that provide reasoning and justification for the rankings.

The following criteria were considered in the alternative evaluation:

- Enhanced Flood Risk Management – all of the alternatives provide flood risk management. However, some of the alternatives provide an enhanced level of protection. Enhancements considered were (1) if passive positive closure is provided so that a "normally closed" position achieves flood control without any action, (2) a maintenance road can be integrated into the alternative, and (3) a flood evacuation road can be provided.
- Capital and Design Cost – this evaluation is based on engineering judgement. Conceptual level cost estimates will be prepared for select alternatives.
- Time to Open/Close – the time required for closure is how much warning time must be provided to close the structure so that it can withstand floodwaters. Closure time can be impacted by the head differential on each side of the structure (such as occurs with the Rolling Gate). With short warning times and quickly rising water surface elevations, closures that take too long to close would be ineffective. In later phases of the study, the actual warning time for design storms should be investigated along with correlation to "critical" water surface elevation levels. Opening time has a direct impact on how quickly maritime traffic can be accommodated along the DWSC. Similar to closing times, opening times can be impacted by the head differential on each side of the structure.

[6] The "importance" weight assigned to each criterion is based on judgment and subsequent verification among the study group.

- Supports Navigation – this factor addresses how easily the current level of maritime traffic can be supported.
- Supports Bridge Construction – this factor addressed whether a road can be integrated into the gate structure.
- O&M Effort – the overall benefit of any closure needs to consider the level of effort related to both initial and ongoing operational and maintenance efforts of the closure structure itself. Any associated impacts on O&M of the surrounding levee system are not considered herein.
- Relative Project Impacts – this factor considers the differential impacts among alternatives which would primarily accrue to short-term water quality impacts during construction, long-term post-construction water quality impacts, and long-term aesthetic impacts. Water quality is a potential issue due to a reduction in water circulation that would take place with longer-term closures unless smaller gates are installed allowing flow to the Port. Aesthetics—mostly visual—could be considered a negative impact if the closure structures were large enough to be seen for several miles such as may occur with the lift gate or that may occur with large stockpiles of adjacent rock as would need to occur for the temporary rock berm.

10. Comparison of Alternatives and Initial Ranking

The "Alternatives Matrix" on page 32 consists of criteria considerations on the left-hand column and the alternatives along the top.

10.1 Matrix Construction

- The criteria are arranged in their order of priority, with "enhanced flood risk management" and "capital and design cost" at the top and "relative project impacts" and "O&M effort" at the bottom. In order to capture these priorities, each criterion is assigned a "factor value" which is used in the evaluation described in Section 10.3, "Matrix Methodology," below. The following table indicates the various factor values that are assigned.
- The "rating" for each alternative for each criterion is shown in a qualitative manner, with "high," "medium," and "low" reflected by the green, yellow, and red cells, respectively.

Criterion	"Factor Value" displayed as Row Height
Enhanced Flood Risk Management	90
Capital and Design Cost	80
Time to Open / Close	55
Supports Navigation	50
Supports Bridge Construction	50
O&M Effort	45
Relative Project Impacts	40

10.2 Rationale for the Assigned Values

- Enhanced Flood Risk Management – The first consideration in this factor is whether the alternative provides a passive closure to floodwaters, or if implementation is required for flood control. Operable gates that are normally left in the closed position and opened only to allow for immediate passage of maritime traffic are considered passive protection and provide an enhanced level of flood risk management. An alternative that provides a maintenance road for use during a flood event contributes to enhanced flood risk management. An improved road that also allows for evacuation provides additional enhancements. A road on a gate was only considered to provide an evacuation route if the gate is operated normally in the closed position. A normally open gate would likely not be well utilized by evacuees as the location is normally not seen as providing an evacuation route. A "high" value to this factor was assigned if all 3 conditions were met (passive flood control, maintenance road, evacuation road.) A "low" value was assigned if there was no passive control of floodwaters (i.e. implementation is required to achieve flood protection). All other alternatives were assigned a "medium" value.
- Capital and Design Cost – Engineering judgement was used to identify high to low capital costs based on past experience with these types of closures and/or published magnitudes of costs. Clearly, the sector gate alternatives are relatively more expensive as is the rolling gate. The pneumatically-actuated steel plate gate and rebuilding the levee/berm are the least expensive. Additional evaluation followed the initial screening done as part of the matrix evaluation, and are associated with the alternatives recommended for further study.
- Time to Open / Close – Long closure times reflect less effective risk reduction when high flows are impending. Most of the gate closures have relatively fast closure times that are on the order of minutes. These and of course the permanent levee and berm alternative were given a "high" value. The steel barge gate can take hours rather than minutes to close and was assigned a "medium" value. The temporary rock berm was given a "low" value because, as an emergency preparedness measure, it would take days rather than hours to construct. No permanent alternatives were considered that have a "low" value for the open/close criterion.
- Supports Navigation – A "high" value was assigned to alternatives that allow routine navigation with no restrictions. This applies to all of the normally open gates. A "medium" value is assigned to those alternatives where maritime traffic is allowed on a planned schedule where the closure would need to be opened. This includes the gates that are maintained in the normally closed position. Where navigation is not supported and the DWSC is permanently closed, a "low" value is assigned.
- Supports Bridge Construction – this factor is given a "high" value if a bridge that can accommodate vehicular traffic can be integrated into the closure structure and the alternative is left in a normally closed position. A "medium" value is assigned for

alternatives that accommodate an integrated bridge that is intended to be left in the normally open position. A "low" value is given for those alternatives that cannot accommodate a bridge for vehicular traffic.

- O&M Effort – Engineering judgement was used to define "high", "medium" and "low" operation and maintenance effort. The rolling gate and the barge gate involve a higher O&M effort primarily due to the need to ensure a lack of interfering debris on the channel bottom, and with the barge gate, proper alignment for placing the barge structure. This can often entail a team of divers each time the closure is implemented. Most of the other gates have a medium level of effort just by virtue of their "moving parts." The permanent rock berm and earthen levee have a relatively low O&M effort, while the temporary rock berm has a high level of effort because of the labor- and equipment-intensive effort at placing and removing the rock.
- Relative Project Impacts – All of the alternatives that provide a normally open channel were assigned a "high" value because normal flow circulation can be maintained. The exception is the lift gate which was judged to be have a significant visual impact and was assigned a "medium" value. All alternatives that are normally closed and only opened periodically were also assigned a "medium" value. The permanent closure of the rock berm / levee alternative was assumed to have a "medium" value for this criterion because even though normal flow circulation would be permanently changed, mitigation measures such as an easily operable tainter gate could be used to promote circulation.

11.Matrix Methodology

A numbering system is used to rank the alternatives according to the rationale discussed above. As is typical of planning tools that are used at this level of comparison, the numbers are more indicative of *relative* ranking among criteria than being representative of absolute values. For example, costs have not yet been assigned to the alternatives other than using engineering judgement on cost being high, medium, or low.

- To capture the relative values of the green, yellow, and red cells, number values of 5, 3, and 1, respectively, were assigned.
- These values were then multiplied by each criterion's weighted priority represented by its row height. In the "Alternative Matrix" page, below, the numbers in each cell represent this calculation. For example, the Enhanced Flood Risk Management factor has an assigned weight/row height of 90. This was multiplied by the "high"/green value of 5 to reach 450 for all of the green alternatives for that criterion.
- Finally, each alternative's value for each criterion was added up for their total score, which was then ranked numerically. The rankings are shown at the bottom of the matrix.

Alternative Matrix

FACTOR VALUES	CRITERIA / CONSIDERATIONS ↓	PERMANENT ALTERNATIVES								
		USACE Sector Gate		Steel Barge Gate		Lift Gate		Rolling Gate		Permanent Rock Berm or Earthen Levee
		Normally Open	Normally Closed	Normally Open	Normally Closed	Normally Open	Normally Closed	Normally Open	Normally Closed	
90	Enhanced Flood Risk Management	90	450	90	450	90	450	90	450	450
80	Capital and Design Cost	80	80	240	240	80	80	80	80	400
55	Time to Open/Close	275	275	165	165	275	165	275	165	275
50	Supports Navigation	250	150	250	150	250	150	250	150	50
50	Supports Bridge Construction	150	250	150	250	150	250	150	250	250
45	O&M Effort	135	135	45	45	135	135	45	45	225
40	Relative Project Impacts	200	120	200	120	120	120	200	120	120
	RANKINGS	#6	#2	#7	#3	#8	#4	#9	#5	#1
	Total Score -->	1180	1460	1140	1420	1100	1350	1090	1260	1770
	Offset from highest ranked -->	590	310	630	350	670	420	680	510	0

12.Results

The following closure alternatives appear to warrant further study based on their relative rankings.

Ranking:

1. Rock Berm or Earthen Levee (Permanent)
2. USACE Sector Gate (Normally Closed)
3. Steel Barge Gate (Normally Closed)

The temporary rock berm was not considered applicable to the rankings because it is a separate subset of the alternatives. Still, the total score is shown on the matrix and the alternative is discussed below.

13.Discussion

The ranking of the *Rock Berm* or *Earthen Levee* as #1 is driven by the enhanced flood risk management and capital cost criteria. It is the only alternative that is considered to have a relatively low cost and meets all of the enhanced flood risk management goals. However, as a permanent solution this is also the only alternative that does not support continued navigation. Implementation of a permanent closure structure or completion of DWSCw levee by the USACE may take some time and during this period the City would continue to be exposed to an unacceptable level of flood risk. The rock berm alternative may be a viable temporary closure structure that could reduce the risk of flooding to the City and therefore warranted continued evaluation.

The *USACE Sector Gate* in the normally closed position was ranked as #2. Compared to most of the other operable gates that were evaluated that were also assessed as "high" cost options, the sector gate has the advantage of being opened quickly with no hydraulic limitations.

The *Steel Barge Gate* was ranked as #3. This is the only alternative with a "medium" cost and meets all of the flood risk management goals. This alternative supports both bridge construction and navigation. This alternative, operated in the normally closed position, ranks higher than operated in the normally open position (which ranked #7). This is driven by the fact that in the normally closed position it meets all of the enhanced flood risk management goals, while in the normally open position it does not meet the positive closure or the evacuation route goals.

The lift gate and rolling gate alternatives did not make the "top 3." The differentiators of the lift gate were primarily cost and relative project impacts. Considering the size and height of the structure, it appeared that the gate would become more expensive than the sector gate due to the extreme foundational supports that would be necessary while being more time consuming to operate compared to the sector gate. It would also seem to be a blight on the visual landscape. The rolling gate has higher costs than the barge gate along with operational concerns due to both hydraulic pressure differences on either side of the gate when needing to be opened and potential debris issues on the rolling track when needing to be closed.

Therefore, these three permanent alternatives are further evaluated to confirm the validity of the assumptions made in the initial assessment.

1. Rock Berm or Earthen Levee
2. Sector Gate
3. Steel Barge Gate

14. Refined Alternative Array

The following sections provide additional detail related to each of the alternatives recommended for further evaluation. Conceptual costs are also provided for each of these alternatives. For each alternative a contingency of 50% is included in the costs except for the earthen levee and rock berm permanent closures which is assigned a 30% contingency. This is because of the relative familiarity with these types of structures and reduced level of design difficulty. Cost summary spreadsheets are provided in Attachment 2.

