Innovative approaches
Practical results
Outstanding service

Nolte Dam Preliminary Engineering Study
(DRAFT)

Prepared for:

City of Seguin
&
Meadow Lake Nolte Dam Association

March 2023

Prepared by:

FREESE AND NICHOLS, INC.
10431 Morado Circle, Suite 300
Austin, Texas 78759
(512) 617-3100

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Prepared by:

FREESE AND NICHOLS, INC.
10431 Morado Circle, Suite 300
Austin, Texas 78759
(512) 617-3100

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TABLE OF CONTENTS

1.0 Introduction 2
1.1 Original Dam Construction 2
1.2 Project Purpose 3
2.0 Site Walkthrough 4
3.0 Gate Replacement Considerations 7
3.1 Risk Assessment 7
3.2 Risk Assessment Conclusions 13
4.0 Bear Trap Gate Replacement Considerations 15
4.1 History and General Description 15
4.2 Historical Operation and Maintenance 15
4.3 Modernization 15
4.3.1 Recommended Improvements 15
4.3.2 Operational Improvements (Provided by Sorenson Engineering) 18
4.4 Construction Flood Risk Considerations/Dewatering 22
4.5 Site Access 23
5.0 Structural Stability 24
5.1 Stability Criteria 24
5.2 Material Properties 25
5.3 Loads and Load Cases 25
5.3.1 Gravity Loads 25
5.3.2 Hydrostatic Loads 25
5.3.3 Soil/Silt Loads 26
5.3.4 Uplift 26
5.4 Stability Analyses 26
5.4.1 Existing Conditions 26
5.4.2 Future Conditions 30
5.4.3 Training Wall Stability 31
5.4.4 Hydraulic Inadequacy 32
6.0 Opinion of Probable Project Cost (OPCC) 33
6.1 Level of Project Definition 33
6.2 Unit Prices 33
6.3 Risks and Contingency 34
6.4 Price Base 35
6.5 Excluded Costs 35
7.0 Conclusions and Recommendations 37
8.0 References 41

1.0 INTRODUCTION

Nolte Dam, also known as Lake Meadow Dam or TP-5, is located approximately three miles south of Seguin, TX on the Guadalupe River. The dam was completed in 1930 by the Texas Power Corporation. The dam consists of three 85-foot wide by 12.7-foot high Huber and Lutz roof-weir service spillway gates; a turbine electrical generating plant; a 2,000-foot long earth fill embankment; and an 820-foot long emergency spillway located at the far left end of the left embankment. Key dam elevations are shown in Table 1-1. A 2013 study by Freese and Nichols, Inc. (FNI) found that Nolte Dam can safely pass 28 percent of the PMF. Nolte Dam is an intermediate size, high hazard dam and is required by TCEQ to pass 75 percent of the PMF. Figure 1-1 shows an aerial view of Meadow Lake and Nolte Dam.

Table 1-1: Nolte Dam Key Elevations

Dam Feature	Elevation (feet-msl)
Normal Pool	457.9
Emergency Spillway	472.6
Top of Dam	475.0

Figure 1-1: Aerial View of Nolte Dam Spillway

1.1 ORIGINAL DAM CONSTRUCTION

Nolte Dam is one of a series of six dams intended to produce power from the Guadalupe River. The dams were designed by Fargo Engineering around 1927. Final construction of the six dams was completed around 1933 by the Texas Power Corporation who then assumed ownership of the dams. The dams are collectively known as the Guadalupe Valley Hydroelectric System (GVHS). GBRA was formed in 1933 by the Texas legislature with a primary responsibility to manage the water supply and water conservation in

the Guadalupe River Basin. Shortly after formation, GBRA assumed ownership and operations responsibility for the GVHS and has been successfully operating the dams throughout nine decades. GBRA's Guadalupe Valley Hydroelectric Division operates the six dams and hydroelectric plants located in Guadalupe and Gonzales counties that generate electricity for the Guadalupe Valley Electric Cooperative (GVEC).

All six GVHS dams utilize Huber-Lutz (bear trap) style gates for passing river flows and each dam was designed with hydropower turbines. Two of the six dams have three bear trap gates in their principal spillway, all others have two gates. The bear trap gates are situated upon a concrete base structure with features that accommodate the structural steel gate structure within pockets when it is lowered to pass flood waters. A concrete pier separates gates from one another and the gates are bounded by concrete abutments on each end of the spillways. The side seals of the gates traverse along a vertical concrete face at each pier and abutment. All gates share a common height of approximately 12 feet and spans range from 85 feet to 99 feet per gate depending on the location at the various GVHS dam sites. The primary gate structure consists of structural steel framework. The skin across the top of all framework consists of wooden planks with splined joints for water-tightness.

1.2 PROJECT PURPOSE

The bear trap gates have been in service for almost 90 years at the GBRA facilities. FNI previously evaluated three gate replacement options to the existing bear trap gates. These included replacement with modern bear trap gates, Obermeyer gates, or hydraulic crest gates.

Meadow Lake Nolte Dam Association (MLNDA) and the City of Seguin requested FNI to further refine the requirements for replacement of the existing bear trap gates with either Obermeyer gates or modernized bear trap gates, building on previous studies and evaluations. The primary considerations for this current study focused on risks between the two gate types, the overall stability of the spillway, the need for stability remedial actions to the left and right spillway training walls, further evaluation of dewatering considerations and care of water during construction, recommendations for foundation investigations, and an updated opinion of probable construction cost for the selected gate.

The development of this report has been a joint effort between the owner, engineer, and proposed operator (Sorenson Engineering).

2.0 SITE WALKTHROUGH

On December 8th, 2021 FNI conducted a site walkthrough at Nolte Dam along with GBRA and MLNDA personnel to document observations of the existing conditions. Below are the personnel who attend the the site walkthough.

Name	Organization
Mathew Moses, P.E.	FNI
Anthony Dundee, P.E.	FNI
Andy Taylor	MLNDA
John Moryl	GBRA

The site was accessed from the east property entrance off of Schneider Road (or Road 466). There is a very narrow bridge that must be crossed shortly after entering onto the GBRA access road. This bridge will pose access restrictions onto the site for larger vehicles and equipment. Once the bridge is crossed, the site is accessed by traveling along the dirt access road.

The spillway was viewed from the left side, upstream and downstream of the embankment crest and from the control room. At the time of the site inspection all three bear trap gates were fully raised with an upstream water surface elevation approximately at the top of gate. The downstream water surface elevation was slightly above the end sill, submerging most of the stilling basin from view.

Upstream of the embankment on the left side of the spillway, there is a generally flat area adjacent to the reservoir that appears is most often used for parking and turn around. The reservoir can be directly accessed from this location. It is also a location where a boat can be launched to access the spillway gates. Downstream of the embankment on the left side of the spillway, there is a slightly sloping and partially flat area adjacent to the left spillway training wall. Access to the river downstream of the gates from this location is very limited. On the west side of the spillway, there is a short section of embankment beyond the right spillway training wall, and beyond that is flat. The reservoir and downstream river appear to be inaccessible from the west side, due to topography and the elevation difference between the water surfaces and top of the right training wall.

During the site visit, special focus was placed on accessibility to the site and possible locations to place a crane. This is discussed further in Section 4.

Figure 2-1: Nolte Dam Overview (looking upstream)

Figure 2-2: Nolte Dam Headwater and Tailwater Levels (view from control room)

Figure 2-3: Upstream of Nolte Dam (looking downstream from left abutment)

3.0 GATE REPLACEMENT CONSIDERATIONS

3.1 RISK ASSESSMENT

Building on previous studies and evaluations, a comprehensive risk assessment approach was used to determine a path forward for gate replacement, comparing bear trap gates to Obermeyer Gates.

The Team has adopted the "ALARP" principle as its acceptance criteria for Risk. This requires that any identified Risk be reduced to a level, which is considered "As Low As Reasonably Practicable" when compared with current normative industry safety levels for the task. This is a practical approach, which relies upon the knowledge and experience of the Risk Management Team.

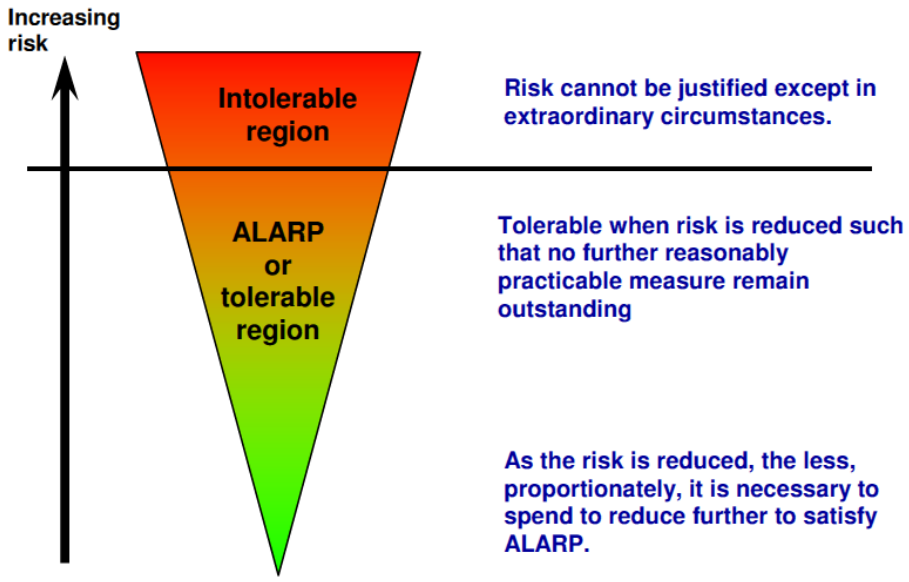

Figure 3-1: The ALARP Principle

The following Risk Assessment Criteria (RAC) was used for the Hazard Identification Risk Assessment (HIRA).

RISK = SEVERITY x PROBABILITY

The risk assessment matrix considers both severity and probability in order to determine a risk ranking.

Risk Assessment Matrix

Potential effect of impact					Probability rating					
Hazard severity category	Descriptive words	Personal illness/injury	Environmental *(Any incident that ...)*	Reputation Impact	Cost of loss (US $)	A: Very likely	B: Likely	C: Possible	D: Unlikely	E: Very unlikely
1	Very High	Fatality(s), terminal lung disease or permanent debility	Potentially harms or adversely affects the general public and has the potential for widespread concern regarding the Company's operations. Can have a serious economic liability on the business. Spill/Pollution >100m³	Sever impact on Company's reputation affecting relationship with Customers, Authorities and the general public (Negative press)	>$1m	1				
2	High	Serious injury with possible permanent injury, poisoning, sensitization or dangerous infection	Potentially harms or adversely affects employees and the environment at the Worksite. Requires specialist expertise or resources for correction Spill/Pollution 100ltr – 100m³	Major impact. Likely to escalate and affect Company"s reputation and relationship with Customer and the Authorities	>$250,000					
3	Moderate	Serious personal Injury leading to a lost time accident or persistent dermatitis or acne	Potentially harms or adversely affects employees and the environment at the Worksite. Requires general expertise or resources for correction Spill / Pollution 10ltr – 100ltr	Moderate impact. May cause requirement for corrective actions.	>$50,000			2		
4	Slight	Minor injury requiring first aid treatment or headache, nausea, dizziness, mild rashes	Presents limited harm to the environment and requires general expertise or resources for correction Spill/Pollution 1-10 ltr.	Slight impact	>$10,000					
5	Negligible	Negligible injury or health implications, no absence from work	Presents limited harm to the environment and requires minor corrective action Oil spill < 1ltr.	No impact	<$10,000					3

Probability	Descriptions
A: Very likely	Almost inevitable that an incident would result
B: Likely	Not certain to happen, but an additional factor may result in an incident
C: Possible	Could happen when additional factors are present but otherwise unlikely to occur
D: Unlikely	A rare combination of factors would be required for an incident to result
E: Very unlikely	A freak combination of factors would be required for an incident to result

Risk Priority codes		
1	*High risk*	Must not proceed – change task or further control measures required to reduce risk
2	*Medium risk*	Can proceed with regional management authorization
3	*Low risk*	Permissible by those trained and authorized to do so

***Note**: Risk priority code of less than 3 is not acceptable for hazards that effect personnel*

Figure 3-2: The Risk Assessment Matrix

The following tables provide risk assessments for the two gate options:

Activity	Hazard	Consequence	Mitigating Actions	Residual Risk		
				S	P	RPC
CONSTRUCTION						
Overall Construction	• Compatibility with existing structure	• Additional or unforeseen modifications to structure	• Replace with existing gate design known to be compatible with existing structure • Perform geotechnical investigation of existing conditions	3	E	3
Overall Construction	• Flood Risk	• Elevated upstream reservoir levels • Increased flooding downstream • Damage to structures	• Replace with existing gate design which minimizes construction schedule and exposure to flooding, existing gate design requires no concrete infill work which is vulnerable to flooding • Implement dewatering system that protects worksite but with smallest height possible to not increase reservoir levels and minimize damage to structure if flooding occurred	4	C	3
Overall Construction	• Scope creep • Schedule creep	• Additional or unforeseen costs • Increased exposure to flood risk	• Replace with existing gate design providing lowest exposure to scope or schedule creep • Proper design and engineering with clear requirements for contractors	2	D	3
MAINTENANCE						
Routine Maintenance	• Gates under load • Wet working conditions • Access • Confined spaces	• Gate failure • Personnel injury	• Lower lake level to remove load from gates • Properly engineered locking bars to lock gates in raised position for access to routine maintenance	3	D	3
Major Maintenance	• Gates under load • Ability to access hinges for full inspection and repairs • Wet working conditions • Access • Confined spaces	• Unable to access for maintenance • Hinge failure • Personnel injury	• Lower lake level to remove load from gates • Lower gates and implement dewatering system/coffer dam to protect worksite for major maintenance • Implement design that allows full inspection of hinges and repair of hinges with the gates in the fully lowered position • Implement markings on pins to indicate proper pin position to determine any concerns for wear or misalignment • Design to include ability to efficiently replace parts of the gate which have known service life: decking, seals, etc.	3	D	3
OPERATIONS						

Activity	Hazard	Consequence	Mitigating Actions	Residual Risk		
				S	P	RPC
Overall Operations	• Change in hydraulic performance • Change in capacity or discharge characteristics	• Adverse upstream or downstream impacts	• Replace with existing gate design to ensure same historical hydraulic performance	5	E	3
Overall Operations	• Foundation Stability	• Foundation failure	• Anchoring of foundation and relief wells	5	E	3
Overall Operations	• Debris handling • Vandalism • Clogging of water intake • Excessive seal leakage • Leakage b/w members • Sediment/silt	• Ability to operate gates • Gate responsiveness • Reliability • Damage to decking	• Replace with existing gate design known to handle large debris and no known issues with vandalism • Replace with new gate: new welded and coated steel, improved hinge design, improved decking materials, and improved seals and side sealing • Substantial improvement of water intake • Routine removal of silt in tunnels and cavities underneath gates • Implement routine and major maintenance (see above)	4	C	3
Lowering of Gates to pass flood waters	• Immediate response in ability to lower gates	• Adverse upstream or downstream impacts • Damage to structures	• Automate lowering of the gates with ability to lower remotely • Back-up/redundant power for automation equipment • Operators available for manual lowering in less than 30 minutes	1	E	3
Operations during high tail waters	• Unable to raise gates	• Temporary loss of lake	• Addition of submersible pump and repair of isolation valve to eliminate issue and ability to raise gates even with high tailwaters • Operators available for manual lowering in less than 30 minutes	4	D	3
Operations during Canyon Reservoir releases	• Ability to maintain headwater elevations	• Uncontrolled releases downstream • Elevated upstream levels • Fluctuations in headwater elevations	• Automation of single gate with ability for small adjustments in gate position and water levels during period of releases • Ability to adjust gate position remotely • Operators available to manually take over operations in less than 30 minutes	4	D	3
Raising of Gates over full range	• Operators not available	• Temporary loss of lake	• Operators available to raise gates in less than 30 minutes. Planned for on-site operators to be present during all flood events. In most cases operators will already be available for raising of gates	4	D	3

Table 3-1: Bear Trap Gate Risk Assessment

Activity	Hazard	Consequence	Mitigating Actions	Residual Risk		
				S	P	RPC
CONSTRUCTION						
Overall Construction	• Compatibility with existing structure	• Additional or unforeseen modifications to structure	• Obermeyer gates fit same area as existing gates and have a similar profile • Perform geotechnical investigation of existing conditions	3	D	3
Overall Construction	• Flood Risk	• Elevated upstream reservoir levels • Increased flooding downstream • Damage to structures • Vulnerability of concrete infill work	• Obermeyer gates utilize existing foundation with exception of additional concrete infill work for existing cavities • Implement dewatering system that protects worksite but with smallest height possible to not increase reservoir levels and minimize damage to structure if flooding occurred	3	C	2
Overall Construction	• Scope creep • Schedule creep • Addition of downstream shielding plates	• Additional or unforeseen costs • Increased exposure to flood risk	• Proper design and engineering with clear requirements for contractors	1	C	1
MAINTENANCE						
Routine Maintenance	• Minimal	• Minimal	• None	5	E	3
Major Maintenance	• Gates under load • Access • Confined spaces • Crane access • Heavy Lifting required	• Unable to access for maintenance • Personnel injury • Crane required to replace bladders • Additional costs	• Lower lake level to remove load from gates • Lower gates and implement dewatering system/coffer dam to protect worksite for major maintenance	3	C	2
OPERATIONS						
Overall Operations	• Change in hydraulic performance • Change in capacity or discharge characteristics	• Adverse upstream or downstream impacts	• Obermeyer gates fit same area as existing gates and have a similar profile • CFD modelling performed and found minimal impact on spillway hydraulics	5	D	3
Overall Operations	• Foundation Stability	• Foundation failure	• Anchoring of foundation and relief wells	5	E	3

Activity	Hazard	Consequence	Mitigating Actions	Residual Risk		
				S	P	RPC
Overall Operations	• Debris handling • Vandalism • Sediment/silt	• Ability to operate gates • Gate responsiveness • Reliability • Damage to bladders requiring replacement	• Addition of downstream shielding plates to protect bladder. While this is expected to mitigate risk of damage to bladders no Obermeyer gate installation worldwide has implemented this and could lead to unforeseen risks • Implement routine and major maintenance (see above)	2	C	2
Lowering of Gates to pass flood waters	• Immediate response in ability to lower gates	• Adverse upstream or downstream impacts • Damage to structures	• Obermeyer gates are inherently fully automated and automated lowering included. • Gates will automatically lower if power is loss • Operators available for manual lowering in less than 30 minutes	1	E	3
Operations during high tail waters	• Unable to raise gates	• Temporary loss of lake	• Obermeyer gates are inherently fully automated and not affected by high tail waters	4	E	3
Operations during Canyon Reservoir releases	• Ability to maintain headwater elevations	• Uncontrolled releases downstream • Elevated upstream levels • Fluctuations in headwater elevations	• Obermeyer gates are inherently fully automated and been proven to reliably maintain water levels • Operators available to manually take over operations in less than 30 minutes	4	E	3
Raising of Gates over full range	• Operators not available	• Temporary loss of lake	• Obermeyer gates are inherently fully automated and reliably able to raise gates over full range • Operators available to raise gates in less than 30 minutes. Planned for on-site operators to be present during all flood events.	4	E	3

Table 3-2: Obermeyer Gate Risk Assessment

3.2 RISK ASSESSMENT CONCLUSIONS

Construction:

The Obermeyer gate construction provides more exposure to risks compared to the bear trap gate. The longer time to complete the construction exposes the construction site to more flooding risks. The concrete infill work is susceptible to flooding risk as a flood could wash out portions of the infill work if not properly cured. Bear trap construction would not be exposed to this risk as no concrete infill work is required. Removal of the infill work provides a shorter construction duration as well. Downstream shielding plates could be needed to protect the rubber bladders from potential damage, due to both damage from debris handling during flooding and vandalism, adding to the scope and costs.