14.1 Earthen Levee and Rock Berm

The initial assessment rated the earthen levee option as #1. A rock berm was also evaluated but is not likely a good option for a permanent closure due to (1) higher cost which is partly due to additional seepage control required, and (2) the lack of potential for vehicular traffic. The advantage of rebuilding the levee is that there is no operational considerations although maintenance of the system would still need to be performed. This provides a high degree of reduced flood risk as the protection is always in place. A disadvantage of this alternative is that it completely prevents any maritime traffic. Small tainter gates could be considered within the design to allow for water flushing on either side of the levee.

The use of a rock berm was evaluated as an interim action until a permanent solution is implemented. As mentioned above, this would help mitigate the unacceptable flood risk that currently exists while waiting for completion of the DWSCw levee by USACE. As shown in Figure 8, the temporary version of the Rock Berm would not include sheet piling. Note, however, that providing a rock barrier in response to *emergency* conditions would be questionable if intended to be implemented based on a flood warning system or short-term storm predictions. That is because it would take at least a week to drop over 450,000 tons of rock in the channel, even in the best-case scenario in terms of productivities, rock being stockpiled on adjacent land and readily handled for placement, and crews working 24-hours per day.

Figures 7 and 8 show conceptual plans and typical sections for these two alternatives. Note that no geotechnical evaluation was conducted at this level of analysis, so that further design refinements would be required. Both the earthen levee and rock berm options are shown for comparison despite the current focus on the earthen levee. Both options are also summarized in the cost summaries in Attachment 2, along with a time of production related to implementing the rock berm.

The assumed design elevation is 34 feet and the base would rest on the channel invert at an elevation of -37.0 feet. This results in a total earthen berm height of 71 feet. The berm would have a total width of 740’ wide which includes a 30-foot wide road and 3:1 side slopes. These relatively flat slopes would be required to mitigate the potential for seepage. Velocities would be minimal and small facing rock would be assumed to be adequate.

The total cost for the earthen levee is approximately $50,000,000. The total costs for the rock berm alternatives is approximately $69,000,000 and $63,000,000 for the permanent and temporary designs, respectively. The cost of the earthen levee is driven by the total fill required (more than 533,000 cubic yards). The cost of the rock berm is driven by the total rock required (489,000 tons). As was assumed in the initial assessment, these alternatives have significantly lower costs as compared to the other alternatives considered.

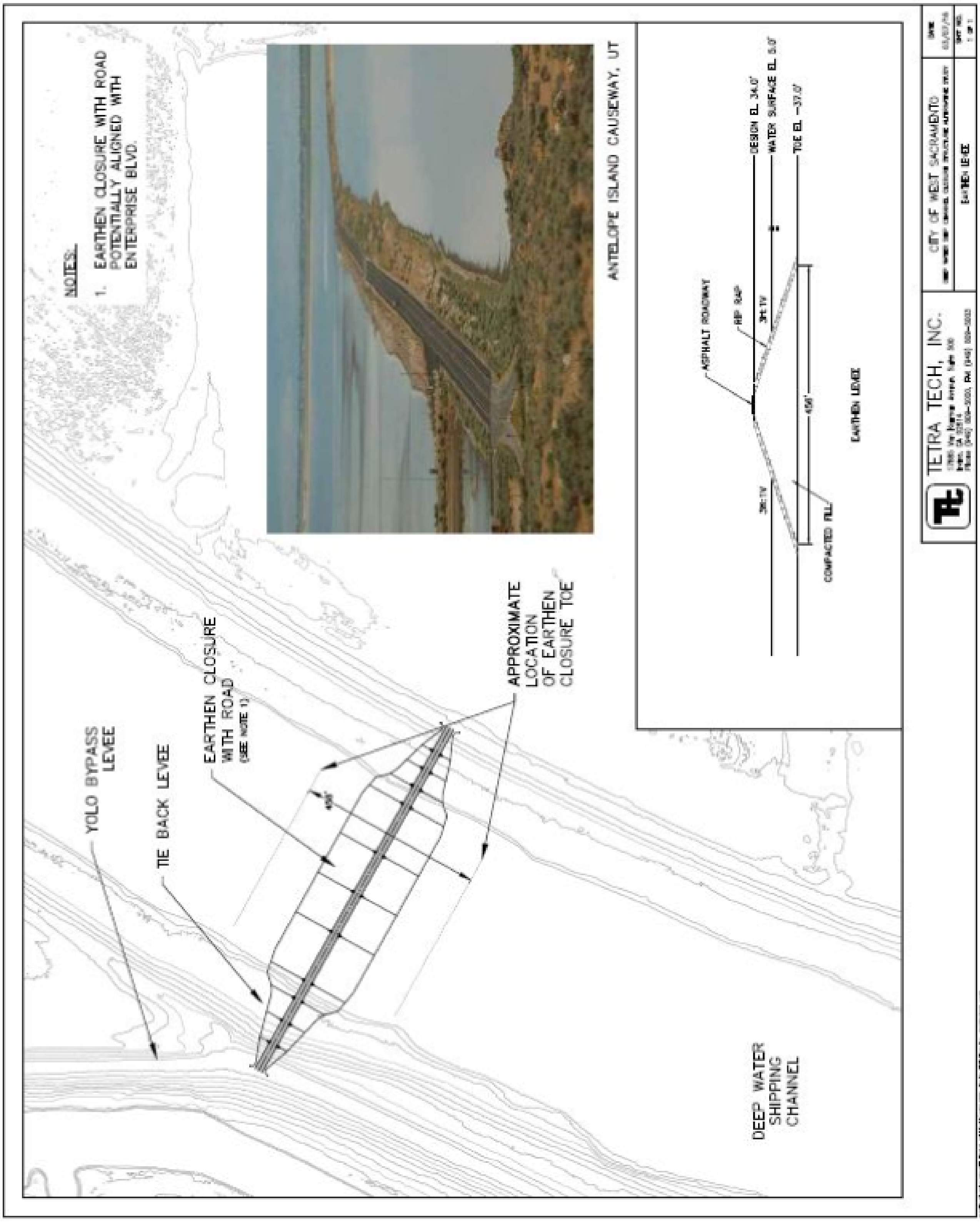

Figure 7. Earthen Levee

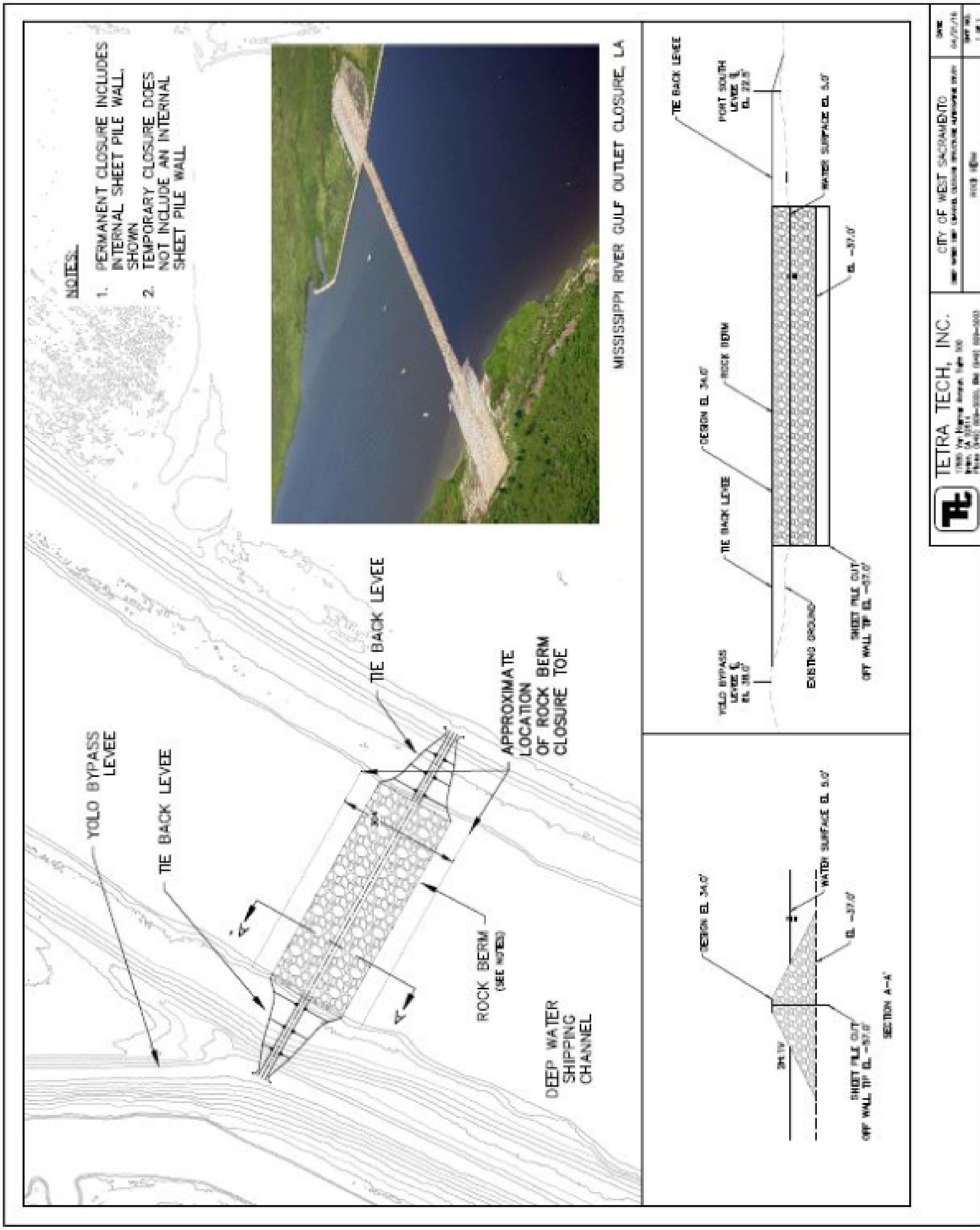

Figure 8. Rock Berm

14.2 Sector Gate

The initial assessment rated the sector gate alternative as #5 when evaluated in the normally closed position and #9 in the normally open position. The advantages in the normally closed position include enhancements to flood risk management (through in-place passive flood control and potential establishment of an evacuation route and maintenance road) as well as support of bridge construction with the least restrictions to vehicular traffic. The normally open position provides the least restrictions to navigation.

Figure 9 shows a conceptual plan and typical section for this alternative. Two options are shown: Option 1 is a traditional sector gate configuration and Option 2 is reconfigured to accommodate a bridge. This conceptual information was used to generate planning level costs. The total sector gate cost is $362,000,000. Incorporating a roadway would cost approximately $3,000,000 for a total alternative cost of approximately $365,000,000.

The drivers in the cost are the sector gate structure and the sector gate monolith. These lump sum values were based on prices developed for other projects. The sector gate structure cost was developed using the cost developed for the IHNC sector gate in New Orleans, Louisiana. The cost per pound ($12/pound) from the IHNC project was applied to the DWSC gate based on the weight per leaf of 1,070 tons identified in the GRR. The sector gate monolith was based on the average cost per kip required in the monolith structure for both the IHNC monolith and the Houma Navigation Canal monolith projects in New Orleans.

This alternative (without the road) is very similar to the alternative identified in the USACE GRR. Float-in construction is assumed similar to the USACE assumption. The USACE total cost for the sector gate is approximately $519,000,000. If contingency costs are NOT included, the USACE sector gate cost is $271,000,000 and the cost in the analysis herein is $241,000,000, which is on a similar order-of-magnitude. USACE assumed a 95% contingency and the current analysis assumes a 50% contingency, which accounts for most of the $163,000,000 difference in costs.

A 50% contingency was selected in this analysis based on judgement considering the very preliminary nature of the option. The USACE contingency was based on an abbreviated risk analysis that identified the following key drivers in the contingency:

1. Project scope growth due to design confidence because this type of work has not been completed within the Sacrament District of the USACE.
2. Acquisition strategy is unknown as there is no contracting plan in place and there is a possibility of an accelerated schedule due to limited construction windows.
3. Construction elements include unique construction methods and specialized equipment and labor.
4. Quantities have a low level of confidence associated with very preliminary quantities.
5. Specialty fabrication or equipment is required for this type of construction which has not been completed in the District.
6. Cost estimate assumptions related to concern about adaptability of the project which was patterned after structures in the New Orleans District to this site.

These contingency drivers were reviewed and contingency mitigation measures considered. The Memorandum included in Attachment 2 provides details of those mitigation measures. Staff who participated in the conceptual design and cost estimate for this study have worked on sector gates, including in New Orleans, and consider the designs to be adaptable to Sacramento. Costs developed in those projects were used to develop costs for this alternative. Based on this experience, staff consider a 50% contingency to be adequate at this conceptual design level.

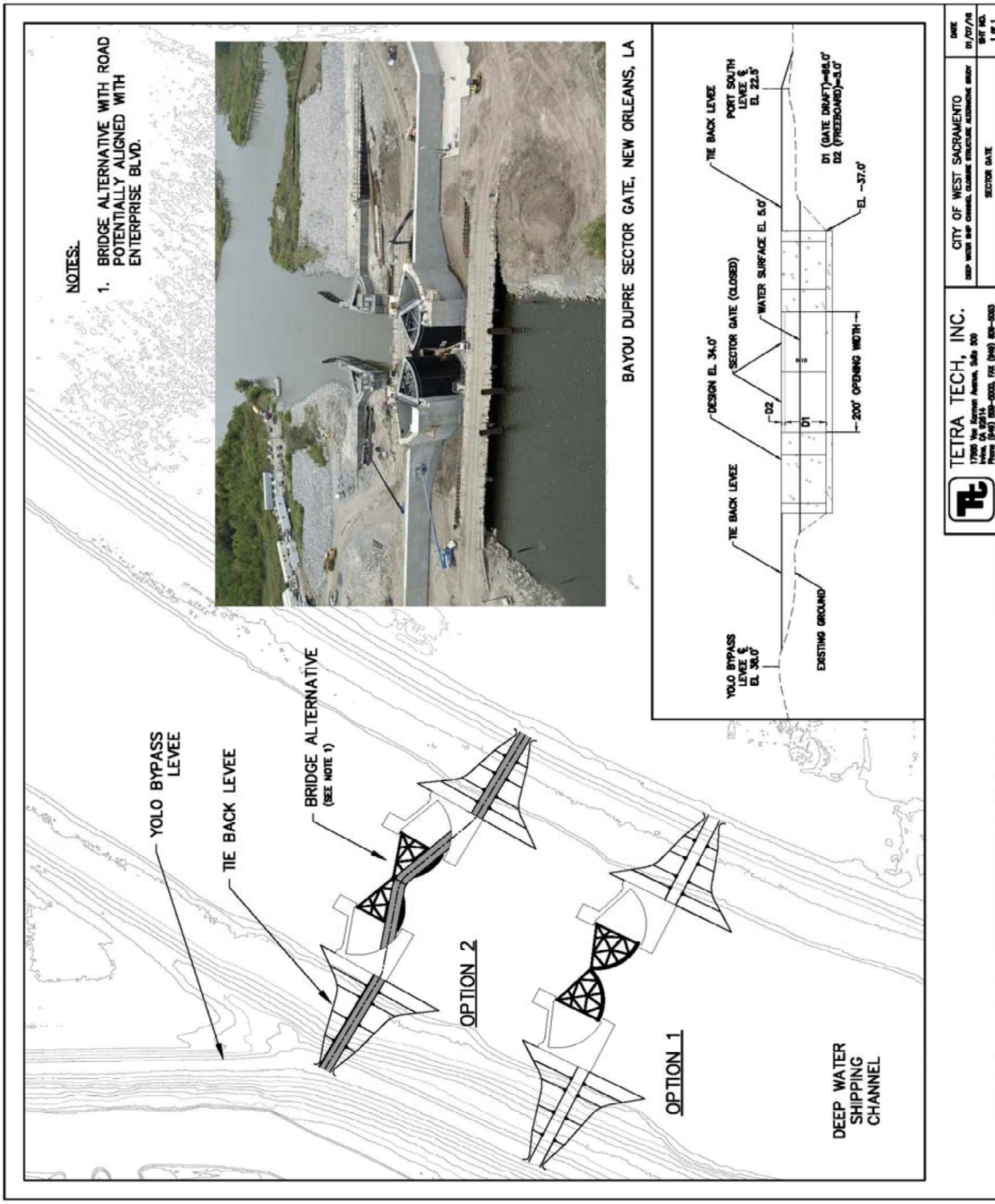

Figure 9. Sector Gate

14.3 Steel Barge Gate

The initial assessment rated the steel barge gate as #3 in the normally closed position and #7 in the normally open position. The advantages in the normally closed position include enhancements to flood risk management (through in-place passive flood control and potential establishment of an evacuation route and maintenance road) as well as support of bridge construction with the least restrictions to vehicular traffic. The normally open position provides the least restrictions to navigation. It should be noted that the steel barge gate includes several steps in the implementation that adds complexity to the operation.

Figure 10 shows a conceptual plan and typical section for this alternative. The conceptual information was used to generate planning level costs. The total gate cost is $238,000,000. Incorporating a bridge would add an additional cost of $3,000,000 bring the total project cost to approximately $241,000,000. For comparison purposes, if contingency costs are NOT included, these figures would total $159,000,000 and $161,000,000, respectively. The drivers in the cost are the monolith structure, the graving site, and the barge gate itself. The lump sum values for the monolith and gate were based on a unit prices developed using the bid estimates for these features obtained in Louisiana on the Houma Navigation Channel Barge Gate.

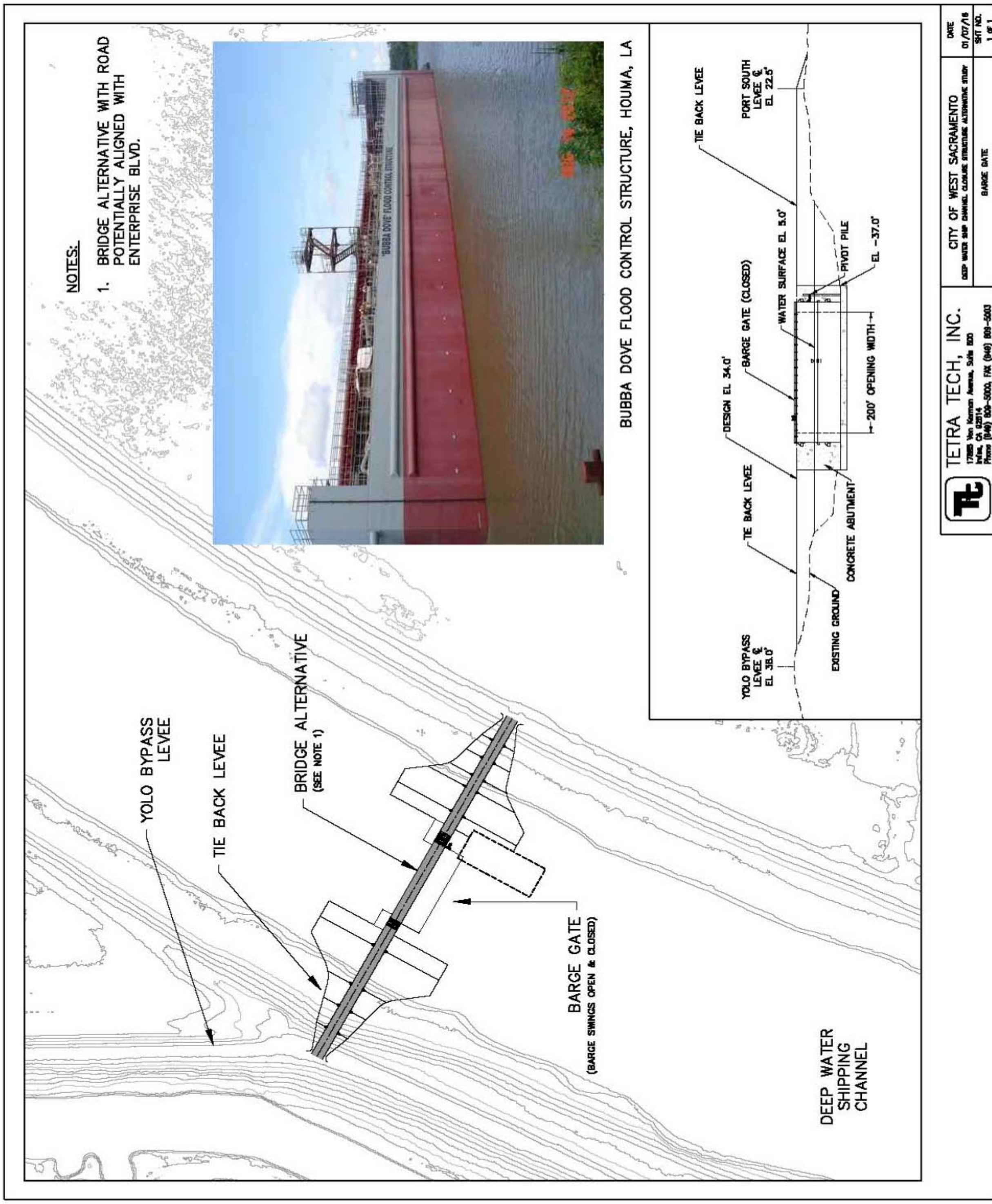

Figure 10. Steel Barge Gate

14.4 Summary

A summary of the three permanent alternatives that were further evaluated is included below.

Table 4. Summary of Final Alternatives

Alternative	Total Cost	Main Considerations
Earthen Levee	$50,000,000	• No operational needs • Lowest total project cost • Road can be incorporated; cost included
Sector Gate	$365,000,000	• Easiest operation • Road can be incorporated; cost included
Steel Barge Gate	$241,000,000	• Some complexity in operation • Road can be incorporated; cost included

Additional evaluation of each of these alternatives is expected following discussions with WSAFCA and additional stakeholders.