Maintenance:

Bear trap gates provide more risks for routine maintenance; however, these risks are considered small. The main difference in routine maintenance between bear trap and Obermeyer gates are in labor costs. When it comes to major maintenance or replacement of infrequent equipment such as bladders for the Obermeyer gates or decking and seals for bear trap gates, Obermeyer gates increase risk exposure. To replace the bladders the upper steel leaves must be removed and then re-installed upon bladder replacement. For Nolte Dam the steel leaves are heavy requiring a crane to handle them. Access for a crane to Nolte Dam would be costly. Comparatively replacing decking or seals on a bear trap gate is feasible with only manual handling.

Operations:

As discussed previously the bladders on Obermeyer gates are susceptible to damage from debris and vandalism, and addition of downstream shielding plates have their own risks. Bear trap gates have a long historical track record for capability to handle debris and vandalism. Sediment and gravel also pose a risk of damage to the bladder due to abrasion on the downstream side of the Obermeyer gates. Bear trap gates are not without sediment and silt issues either, however, the risk is due to buildup that occurs inside the tunnels and cavities and can be mitigated through routine maintenance. Obermeyer gates provide precise automation of gate operations, but bear trap gates provide for more robust and known gate operations for Nolte Dam. While the aim of improvements to bear trap gates is not automation over the full range of gate operations, bear trap gates can be automated to safely and reliably pass flood waters. Operations dealing with raising of the gates after flooding have little risk exposure other than the lake temporarily being lowered.

With the goal of a comprehensive risk assessment accounting for construction, maintenance, and operations the above approach aimed at determining the gate replacement option that provided the least overall risk exposure. Based one the conclusions of the risk assessment modernized bear trap gates have the lowest risk exposure when compared to Obermeyer gates. When comparing risk exposure, a

modernized bear trap was the basis for comparison with all improvements detailed in the study considered. Therefore, the study considers modernized bear trap gates going forward.

4.0 BEAR TRAP GATE REPLACEMENT CONSIDERATIONS

4.1 HISTORY AND GENERAL DESCRIPTION

Bear trap gates were first introduced in the late 1800's. Historically, bear trap gates have been able to provide long-term service, and have proven to be a reliable and cost effective type of water control gate. The existing bear trap gates at the six GBRA facilities were originally constructed in the late 1920's and have provided decades of service, until recently. The fact that these gates remained in service for so long is testament to their reliability and durability. They have been shown to be a very good application for this type of in-stream river system.

In general, bear trap gates consist of two rectangular leaves, which overlap each other near the center. Each of the leaves is hinged at one end, allowing rotation of the ends. The gate is raised by the pressure of the upstream reservoir, in which water is conveyed into the cell under the gate leaves through a chamber controlled by a gate. The downstream leaf begins to rise as the cell fills with water. The rising downstream leaf lifts the upstream leaf to a point where pressure equilibrium is met. Lowering of the gate occurs through a separate gate-controlled release chamber into the downstream reservoir.

4.2 HISTORICAL OPERATION AND MAINTENANCE

Regular maintenance of the GBRA bear trap gates has primarily consisted of replacement of timber sections, replacement of internal structural steel, and removal of sediment accumulation within the gate chambers following passage of floods. It was previously estimated that typical maintenance would be required after each flood event and minimally annually, gate seal replacement and recoating would be required every 20 years, and miscellaneous structural repairs would be required every 10 years.

The existing bear trap gates include locking bars and tie bars. The ties bars, which connect the upstream leaves, are used to limit further movement of the leaves relative to each other beyond full opening or raising. The locking bars are used to secure the gate in place when it is in the fully raised position. The gates are placed in this "locked" position primarily to allow for maintenance within the gates. For the first +/- 80 years of operation, it is understood that GBRA would keep the gates unlocked and pressured (water level inside the gate chamber equal to normal headwater). Over the past +/- 20 years, they have had issues with clogging of the intake, which would lead to occasional uncontrolled lowering of the gates – that is when they started locking the gates to keep them fully raised.

4.3 MODERNIZATION

4.3.1 Recommended Improvements

Replacing the existing bear trap gates with modernized bear trap gates is considered reasonable, both from a cost and operations and maintenance standpoint. Modernization of the gates would include improvements to both the gates and control systems.

Recommended improvements to the bear trap gates have been previously detailed by FNI [3]. The recommendations included improvements to seal types and configurations, smoothing of the pier faces using stainless steel plates to reduce friction, changing out of the wooden timbers to steel plate to reduce timber maintenance, and reconfiguration of the water intake to minimize the effect of clogging on the amount of flow passing through the trashracks.

After further study of the above previously discussed improvements during this current evaluation, the following recommendations are being made:

- It is still recommended to improve upon the seal types and configurations. To address the side seal leakage issue, the existing side seals should be upgraded to a modern gate seal such as Seals Unlimited mold number 6404. The recommended L-shape rubber seal is an inclined bulb seal that would offer additional flexibility while maintaining contact with the pier faces.

- In place of adding stainless steel plating on the pier faces, it is recommended to apply an epoxy coating, such as a Ravenscoat Linings System epoxy, to the existing concrete surfaces to provide a smooth and durable wearing surface over the full sealing surface contact area. Ravenscoat offer several products that provide superior bond to concrete. The concerns with stainless steel plating are challenges with installation and leveling and cost.

- It is recommended to stay with timbers along the upstream and downstream faces of each leaf, and not switch to a steel skinplate. Converting to a steel skinplate would most likely require adding buoyancy to the downstream leaf, possibly adding an undesirable level of complexity to the project. Composite decking in place of timber decking should be considered, which may improve overall durability and life-span, but will need to be further evaluated based on cost and equivalent buoyancy.

- The force required to operate the locking bars can be reduced by redesign of the bars and locking system, and minimizing misalignment issues.

- It will also be necessary to develop a means for improved access for inspection and lubrication of the upstream and downstream gate hinges. Final design will consider a composite hinge assembly with self-lubricating properties, such as Trelleborg's Orkot material, reducing the need for frequent lubrication and providing a substantial improvement to the hinge assembly. Partial inspection of the hinges is possible with the gate in the locked position. However, for full hinge inspection, lowering of the gates and installing a dewatering system, similar to the planned construction dewatering system, is required and will allow full access to the hinges for inspection. Full inspection and frequency of hinge inspection will be determined between the owner and operator of the dam and schedule necessary lowering of the reservoir to perform the inspections.

- It is recommended to evaluate the type of members that make up the individual truss systems within each bear trap gate. The existing trusses are primarily made up of back-to-back double angles. Over time, the coating system has failed. Proper coating the inside faces of back-to-back angles is difficult, due to the minimal space between angle legs. It is recommended to consider the use of T-sections in place of the double angles in the new gate design to eliminate these difficult to access spaces.

- The modernized replacement bear trap gates would be fabricated from welded steel and coated with an epoxy paint. Welded connections are a more reliable and robust connection then the previous riveted connections. The combination of welded connections and current epoxy coatings will help ensure maximum durability and coating life. The protective coating system for the gates and the seals would have a design life of 15 to 20 years. Final design should also consider an option to hot-dip galvanize or metalize the replacement gates to provide further protection and reduced maintenance throughout the service life of the gates.

Water Intake Improvements

The existing water intake for Nolte Dam is in the regulating pier located at the right side of the spillway (looking downstream). The water intake is a 5-foot by 5-foot inlet opening in the side of the upstream pier nose. Lake water enters the intake by passing through a steel grate trash rack. The existing trash screen is a simple flat steel grill screen system. The trash rack is mounted flat against the concrete surrounding the intake opening. The flat shape of the existing screen and high-flow velocity at the intake draws debris to the screen and chokes off the flow. The trash rack is subject to frequent blockage by river debris and various other items transported by the river flows. The screens have 1 to 2-inch openings are are relatively difficult to clean. Typical items that have blocked the intake in the past are mattresses, plastic swimming pools, plastic tarps, trash bags, trees, brush, and numerous other miscellaneous items. When the water intake trash rack clogs with debris, the gates are unable to receive adequate volumes of water to keep them floated and as a result drop to the fully down position. This gate drop results in significant water releases and temporarily lowers the reservoir until the intake can be cleared of the blockage.

This single plane opening of the existing trash rack appears to be problematic for providing a dependable volume of water into the intake structure. A new trash rack geometry is proposed that presents more surface area in the flow stream and can still function when partially clogged.

The proposed intake modifications include development of a truncated square pyramid (square frustum) enclosure with the truncated face of the screen configured as a 5-foot by 5-foot square so that any one side remaining open would provide for full flow into the intake. A conceptual sketch of the proposed modified intake screen configuration is shown on Figure 4-1. This improved screen would provide five intake faces, which would all have to be simultaneously clogged to render the intake inoperative. The

geometry of the enclosure screen configuration provides that that the top and bottom are effectively self-cleaning due to their inclination off the concrete wall.

An alternative to consider would to use a wedge wire intake screen with a feature to flush debris from the inside out using compressed air. Bursts of air would be applied to the plugged slots to provide thorough automatic clearing. The new trashracks or screens should be stainless steel. At this point in time based on improvements to the primary intake, a secondary or redundant intake, is not considered necessary.

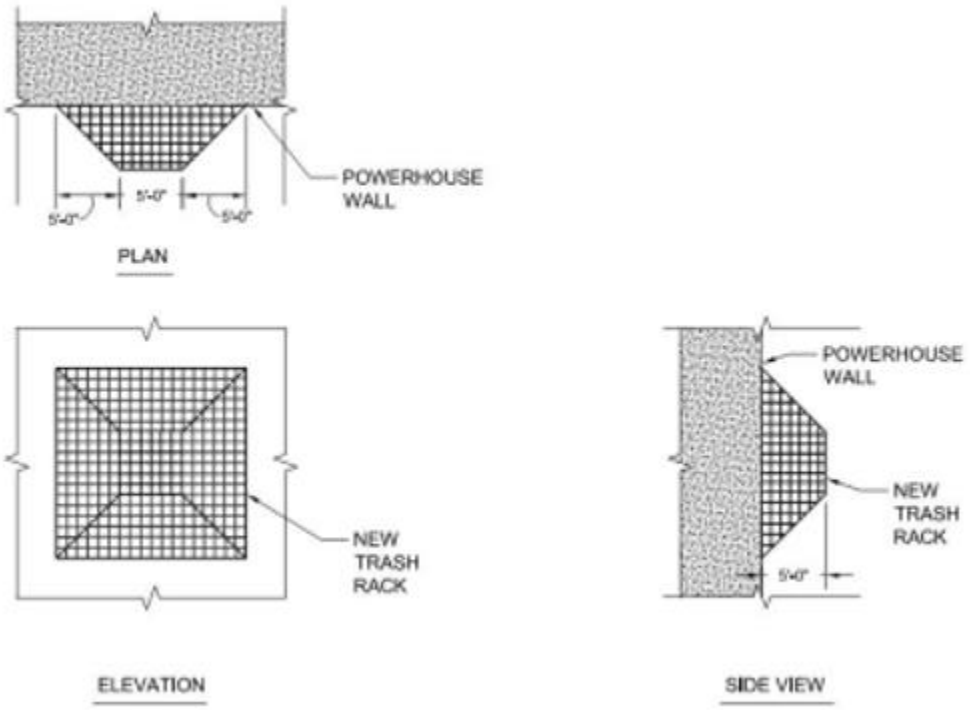

Figure 4-1:- Modified Intake Screen

4.3.2 Operational Improvements (Provided by Sorenson Engineering)

On the controls side of gate operations, we have been in consultation with Ted Sorenson of Sorenson Engineering. He has been assisting our team with recommendations for gate operation improvements. One of the primary concerns and focus has been on maintaining the ability to safely and reliably lower the bear trap gates during flood events. Below is a summary of existing operating conditions and considerations for future operations and maintenance of the bear trap gate control systems:

- The bear trap gates are raised by inflow of upstream water which is routed to the underside of the gates via tunnels from the intake gallery. Gates are lowered by restricting intake water and opening drain valves to release water downstream of the spillway. A simple hydraulic control diagram is shown in Figure 4-2. The control house and intake/drain gallery is located on the left abutment of the spillway (looking downstream). Each gate can be locked in the fully raised position.

- No primer pump currently exists. It is recommended to add a pump to initiate the gate raise under elevated tailwater conditions. Consider the use of a Flyght submersible pump rated for 2 cfs discharge flow.

- The existing intake Isolation gate is in open position and is likely frozen in place due to nonuse. With implementation of a pump, the operation of isolation gate is mandatory. Consider repair or replacement of the intake isolation gate to restore proper function.