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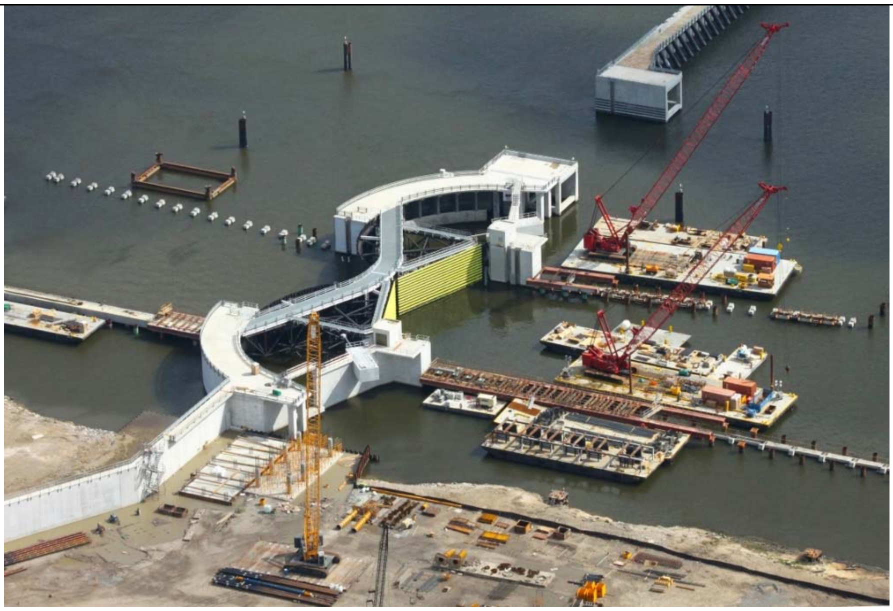
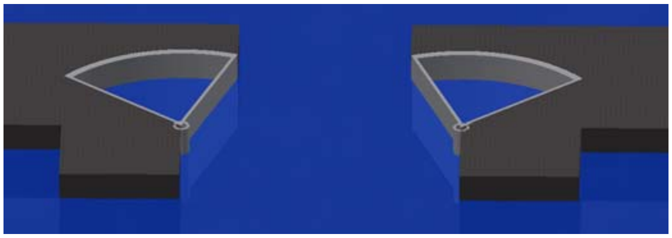
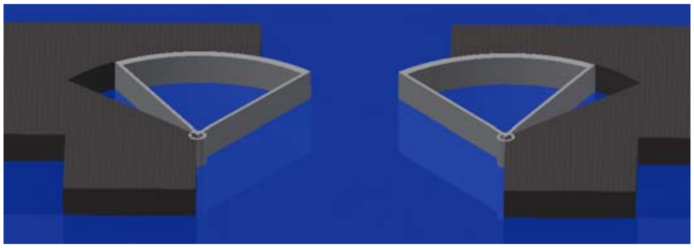
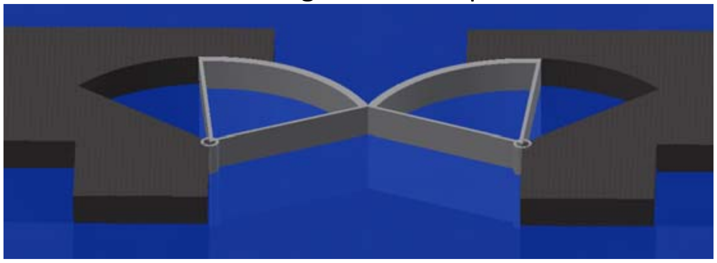
ATTACHMENT 1

INITIAL SUMMARY OF ALTERNATIVES

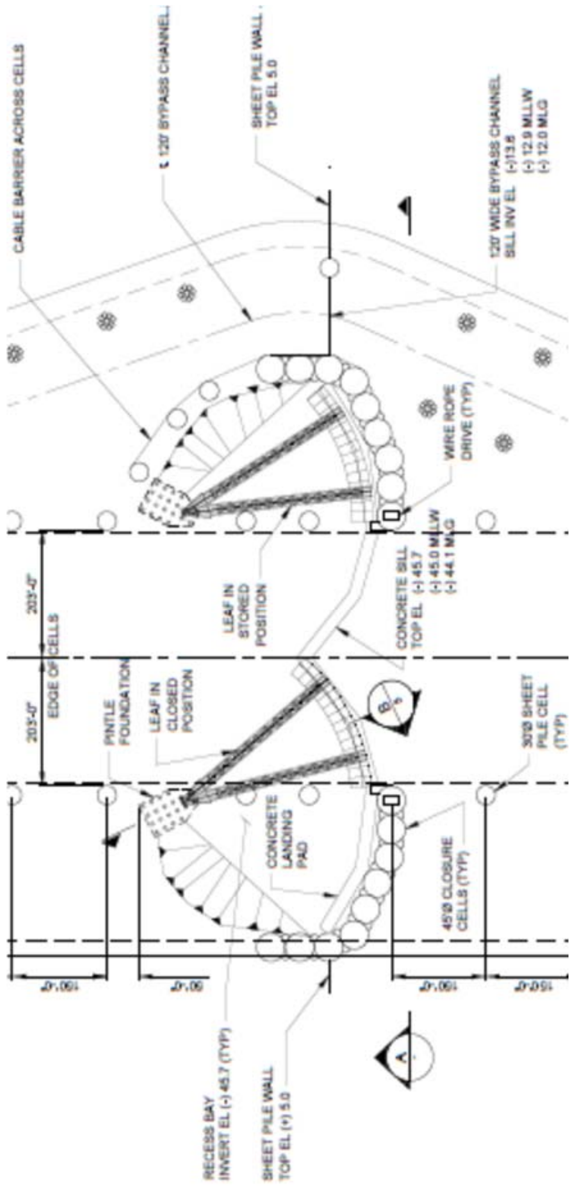
The alternatives described in Section 7 are detailed below.

#1. USACE Sector Gate	Permanent, operable closure structure
Description	The Sector Gate recommended in the GRR has a 200 foot wide opening, a base elevation of -37.0 feet, and top of structure elevation of 34.0 feet. The structure would consist of conventionally reinforced concrete and post tensioned concrete supported on a pipe pile foundation. The concrete structure would use float-in construction. The concrete shell would be built similar to barge type construction in a graving site adjacent to the project site. The float-in design eliminates the need for cofferdams, structure site dewatering systems, and a structure site bypass. With a realignment of the gates, a roadway can be incorporated.
Capital Cost	The cost identified in the USACE GRR is approximately $528,500,000 (which includes a 95% contingency).
Design Cost	The design cost is high $$$$$ driven by the number of structural, mechanical, and electrical components.
Navigation Impacts	There would be minimal impacts on navigation. When the gate is open there would be no impacts. During high floods navigation would not be possible; however, during these events navigation would be suspended regardless of the status of the closure.
Closure Time	The closure time is minimal (less than 10 minutes). This alternative has the option of being left in the closed position during the flood season and opened to allow navigation traffic when needed.
Opening Time	The opening time is minimal (less than 10 minutes). The sector gate can be operated regardless of the head differential upstream and downstream of the gate.
O&M Costs	The O&M cost is high driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to heavy equipment construction requirements but less than Alternative 2, “Sector Gate with Diversion.”
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.

Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]
Picture 1: IHNC Sector Gate. Picture by Tetra Tech	
Gate Operation	Gate is opened and navigation can pass unimpeded.  Midway position of sector gates. No navigation is allowed.  Gate is closed and navigation is not possible. 

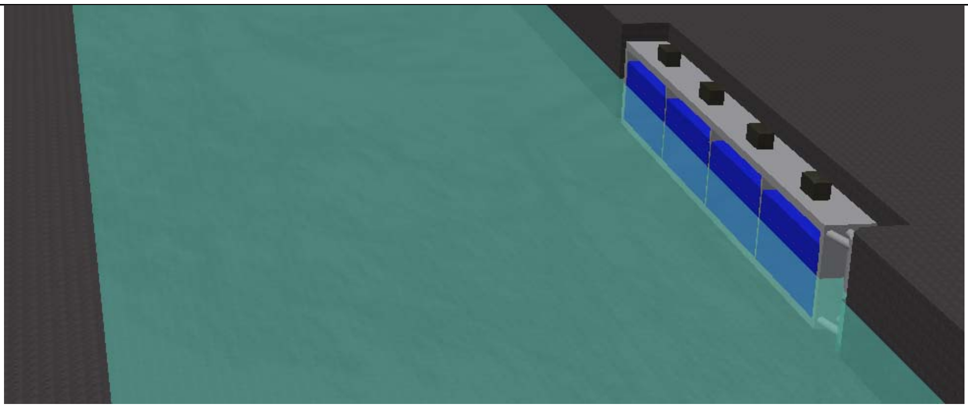
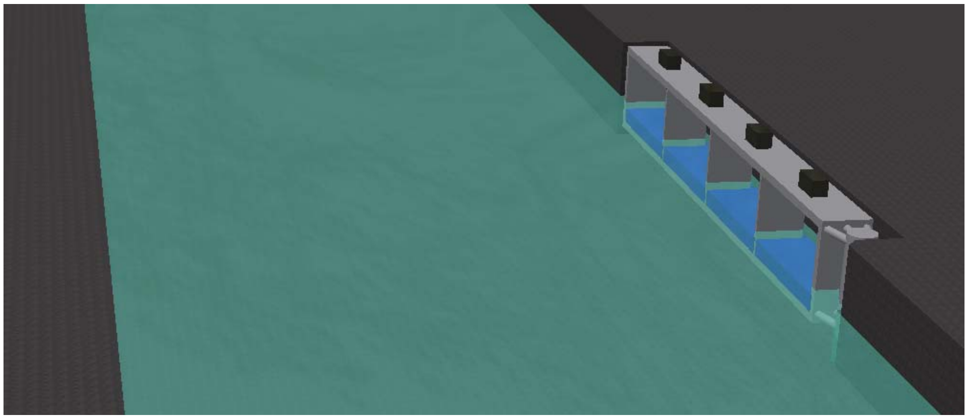
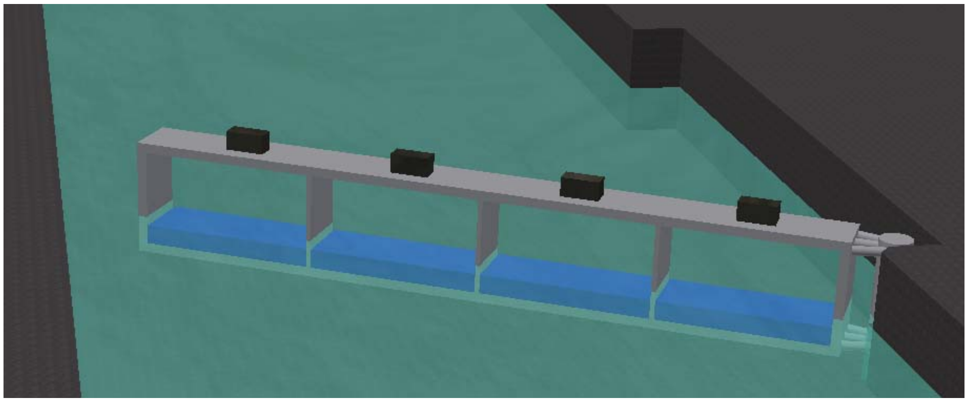
#2. Sector Gate with Diversion	Permanent, operable closure structure
Description	This Sector Gate differs from the one recommended in the GRR in that construction would require diversion of the DWSC flows rather than a float-in construction. A roadway bridge is provided across the closed sector gate. The bridge has traffic limitations on the type of vehicle crossing due to the geometry of the curves but can be realigned to allow larger vehicles.
Capital Cost	The cost is high $$$$$. It would be significantly less than the USACE sector gate but still a high cost compared to the other alternatives identified.
Design Cost	The design cost is high $$$$$ driven by the number of structural, mechanical, and electrical components.
Navigation Impacts	Like #1, there would be minimal impacts on navigation. When the gate is open there would be no impacts. During high floods navigation would not be possible; however, during these events navigation would be suspended regardless of the status of the closure.
Closure Time	The closure time is minimal (less than 10 minutes). This alternative has the option of being left in the closed position during the flood season and opened to allow navigation traffic when needed.
Opening Time	The opening time is minimal (less than 10 minutes). The sector gate can be operated regardless of the head differential upstream and downstream of the gate.
O&M Costs	The O&M cost is high driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to diversion of water.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