- Current operation for intake gate 1 is with an electric actuator, with a manual override. Intake gates 2 and 3 are fitted for manual hand wheel operation. Inspection of the stems down to the butterfly valve shows no bending or "bowing". The GBRA operator reported no difficulty operating the intake gates. It is recommened to refit all three intake gates with electric operators, with manual overrode handwheels, fitted for either automatic or manual operation.

- Drain gates 1, 2 and 3 are fitted for manual hand wheel operation. Inspection of the stems down to the valves show no bending or "bowing". The GBRA operator reported no difficulty operating the drain gates. It is recommended to refit all three drain gates with electric operators, with manual override handwheels, fitted for either automatic or manual operation.

- Gate position indications appears to be fitted with weight and pulley system for gates 1, 2 and 3. It is recommended to adapt with new electronic inclinometer or improved weight and pulley to provide reliable gate position feed back to control system for each gate.

- Gate bay flush valves are manually operated and used primarily to flush silt. It is understood that silt flushing occurs every two to three years. It is recommended to inspect these valves but it is anticipated to continue to use these valves and system as-is.

- As a new feature, it is recommended to provide automatic gate position based upon upstream pool level by use of PLC. In the event of upstream high-level alarm and/or equipment malfunction, default is to lower the gates by closing the intake valves and opening drain valves. Recommended to also provide operator alarm call outs with operator response within 15 to 30 minutes. Also provided remote set point controls and camera surveillance system for operator use. Provide 45 KW propane powered standby generator for operation during grid outage.

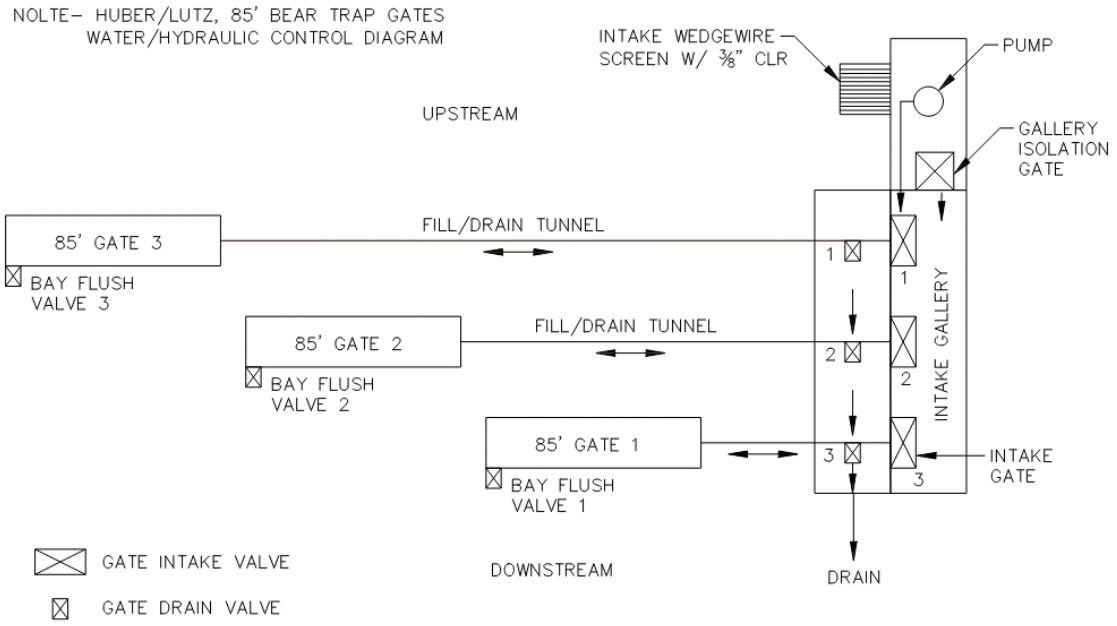

Figure 4-2: Hydraulic Control Diagram – Existing Bear Trap Gates – Nolte Dam

Automation Improvements:

Below covers the range of operations the gates perform, improvements to each, and degree for which each can be automated:

- Lowering of the gates to pass flood waters: As described above, automating the lowering of the gates is feasible. The single most important operation is to safely and reliably lower the gates to pass flood waters. All other operations come with significantly lower risk exposure (see Section 2.1 above for risk assessment of gate operations).

- Raising of gates during high tail waters: As described above, the addition of a submersible pump and repair of the isolation valve will allow raising of the gates even during high tail water events.

- Maintaining pond level during Canyon Reservoir releases: The controls package described above should allow for automating a small range of variable flows over a single gate. With the gate already partially raised, water underneath the gate and holding position, and once releases have stabilized the controls would allow automation of a gate to maintain normal pond levels. It is envisioned that only one gate would be automated in this manner and the other two gates automated for lowering only. An operator would be on stand-by and available within 30 minutes should any issues arise.

- Raising of gates over full range: Raising of the gates over the full range will be performed by operators. Operators will be on-site during flood events and since almost all raising of the gates

happens after flooding the operators will already be available. As a requirement an operator will be on stand-by at all times and available within 30 minutes.

To fully automate a modernized bear trap gate would require a different configuration. A clarifying/de-silting pond was investigated that would allow for clean and constant water to enter the gates for raising and lowering. A pond near the water intake would be constructed with water gravity fed by piping into the gates. The pond would allow all sedimentation to settle out creating clean water, similar to an Obermeyer gate using clean compressed air or hydraulic gates using clean hydraulic fluid. The fundamentals remain the same; a clean and constant medium, gas or liquid is required to make full automation possible. Once this configuration was in place the controls could be programmed to allow for full automation and operations over the full range. Additional permitting may be required to construct the pond to allow digging at or near the river basin. Sedimentation that accumulates inside the gates can be easily managed through routine maintenance and removal by gate operators. It is expected that the improvements, described above, for the water intake will enhance significantly the water delivery into the gates and ultimately improve operations. Since operators will already be available in flood events to raise the gates, automating the raising of the gates provide minimal improvements. For these reasons full automation is not included and the partial automation described above, preferred. Full automation will remain an option should this upgrade be desired in the future.

Maintenance Operations:

It is envisioned that maintenance will require different gate positions to accommodate certain maintenance activities, as discussed below:

- Gate locked out and under load: Perform sedimentation removal, coating touch-ups, and inspections. No replacement work or structural work to be performed in this condition due to gates under load.

- Gate locked out with no loads: The lake would first be lowered with one gate locked out. After maintenance the lake would be re-filled and a subsequent gate locked out and the lake lowered again. This would repeat until all gates have been maintenanced. Due to access issues, seal replacement may require maintenance in this manner and the decking on the lower leaf could also be done.