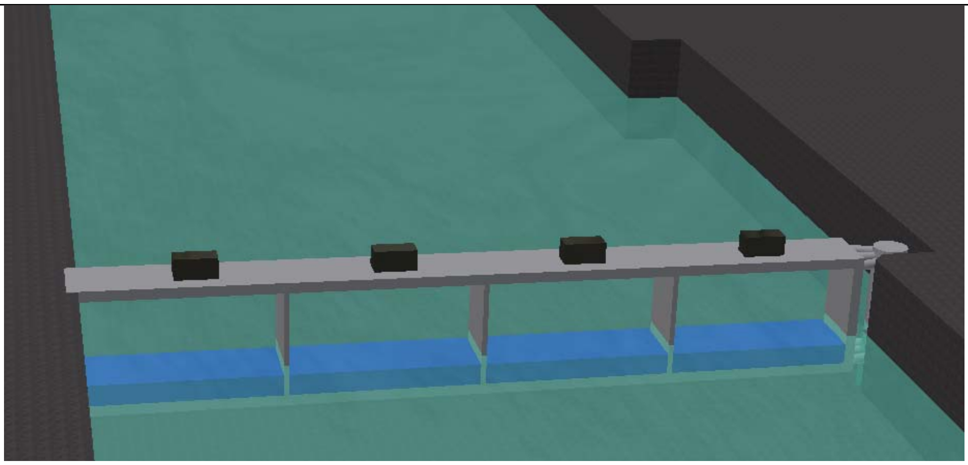
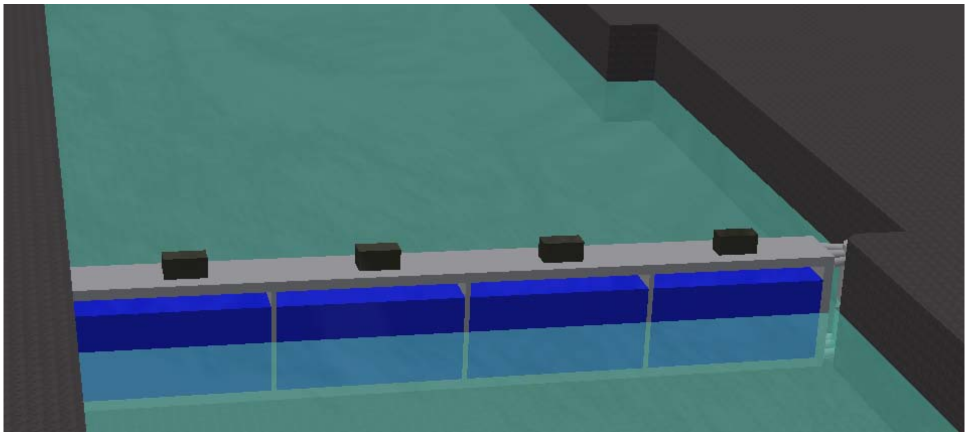
Picture 1: Conceptual Design, Gate 400 feet wide, 50 feet high. Drawing by Tt.



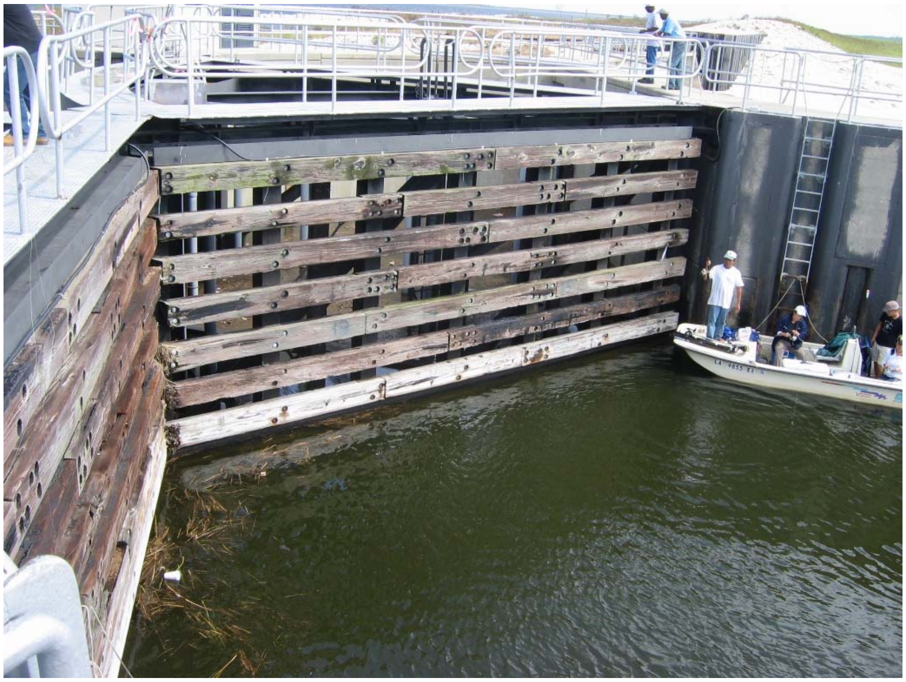
#3. Steel Barge Gate	Permanent, operable closure structure
Description	The steel barge gate consists of a floatable barge that is operated by swinging the gate opened/closed and resting it atop landing supports in the opened/closed position. The barge gate would seat onto a slab / cutoff wall that can resist uplift. A roadway may be added across the barge for vehicular traffic.
Capital Cost	The cost is high $$$$ but less than the sector gates because of the smaller abutments associated with the structure. Components can be fabricated and floated in.
Design Cost	The design cost is high $$$$ (less than sector gate) driven by the number of structural, mechanical, and electrical components.
Navigation Impacts	Like #1, there would be minimal impacts on navigation. When the gate is open there would be no impacts. During high floods navigation would not be possible; however, during these events navigation would be suspended regardless of the status of the closure.
Closure Time	The closure time is minimal (less than 10 minutes) to move the gate; additional time is required to ballast the gate. The barge gate has limitations to operations based on a combination of wind speed and water velocity. This alternative has the option of being left in the closed position during the flood season and opened to allow navigation traffic when needed. The barge swings into place quickly. It is then ballasted to sink it using the on-board pumps; this takes longer (several hours). The ballasted barge seals on the bottom.
Opening Time	The opening time is moderate. The barge gate cannot be operated with a head differential upstream and downstream of the gate.
O&M Costs	High cost due to structural, mechanical, and electrical components.
Environmental Impacts during construction	Medium – water must be diverted during construction but the time of construction is less than a sector gate.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large and less attractive than a sector gate.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: Bubba Dove Barge Gate, Houma Navigation Canal. The steel barge gate is 250-feet wide approx. 42 feet high. Design by CB&I (the former IHNC Shaw team). Picture by Tetra Tech	
Picture 2: Bubba Dove Barge Gate, Houma Navigation Canal. The steel barge gate is 250-feet wide approx. 42 feet high. Design by CB&I (the former IHNC Shaw team). Picture by Tetra Tech	

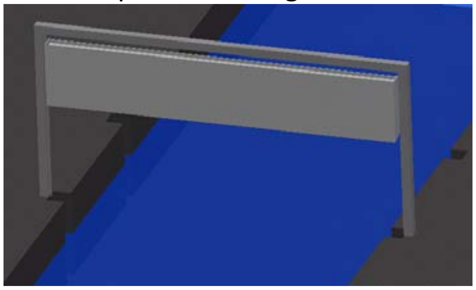
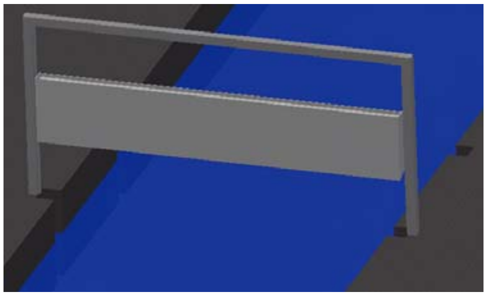
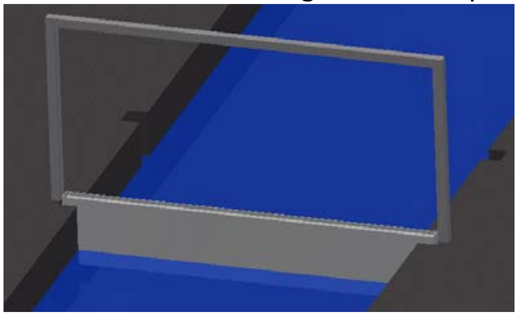
Gate Operation	 Barge gate (swing gate) ballasted and resting on the bottom sill. This is the "fully open" position.  Barge gate (swing gate) de-ballasted, i.e. water inside the barge is pumped out, causing the barge to float above the sill.  Now floating, the barge gate (swing gate) rotates around its pivot pile, moving from the closed to the open position.

	 Still floating, the barge gate (swing gate) stops at the closed position.  Barge gate (swing gate) is ballasted, i.e. water is pumped into the gate interior, until the gate is resting on the bottom sill. This is the “fully closed” position.

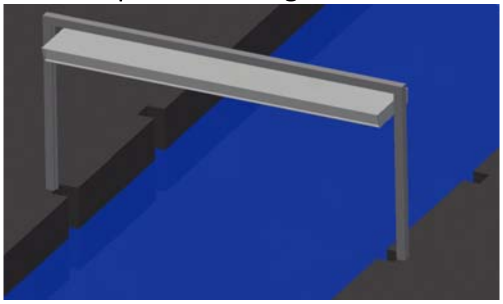
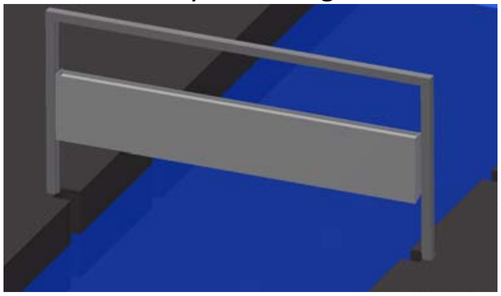
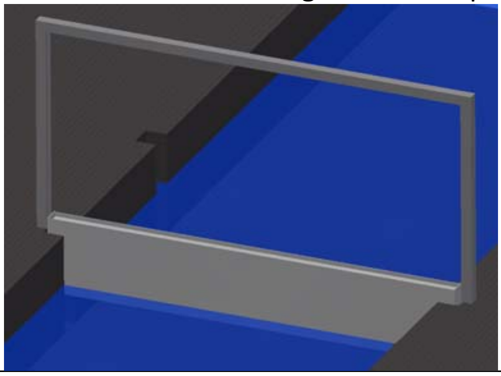
#4. Resized Sector Gate	Permanent, operable closure structure
Description	Similar to the GRR sector gate but the height and width are minimized by constraining the channel. A sector gate on a narrower channel would require a separate lift bridge for vehicular traffic.
Capital Cost	High Cost $$$$ but less than the GRR sector gate due to smaller dimensions
Design Cost	The design cost is high $$$$$ driven by the number of structural, mechanical, and electrical components.
Navigation Impacts	Medium impact. Navigation would be limited by reduced side clearance and depth of channel. This alternative has the option of being left in the closed position during the flood season and opened to allow navigation traffic when needed.
Closure Time	The closure time is minimal (less than 10 minutes).
Opening Time	The opening time is minimal (less than 10 minutes). The sector gate can be operated regardless of the head differential upstream and downstream of the gate.
O&M Costs	The O&M cost is high driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to diversion of water.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: (Old) Bayou Bienvenue Sector Gate (New Orleans). 56 feet wide, 25 feet high. Picture by Tetra Tech.	

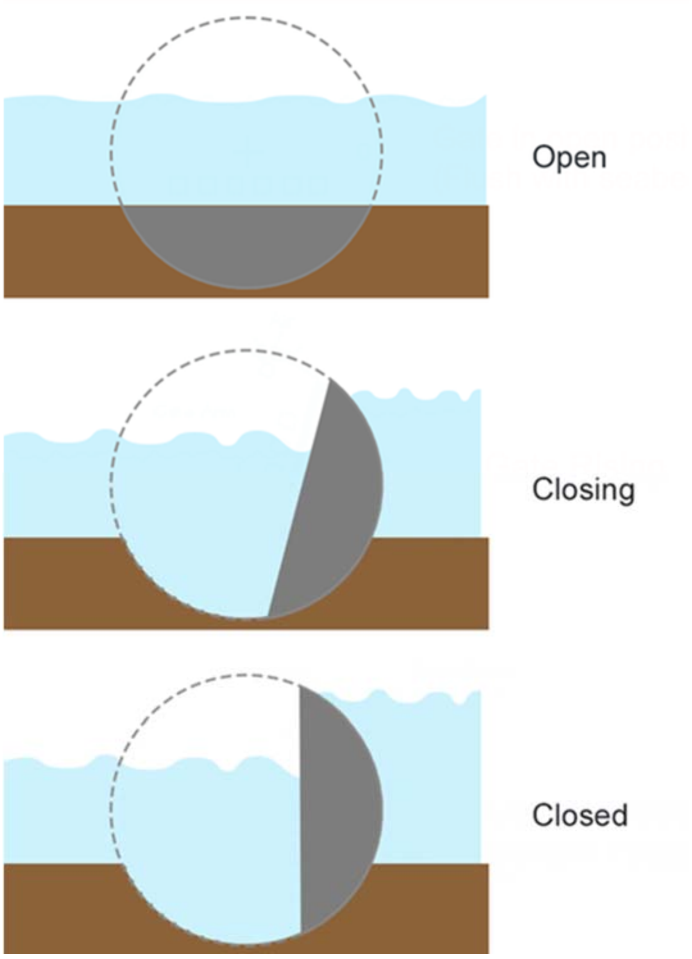
#5. Lift Gate	Permanent, operable closure structure
Description	A lift gate requires an overhead structure for lifting in addition to the concrete foundation. A roadway can be incorporated on the top of the gate.
Capital Cost	High Cost $$$$$. Typically the cost of the concrete monolith is less than the sector gate (due to smaller dimensions), but the additional steel for the long span may offset many of those savings. For this application the concrete foundation is very large – on par with the sector gate. The lift gate shown below was a value engineering change from a sector gate but dimensions were smaller than what is proposed for DWSC.
Design Cost	The design cost is high $$$$$ driven by the number of structural, mechanical, and electrical components.
Navigation Impacts	Minimal impact. Navigation may be limited by vertical clearance under the gate, but can likely attain clearance beyond what is needed (i.e. can get to 160'). This alternative has the option of being left in the closed position during the flood season and opened to allow navigation traffic when needed.
Closure Time	The closure time is minimal (less than 10 minutes).
Opening Time	The opening time is minimal (less than 10 minutes). The lift gate can be operated regardless of the head differential upstream and downstream of the gate. But if there is a head differential expected it needs to be installed with wheels that have additional cost and maintenance.
O&M Costs	The O&M cost is high driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to diversion of water.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City.

	[Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]
Picture 1: Bayou Bienvenue Lift Gate (New Orleans). 56 feet wide, 34 feet high. (Lift bridge beyond) Picture by Tetra Tech.	
Gate Operation	Gate is open and navigation is allowed.  Gate is in the midway open/close position and navigation is not allowed.  Gate is closed and navigation is not possible 

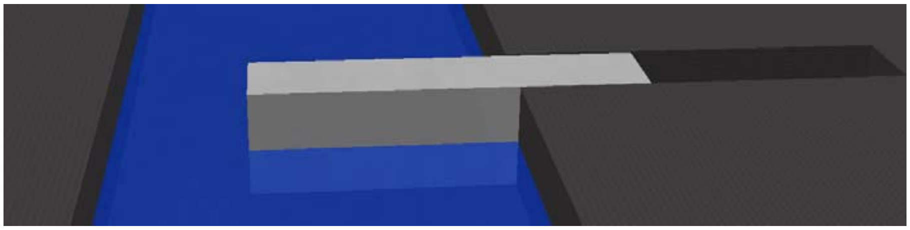
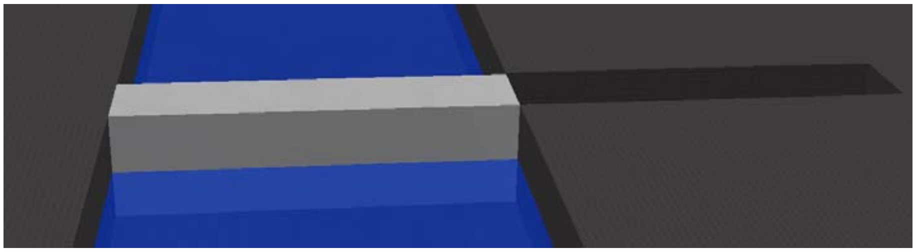
#6. Operating Bulkhead Gate	Permanent, operable closure structure
Description	The operating bulkhead gate is mechanically raised or lowered by a wire rope hoist. It is stored in the horizontal, lifted arrangement to reduce the effects of wind and seismic loads (compared to a traditional lift gate). This arrangement would require construction of a separate lift bridge for vehicular traffic.
Capital Cost	High Cost $$$$$. Likely more than sector gate due to large concrete foundation requirements.
Design Cost	The design cost is high $$$$$ driven by the number of structural and mechanical components.
Navigation Impacts	Minimal impact. Navigation would potentially be limited by the vertical clearance (but can likely have greater than needed, i.e. can go to 160'). The clearance with a gate that is horizontal in the lifted position is greater than the clearance below a classical vertical lift gate.
Closure Time	The closure time is minimal (less than 30 minutes).
Opening Time	The opening time is minimal (less than 30 minutes). The bulkhead gate can be operated regardless of the head differential upstream and downstream of the gate; it can be operated in flowing water.
O&M Costs	The O&M cost is medium driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to diversion of water.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: Operating bulkhead gate being installed, Olmsted Locks and Dam. The bulkhead gate is 110-feet wide, 50 feet high. Picture by Tetra Tech.	
Gate Operation	Gate is open and navigation is allowed.  Gate is midway and navigation is not allowed.  Gate is closed and navigation is not possible 

#7. Navigable Barrier Gate	Permanent, operable closure structure
Description	The gates operate by rotating. They are hollow and fill with water when submerged and empty as they emerge from the river. This arrangement would require construction of a separate lift bridge for vehicular traffic.
Capital Cost	High Cost $$$$$, possibly more than the sector gate due to the systems complexity.
Design Cost	The design cost is high $$$$$ driven by the number of structural and mechanical components.
Navigation Impacts	Medium impact. Navigation would potentially be limited by the vertical clearance.
Closure Time	The closure time is several hours.
Opening Time	The opening time is several hours. The gate can be operated when there is no head differential upstream and downstream of the gate.
O&M Costs	The O&M cost is high driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to diversion of water.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: Navigable gate, Thames barrier, London. The navigable gate is 200-feet wide, 60 feet high. Picture from the internet: https://en.wikipedia.org/wiki/Thames_Barrier	
Gate Operation	

#8. Rolling Gate	Permanent, operable closure structure
Description	The gates operate by rolling and are stored in recesses in the lock wall. The dry storage results in longer life span (not applicable if the gate is left in the closed position).This arrangement would require construction of a separate lift bridge for vehicular traffic.
Capital Cost	High Cost $$$$$, possibly more than the sector gate due to the systems complexity.
Design Cost	The design cost is high $$$$$ driven by the number of structural and mechanical components.
Navigation Impacts	Low impact. The gate moves into an adjacent recess.
Closure Time	The closure time is low (minutes).
Opening Time	The opening time is low (minutes). The gate can be operated when there is no head differential upstream and downstream of the gate.
O&M Costs	The O&M cost is high driven by the number of structural, mechanical, and electrical components.
Environmental Impacts during construction	High impact due to diversion of water.
Environmental Impacts post construction	No impact following construction. This assumes there is no movement that needs to be preserved during high flows.
Visual Impacts	Impact is high. The structure is large.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: Rolling gate, Panama Canal The gate is approximately 192-feet wide, 107 feet high, 32 feet deep. Picture by Tetra Tech.	
Gate Operation	Gate is open and navigation is allowed  Gate is in the midway position and navigation is not alllowed  Gate is closed and navigation is not possible 

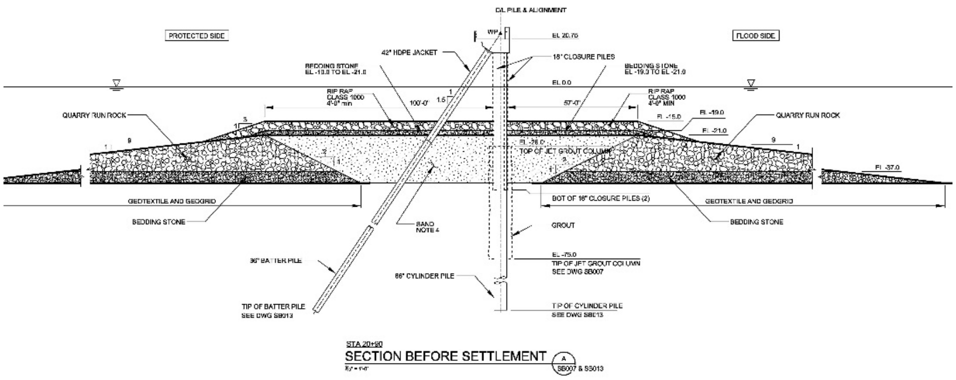
#9. Pneumatically-Actuated Steel Plate Gate	Permanent, operable closure structure
Description	The steel plates in this structure are hinged at the bottom and raised by inflating a bladder. The structure is permanently mounted at the channel bottom and fixed to a reinforced concrete foundation using clamp plates and anchor bolts. The plates lie flat until the bladder is inflated by pumping air inside the rubber body until the design height or pressure is reached.
Capital Cost	Low. Requires the gates, bladders, air system, and foundation.
Design Cost	Low.
Navigation Impacts	There would be minimal impacts on navigation. When the dam in deflated there would be no impacts. During high floods navigation would not be possible; however, during these events navigation would be suspended regardless of the status of the closure.
Closure Time	About an hour
Opening Time	About an hour
O&M Costs	Medium.
Environmental Impacts during construction	
Environmental Impacts post construction	Low. Impacts only occur while the bladder is inflated.
Visual Impacts	Impact is low. The structure sits on the bottom of the channel while deflated.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: Pneumatically-Actuated Steel Plate Gate Picture from Obermeyer Hydro, Inc.'s website. (http://www.obermeyerhydro.com/SpillwayGates	
Picture 2: Pneumatically-Actuated Steel Plate Gate Picture from Obermeyer Hydro, Inc.'s website (http://www.obermeyerhydro.com/SpillwayGates	