- Gates fully lowered: This maintenance operation would require a dewatering system/cofferdam with height sufficient to allow 1 foot of freeboard above the upstream hinges. This would allow for full decking replacement for both upper and lower leaves and full hinge inspection. For structural repairs, decking would need to be removied first to allow access. Gates fully lowered is preferred for these types of maintenance as it eliminates loads on the gates and confined spaces for workers, maintains full discharge capacity of spillway, avoiding elevated upstream levels if flooding was to occur, and eliminates working behind full hydrostatic pressure.

4.4 CONSTRUCTION FLOOD RISK CONSIDERATIONS/DEWATERING

There are numerous considerations associated with managing flood risk during removal of the existing bear trap gates and replacement with the new modernized bear trap gates, including:

1. How to protect the work in progress from reservoir headwater and tailwater fluctuations
2. How to plan and configure temporary river diversion facilities
3. How to continue project operations during construction
4. Accessibility to the work area

A temporary dewatering system is recommended to be installed upstream of the gate by the contractor, primarily to maintain a dry work area while managing storm flows, required spillway discharges, and flood events. The greatest concern to an upstream dewatering system is the impact it would have to the upstream reservoir level during flood events. Maintaining too high of an upstream water surface elevation, in combination with a reduction in release capacity due to one of the three gates being out of service, could lead to elevated river levels upstream of the dam.

Protection of the construction site from both headwater and tailwater will require the development of dewatering systems to manage the risk of inundation during the construction activities. Tailwater can be an issue both from releases through the adjacent gate to maintain the upstream reservoir elevation and from generation flows that can result in elevated downstream water levels that may impact the temporary construction staging or work in progress. Downstream tributaries can also contribute to back water effects in the downstream channel that may result in an increased tailwater elevation condition. The Care of Water section of the construction specifications will need to provide the requirements for the contractor to protect the work site from headwater, tailwater, and local drainage and stormwater runoff.

The configuration of the proposed modernized bear trap gate system allows for construction activities to proceed in the existing gate bay for the replacement of a bear trap gate behind an installed dewatering system, while the existing second and third bear trap gates are used to pass flows during construction of the new gate. Once the first new bear trap gate is operational, the dewatering system would be removed, installed in front of the second gate, and the new gate used to pass flows during construction of the second and third modernized bear trap gate.

A possible approach for consideration to dewatering and care of water is as follows:

- Construct a protective upstream cofferdam approximately 4 feet higher than the gate pin with the idea of operating it with one foot of freeboard at all times.
- A downstream cofferdam could be constructed just downstream of the proposed gate modifications to protect from backwaters, specifically during relief well installation.

Final configuration and design of the cofferdams will require coordination with available hydologic and historical river stage data. This approach to protecting the work site would protect the work in progress during the occurrence of smaller river flows, but not against a major flood. The bid items would include "Standby" rates and activities related to cleanup and repairs following an event that results in overtopping the cofferdam levels. This approach requires the bidders to provide preestablished pricing for work and activities related to flood conditions on the river that damage or impact the work in progress. This pre-determined risk management approach provides more reasonable pricing and management of protect costs than negotiating claims for impact costs prepared during or following a significant flood event.

Maintaining upstream water elevations during construction will be a significant challenge. The upstream land owners will need to be prepared for reduced reservoir levels between 7 to 8 feet for the duration of construction. The management of river flows during construction is critical. Having the full discharge capacity of the dam is necessary in reducing risks and eliminating un-natural elevated upstream reservoir levels.

4.5 SITE ACCESS

Accessibility restrictions pose a challenge to gate replacement construction. As previously noted, a narrow bridge must be crossed when the site is accessed from the east (off of Schneider Road, or Road 466). This bridge will pose severe restrictions on vehicle and equipment access. Once past this bridge, access to the spillway is along a dirt access road. This portion of the access road should not pose vehicle or equipment transport issues. On the east side of the spillway, the crest of the dam is narrow and therefore will not accommodate a significant sized crane sited directly on the crest. A control building, also located on the east side of the spillway, limits visibility to a crane operator. Access for a work crane will likely therefore be from an area upstream of the dam adjacent to the river or downstream of the dam and adjacent to the downstream training wall. Crane access is also possible on the west side of the spillway. On the west side, the approach is flat until the crane approaches the short section of narrow embankment and the right training wall. The expected necessary lift reach could be over 200 feet to the middle of the center gate. Maximum gate component weights will need to be closely monitored in combination with this long reach. A floating barge should be considered as another access alternative but will need to be closely evaluated and carefully monitored due to normal river releases being passed through the gates adjacent to the gate being replaced, which can result in potentially swift currents immediately downstream of the construction area.

Consideration should also be given to constructing a pad on the stilling basin or on the concrete adjacent to the stilling basin with bearing capacity sufficient for a crane. This would allow crane access downstream and parallel to the dam significantly reducing crane capacity and reach required. Site preparation would need to include for constructing a road to provide access to the pad and stilling basin area.

5.0 STRUCTURAL STABILITY

A stability analysis was performed to assess the existing conditions of the spillway at Nolte Dam as well as for the proposed gate modifications for compliance with current dams safety criteria. This chapter provides an overview of the stability analyses, including the stability criteria, analytical methods, load conditions and results. In depth calculations will not be presented as part of this scope of work.

5.1 STABILITY CRITERIA

Structure stability is generally evaluated against four failure modes: sliding, overturning, bearing capacity, and floatation. The stability analyses for the analyzed gravity sections were evaluated following United States Army Corps of Engineer (USACE) guidelines, including EM 1110-2-2200 "Gravity Dam Design" [USACE, 1995] and EM 1110-2-2100 "Stability Analysis of Concrete Structures" [USACE, 2005].

The gravity method of stability analysis was used to evaluate structural stability. The spillway section was analyzed on a per foot basis neglecting contribution of weight from the intermediate piers. This was done due to the long width of the structure between supporting members. A failure plane was considered at the bottom of the foundation keys and the structure above the failure plane has been considered to act monolithically.

Sliding stability is analyzed according to the limit equilibrium method defined by USACE guidelines. The factor of safety against sliding is the ratio of shear strength provided by base friction and cohesion to applied shear force. Overturning stability of the dam is characterized by the location of the net vertical force in the relation to the sections base length. Bearing pressure is compared to an allowable bearing pressure for the foundation material. Floatation stability is determined based on the ratio of resisting gravity loads (weight of structure, weight of water above top of slab, etc.) to the destabilizing uplift pressure.

Texas Commission on Environmental Quality (TCEQ) dam safety guidelines [1] provides criteria for sliding and overturning stability and bearing capacity. Criteria for flotation stability is not specifically discussed in the TCEQ dam safety guidelines; therefore USACE guidelines were used for this failure mode.

Table 5-1 presents the TCEQ/USACE stability requirements for usual, unusual, and extreme loading conditions.