#10 . Sunken Barges	Temporary/emergency closure structure
Description	Barges (likely 3) would be stationed at the port and floated into position and scuttled in order to close off the channel.
Capital Cost	Medium Cost $$$. The barges can be reused for subsequent closures
Design Cost	Medium Cost $$$
Navigation Impacts	Medium Impact. Channel can remain open except when needed for flood mitigation. At that point navigation ceases until the barges are removed. This alternative does not have the option of being left in the closed position during the flood season and opened to allow navigation traffic when needed so would not meet the life safety needs of the project. A probable failure mode is a breach in the DWSC west levee. There is no indication where the breach is likely to happen so must be assumed to occur near the location of the closure. This precludes the required time to implement this solution and therefore does not meet the life safety requirements of the project.
Closure Time	Slow. Barges need to be positioned and sunk and secured.
Opening Time	Slow. Barges and anchors need to be removed.
O&M Costs	Low. Barges can be stored at the port.
Environmental Impacts during construction	N/A. No construction
Environmental Impacts post construction	Low. Impacts only occur while the barge is in place.
Visual Impacts	Medium. The barges are only located in the channel temporarily.
Economic Development	Economic development for this alternative is consistent with the current level of growth in the Port/City. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]

Picture 1: Sunken Barges. Picture from the internet

(https://www.google.com/search?q=images+of+a+barge&biw=1777&bih=1025&tbm=isch&imgil=qoriZLSi5mobJM%253A%253BKixyUZF-h-pP6M%253Bhttp%25253A%25252F%25252Fwww.weeksmarine.com%25252Fnode%25252F103&source=iu&pf=m&fir=qoriZLSi5mobJM%253A%252CKixyUZF-h-pP6M%252C_&dpr=0.9&usg=__xyg4Dg5N_xUYnyWH_cV63ieeQ0c%3D&ved=0CDAQyjdqFQoTCJbojr71_MgCFckrJgodUYMKjg&ei=SDM9VpakGcnXmAHRhqrwCA#imgrc=qoriZLSi5mobJM%3A&usg=__xyg4Dg5N_xUYnyWH_cV63ieeQ0c%3D

#11. Rock Berm with Tainter Gates	Permanent closure and reconnection of the levee
Description	A rock berm is placed across the channel to permanently close it off. Small tainter gates are incorporated to allow for flushing of water upstream and downstream of the berm.
Capital Cost	Low cost
Design Cost	Low. Largely earthwork with minor structures.
Navigation Impacts	High. The rock berm will prevent navigation.
Closure Time	N/A. no closing process – option is permanent.
Opening Time	N/A. no opening process – option is permanent.
O&M Costs	Low – visual inspect required during low water levels to determine that structure is intact.
Environmental Impacts during construction	High. No fish passage is supported.
Environmental Impacts post construction	High. No fish passage is supported.
Visual Impacts	High. The structure is permanent
Economic Development	Economic development offers the ability to re-purpose the Port facility and revitalize the area with new business, community amenities, recreational facilities ,etc. [Flooding impacts/benefits are assumed to be equal for all alternatives that provide the design level of risk reduction.]
Picture 1: MRGO Closure. Drawing by Tetra Tech.	

ATTACHMENT 2

COST ESTIMATE SUMMARIES

Including:

- Cost Estimate Summaries
- Spreadsheet on Time to Implement the Temporary Rock Berm
- Memorandum on the Sector Gate Contingency Analysis

DWSC Closure Structure Alternative Study							
Earthen Levee Including Road							
1	Mob & Demob		LS	1	3,500,000	$	3,500,000
2	Clearing & Grubbing		Acre	5	5,000	$	25,000
3	Civil		LF	550	3,273	$	1,800,150
	3.1	36" Rip Rap	Ton	20,633	85	$	1,753,805
	3.2	Aggregate Base	CY	128	60	$	7,680
	3.3	Geotextile Fabric	SY	7,733	5	$	38,665
6	Tie Back Levees		LF	520	4,953	$	2,575,730
	6.1	Compacted Fill	CY	75,939	30	$	2,278,170
	6.2	Excavation	CY	14,878	20	$	297,560
7	Asphalt Roadway		LF	970	222	$	215,620
	7.1	6" Asphalt Pavement	SY	2,156	50	$	107,800
	7.2	12" Stone Base Course	CY	719	60	$	43,140
	7.3	12" Subgrade	SY	2,156	30	$	64,680
8	Earthen Closure		LF	550	54,891	$	30,189,875
	8.1	Compacted Fill	CY	456,940	30	$	13,708,200
	8.2	36" Rip Rap	Ton	55,000	85	$	4,675,000
	8.3	Geotextile Fabric	SY	29,335	5	$	146,675
	8.4	Braced Sheetpile Cofferdam	LF	1,100	10,600	$	11,660,000
					Subtotal	$	38,306,375
					Contingency @ 30%	$	11,491,913
					TOTAL COST	**$**	**49,798,288**

DWSC Closure Structure Alternative Study							
Rock Berm (Permanent)							
	Contract Items		Units	Quantity	Unit Cost		Total Cost
1	Mob & Demob		LS	1	4,850,000	$	4,850,000
2	Clearing & Grubbing		Acre	5	5,600	$	28,000
3	Civil		LF	550	3,273	$	1,800,150
	3.1	36" Rip Rap	Ton	20,633	85	$	1,753,805
	3.2	Aggregate Base	CY	128	60	$	7,680
	3.3	Geotextile Fabric	SY	7,733	5	$	38,665
4	Rock Berm		LF	550	72,577	$	39,917,090
	4.1	36" Rip Rap	Ton	468,520	85	$	39,824,200
	4.2	Geotextile Fabric	SY	18,578	5	$	92,890
5	Steel Sheetpile Cutoff Wall		LF	550	7,280	$	4,004,000
	5.1	Material	SF	50,050	30	$	1,501,500
	5.2	Installation	SF	50,050	50	$	2,502,500
6	Tie Back Levees		LF	520	4,953	$	2,575,730
	6.1	Compacted Fill	CY	75,939	30	$	2,278,170
	6.2	Excavation	CY	14,878	20	$	297,560
					Subtotal	$	53,174,970
					Contingency @ 30%	$	15,952,491
					Total Cost	$	69,127,461

DWSC Closure Structure Alternative Study						
Sector Gate						
	Contract Items		**Units**	**Quantity**	**Unit Cost**	**Total Cost**
1	Mob & Demob		LS	1	20,000,000	$ 22,000,000
2	Clearing & Grubbing		Acre	5	5,600	$ 28,000
3	Civil		LF	520	4,481	$ 2,330,110
	3.1	36" Rip Rap	Ton	26,763	85	$ 2,274,855
	3.2	Aggregate Base	CY	128	60	$ 7,680
	3.3	Geotextile Fabric	SY	9,515	5	$ 47,575
4	Sector Gate		SF	14,200	15,042	$ 213,600,000
	4.1	Sector Gate Structure	LS	1	57,300,000	$ 57,300,000
	4.2	Sector Gate Monolith	LS	1	111,300,000	$ 111,300,000
	4.3	Graving Site	LS	1	40,000,000	$ 40,000,000
	4.4	Approach Structure	LS	1	5,000,000	$ 5,000,000
5	Tie-In Levees		LF	520	5,845	$ 3,039,500
	5.2	Compacted Fill	CY	89,950	30	$ 2,698,500
	5.3	Excavation	CY	17,050	20	$ 341,000
					Subtotal	$ 240,997,610
					Contingency @ 50%	$ 120,498,805
					Sector Gate no Road Total Cost	$ 361,496,415
6	Tie Back Levee Roadway		LF	520	222	$ 115,580
	6.1	6" Asphalt Pavement	SY	1,156	50	$ 57,800
	6.2	12" Stone Base Course	CY	385	60	$ 23,100
	6.3	12" Subgrade	SY	1,156	30	$ 34,680
7	Bridge Alternative		LF	320	6,031	$ 1,930,000
	7.1	Bridge	LS	1	1,930,000	$ 1,930,000
					Subtotal	$ 2,045,580
					Contingency @ 50%	$ 1,022,790
					Road on Sector Gate Total Cost	$ 3,068,370
					Sector Gate with Road TOTAL COST	**$ 364,564,785**

DWSC Closure Structure Alternative Study							
Barge Gate							
	Contract Items		Units	Quantity	Unit Cost		Total Cost
1	Mob & Demob		LS	1	10,000,000	$	14,500,000
2	Clearing & Grubbing		Acre	5	5,600	$	28,000
3	Civil		LF	590	5,385	$	3,176,955
	3.1	36" Rip Rap	Ton	36,567	85	$	3,108,195
	3.2	Aggregate Base	CY	146	60	$	8,760
	3.3	Geotextile Fabric	SY	12,000	5	$	60,000
4	Barge Gate		SF	14,200	9,687	$	137,552,482
	4.1	Barge Gate	LS	1	29,026,286	$	29,026,286
	4.2	Monolith	LS	1	63,526,196	$	63,526,196
	4.3	Approach Structure	LS	1	5,000,000	$	5,000,000
	4.4	Graving Site	LS	1	40,000,000	$	40,000,000
5	Tie Back Levees		LF	590	6,252	$	3,688,550
	5.2	Compacted Fill	CY	109,565	30	$	3,286,950
	5.3	Excavation	CY	20,080	20	$	401,600
					Subtotal	$	158,945,987
					Contingency @ 50%	$	79,472,993
					Barge Gate no Road Total Cost	$	238,418,980
6	Tie Back Levee Roadway		LF	590	249	$	147,120
	6.1	6" Asphalt Pavement	SY	1,467	50	$	73,350
	6.2	12" Stone Base Course	CY	496	60	$	29,760
	6.3	12" Subgrade	SY	1,467	30	$	44,010
7	Bridge Alternative		LF	270	6,667	$	1,800,000
	6.1	Bridge	LS	1	1,320,000	$	1,320,000
	6.2	Draw Bridges (West)	LS	1	288,000	$	288,000
	6.3	Draw Bridge (East)	LS	1	192,000	$	192,000
					Subtotal	$	1,947,120
					Contingency @ 50%	$	973,560
					Road on Barge Gate Total Cost	$	2,920,680
					Barge Gate with Road TOTAL COST	**$**	**241,339,660**

Timeframe Duration for the Emergency Placement of Rock

TITLE:	Deep Water Ship Channel - Rock Berm							
SUBJECT:	Emergency Placement Durations							
MADE BY:	SKV						JOB NO.:	T34944
CHECKED BY:							DATE:	3/29/2016

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Civil								
36" Rip Rap	200.00	100%	24	TON	20,633	4	25.8	1.1
Aggregate Base	60.00	100%	24	CY	128	1	2.1	0.1
Geotextile Fabric	150.00	100%	24	SY	7,733	4	12.9	0.6
Rock Berm								
36" Rip Rap	1500.00	100%	24	TON	468,520	2	156.2	6.6
Geotextile Fabric	150.00	100%	24	SY	18,578	1	123.9	5.2
Tie Back Levees								
Compacted Fill	82.50	100%	24	CY	75,939	4	230.1	9.6
Excavation	100.00	100%	24	CY	14,878	4	37.2	1.6

Note: Duration times assume a best-case scenario in terms of productivities:

- rock would be stockpiled on adjacent land and readily handled for placement
- crews would work 24-hours per day.

TETRA TECH

MEMO

To:	Ira Artz
Cc:	
From:	Tetra Tech, Scott Vose
Date:	12/16/2015
Subject:	DWSC Structure – Contingency Mitigation

This memo discusses the abbreviated risk analysis (ARA) document that was completed for the West Sacramento GRR Alternatives Selection by the USACE. This memo is focused on the 94.94% contingency that was calculated within the ARA document for the "DWSC Structure" item. Below is a discussion of the primary efforts that could be completed that have a high potential for lessening the overall contingency of this item.

PRIMARY MITIGATION EFFORTS PROPOSED:

1. Significant risks are attributed to the fact that this type of work has not been completed within the District. However, many of these structures have been constructed in Louisiana. Therefore, there are many key personnel in that region that would be able to provide significant insight into this project. It would be highly recommended that these personnel become involved and that they review these risks for validity. There are possibilities that the baseline cost is already very conservative, and therefore some contingency value could already be built into the baseline estimate. The personnel with this expertise may be able to better analyze these issues.
2. As soon as this project advances to a preliminary design, quantities and costs will be developed. However, key quantities could be roughly developed at this time. These could then be compared to the New Orleans projects quantities that were used to "scale" the cost estimates in order to determine a rough scale based on more reasonable project specific quantities. There would still be risks due to the rough estimation of quantities, but this could still limit some risk noted in several sections of the ARA.
3. Review of the current acquisition strategy risks is needed. The PDT discussion references a lack of contracting plan, however the New Orleans project cost estimate should have some sort of contracting plan already attributed to it. If this contracting plan is already conservative in nature, then the risk could be lessened on the contingency impact as conservative costs may already be included in the baseline estimate. Also, the PDT discussion notes that there will be some acceleration risk, but then goes on to note that "no accelerated schedule is anticipated." Seems like this risk needs to be reviewed within the ARA document, and if no accelerated schedule is actually anticipated, then the risk may be able to be lessened.
4. If abbreviated risk analysis is re-run, recommend completing a new document just focused on the elements of the DWSC structure only. That way, if risks only impact one area of the structure (i.e. foundation, dewatering, earthwork, concrete, etc.), the resulting contingency will only impact the costs for that specific item and not the total costs of the entire structure. As currently formulated, all risks impact the entire project cost, which simply is not likely to be the case.

PDT Concerns From Risk Register

The following are the key risks found in each "risk element" discussed in the ARA Risk Register. These are the key elements that contribute to the contingency value for this structure. The ARA concerns and discussions for each element are then followed by possible mitigating solutions that could allow for the use of a lesser contingency value through changing the "Likelihood" and "Impact" selections within the ARA document.

Item #1

<table>
<tr><th>Risk Element</th><th>Concerns</th><th>Risk Discussion</th><th>Likelihood</th><th>Impact</th></tr>
<tr><td>Project Scope Growth</td><td>Design confidence</td><td>"Structure was patterned off a New Orleans project and adapted to this project site. Project is currently not under construction, scope growth not known at this time."</td><td>Likely</td><td>Significant</td></tr>
<tr><td colspan="5">Contingency Mitigation Discussion:</td></tr>
<tr><td colspan="5">To help mitigate this risk and possibly lower the likelihood of this risk occurring, the PDT could try and better analyze the proposed project and determine if the New Orleans project referenced is a reasonable facsimile. If it is found that perhaps the New Orleans structure is slightly larger/over designed for the needs of this project, then potentially both the likelihood and impact of the scope growing could be reduced.</td></tr>
</table>

Item #2

<table>
<tr><th>Risk Element</th><th>Concerns</th><th>Risk Discussion</th><th>Likelihood</th><th>Impact</th></tr>
<tr><td>Acquisition Strategy</td><td>No contracting plan and possibility of accelerated/harsh weather construction schedule</td><td>"There is not a contracting plan at the moment due to the stage of project and may be effected by funding levels. At the moment estimate assumes 8 hr days. All contracts will have some acceleration risk associated with them. No accelerated schedule is anticipated, but due to the limited construction windows, work is expected to not be performed using OT.</td><td>Likely</td><td>Significant</td></tr>
<tr><td colspan="5">Contingency Mitigation Discussion:</td></tr>
<tr><td colspan="5">This risk may need to be reassessed in terms of the likelihood and impact decisions. The comment makes it seem as if there is not a significant risk given the fact that they do not anticipate an accelerated schedule. Perhaps this could be dropped from "likely" to "possible" or even "unlikely." Also, given that this project is for one large gate structure, it is not likely that this would be bid out in multiple contracts and/or bid out to small business. Therefore risks of increases due to various contracting issues may be limited as well, thus possibly decreasing the likelihood and impact also.</td></tr>
</table>

ITEM #3

Risk Element	Concerns	Risk Discussion	Likelihood	Impact
Construction Elements	High risk or complex elements; No water care or diversion; unique construction methods; special mobilization; special equipment or subcontractors; potential for construction mods/claims	"Project in general is very specialized and out of the norm for typical district work; Water and diversion (pumping) will be a major task on this project; All facets of this project are unique in nature; Crane sizes will be unique and will require extra effort; Unknown conditions will effect graving site as well as DWSC foundations; Actual soil conditions are unknown."	Very Likely	Critical
Contingency Mitigation Discussion:				
This project may seem specialized to this region, but these structures have been built all over Louisiana and therefore may not seem as atypical as they appear. Personnel from the Louisiana region could be brought in to assist in completion of this work. Control and diversion of water may not be as significant as current discussions have been geared towards construction much of this with floats and other methods to reduce the dewatering effort. Also, if significant dewatering efforts were included in the cost for the New Orleans structure, then perhaps the risks have already been accounted for in the baseline cost. In terms of the crane sizes and unique construction items, given the size of the project, and this being bid in California, it is reasonable to assume that numerous contractors would be willing to bid on this that have the necessary experience and expertise to complete. The soil conditions are unknown at this time, which is a significant risk. However, if the New Orleans project included significant structures for the subsurface foundation then perhaps the costs for this risk are already included in the baseline construction cost, and the risks could be lowered.				

ITEM #4

Risk Element	Concerns	Risk Discussion	Likelihood	Impact
Quantities for Current Scope	Level of confidence based on design/assumptions; appropriate methods applied to calculations; sufficient investigations to develop quantities.	"Quantities based on a similar structure in New Orleans and scaled to this project; The New Orleans structure has not been constructed and it is likely that costs will be higher than currently projected; Additional refinements and investigation will be needed at a later phase."	Very Likely	Significant
Contingency Mitigation Discussion:				
This risk will decrease as the project progresses. But to start, developing some rough general quantities for this project should be developed and compared to those of the New Orleans project to get a sense of whether the scaling used for the cost estimate was accurate or not. A preliminary construction estimate could then be developed from these quantities which could lessen risks in other areas as well.				

ITEM #5

Risk Element	Concerns	Risk Discussion	Likelihood	Impact
Specialty Fabrication or Equipment	Confidence in contractor's ability to install	"This type of construction has not been done in this district."	Likely	Significant
Contingency Mitigation Discussion:				

Just because the work has not been done in the district does not necessarily mean that there are no contractors with sufficient experience/expertise to complete this work. As noted in other risk areas, this work has been completed at numerous locations throughout Louisiana and one would assume the contractors there would have the capability to complete work in California.

ITEM #6

Risk Element	Concerns	Risk Discussion	Likelihood	Impact
Cost Estimate Assumption	Lack confidence on critical cost items.	"Even though this feature was created and estimated by New Orleans District based on a similar project they estimated and which has not been built yet, there is a significant concern to site adaptability of the structure as well as the graving site physical items not being developed enough to capture the costs well enough.	Likely	Significant
Contingency Mitigation Discussion:				
This risk could be lessened by consulting with personnel in the New Orleans area that have worked on these projects before. Their knowledge could shed more insight into whether the base cost used is reasonable to be used for this project. Perhaps, through their experiences, they see the base cost as very conservative for this new structure. Then the risk's likelihood and impacts could be lessened if the base estimate is already conservative.				

ITEM #7

Risk Element	Concerns	Risk Discussion	Likelihood	Impact
External Project Risks	Potential for adverse weather; inflations in fuel/materials; political influences/lack of support; land prices increasing; cultural resources found; late construction season/delays.	"Severe weather or a flood event can also impact the schedule; unanticipated inflations in fuel and key materials would impact costs; large operating equipment prices are a concern; could be community resistance to construction of large structure near residential and agricultural land; need to avoid parcels with HTRWs and endangered species.	Likely	Significant
Contingency Mitigation Discussion:				
These risk are all typically outside the PDT's sphere of influence and therefore are more difficult to mitigate beforehand. Having upfront support from the numerous local sponsors could lessen these risks. Also, developing a rough, conservative project schedule could also allow for better insights into the schedule risks. Then these could also be attempted to be mitigated beforehand.				

TOTAL CONSTRUCTION COSTS AND CONTINGENCY PERCENTAGE CHANGE COMPARISONS

The abbreviated risk analysis has been re-run to account for several changes to the likelihood and impact choices. The original cost and contingency value has been provided for reference, and then two other cost alternatives have been shown. The first option ("Option 1") shown has taken only the risk elements that have a 4 or 5 impact level (combination of likelihood and impact, with 1 being lowest impact to contingency and 5 being the highest) and lowered those to a 3. The remaining risk elements were all left as is. The second option ("Option 2") shows the similar assumption on all the 4 and 5 risk elements, but also lowered all the other risk elements one level (ex. risk level of 3 was reduced to a 2, 2 to 1, etc.). The table below provides the comparison of the current cost estimate and contingency to these two options that provides a comparison of where contingencies may fall out if the ARA document is modified.

Item	Baseline Cost	Contingency %	Contingency Value	Total Cost	Difference From Original Total
Original Estimate	$271,083,003	94.94%	$257,372,820	$528,455,823	-
Option 1	$271,083,003	71.89%	$194,880,650	$465,963,653	($62,492170)
Option 2	$271,083,003	43.60%	$118,186,155	$389,269,158	($139,186,665)