Table 5-1: Stability Criteria

Loading Condition	Minimum Factor of Safety - Sliding	Minimum Factor of Safety - Flotation	Overturning Resultant Location Along Base of Structure	Foundation Bearing Pressure
Usual	2.0	1.3	Middle 1/3	< Allowable
Unusual	1.7	1.2	Middle 1/2	<Allowable
Extreme	1.3	1.1	Within Base	< 1.33xAllowable

5.2 MATERIAL PROPERTIES

The material and strength properties used in this preliminary stability analysis are shown in Table 4-2. These values were developed based on original boring data, previous site investigations and testing, and engineering judgement based on current stability of the spillway. Borings within the channel river were done during original design. Specific foundation material properties beneath the spillway were estimated due to a lack of testing data available.

Table 5-2: Material Properties

Property	Value
Unit Weight of Water	62.4 pcf
Unit Weight of Concrete	150 pcf
Unit Weight of Soil	120 pcf
Unit Weight of Saturated Soil	130 pcf
Foundation Bearing Pressure	3,000 psf
Internal Friction Angle at Failure Plane	34 degrees
Coheison at Sliding Failure Plane	0 psf
At-Rest Earth Pressure Coefficient	0.44

5.3 LOADS AND LOAD CASES

Two load cases were considered for the preliminary stability analysis: normal operating conditions and flood conditions, which are classified as usual and unusual loading conditions, respectively. The following sections discuss the individual loads imposed on the structure for the stability analysis.

5.3.1 Gravity Loads

The primary gravity loads considered in the stability analysis include the self-weight of the dam, concrete infill between the gate sill which is required for the installation of the new obeyermeyer gates, and the weight of the gate.

5.3.2 Hydrostatic Loads

Hydrostatic loading includes the driving and resisting lateral loads which correspond to headwater and tailwater conditions. Additionally, the water weight above the top surface of the structure is considered based on the water levels in the river. Table 5-3 indicates the water surface elevations considered for the stability analysis. To note, elevations are based off the record drawings datum.

Table 5-3: Design Water Surface Elevations

Load Case	Headwater Elevation (ft)	Tailwater Elevation (ft)
Normal Operations	378.13	355.50
Flood	378.13	378.13

5.3.3 Soil/Silt Loads

Lateral soil loads were considered on the upstream and downstream face of the spillway. The lateral force due to soil pressure is based on the effective density of soil due being fully submerged in both load cases considered. The soil levels upstream and downstream of the structure were taken at an elevation of 366.13 and 355.5 respectively. Similar elevations are referenced to the as-built drawing datum.

5.3.4 Uplift

The original design included an underdrain system to collect water passing under the structure and reduce uplift under the footprint of the spillway. This underdrain system consists of lateral and longitudinal pipes under the gated portion of the spillway slab that drain into the stilling basin and laterial pipes under the stilling basin slab that also drain into the stilling basin. The first line of drains begins just downstream of the upstream key. Based on the original boring logs, it appears that the spillway slab rests on a layer of gravel.

In addition, the original design included both an upstream and downstream steel sheet pile cutoff. The depth of the cutoffs is unknown.

Several uplift profiles were evaluated as part of the stability analyses in evaluating both existing and future conditions and are discussed in detail in the following section.

5.4 STABILITY ANALYSES

5.4.1 Existing Conditions

The first step in evaluating stability of the spillway was to establish potential foundation material strength properties and existing uplift conditions. The existing condition and performance of the underdrain system and sheet pile cutoffs is unknown, and the drain performance and effectiveness of the sheet pile directly affects actual uplift pressures.

Given the above unknowns, it was decided to evaluate best and worst case uplift conditions to bracket potential existing conditions.

For the worst case condition, it was assumed that the drains are inoperable and the cutoffs are ineffective (due to age and possible deterioration from corrosion), which leads to an uplift profile varying from full headwater to tailwater under the length of the spillway, as shown in Figure 4-1. Under this assumption, the existing spillway is shown to be unstable, with a flotation factor of safety less than 1.0.

For all existing condition stability analyses, the bear trap gates were in their fully raised position, locked in place, and fully drained.

Figure 5-1: Existing Spillway – Full Uplift

Given the spillway is currently in place (i.e., has not failed), the drains must still be in some form operational, with the corresponding uplift forces being less than that based on full headwater to tailwater. For the best case condition, it was assumed that the drains are fully operable and the cutoffs are still effective. Under this condition, a uniform uplift pressure equivalent to tailwater under the length of the spillway was applied, as shown in Figure 4-2.

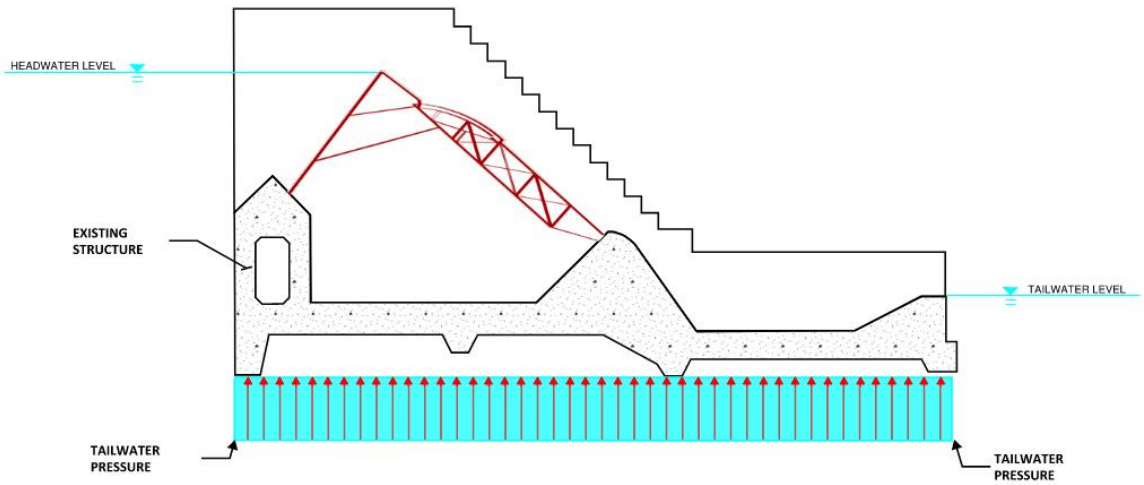

Figure 5-2: Existing Spillway – Reduced Uplift

Although this condition does not meet regulatory dam safey standards, flotation and overturning stability, along with bearing pressure, would be acceptable. As previously noted, specific test data is not available for foundation materials beneath the spillway. The required internal angle of friction along the proposed failure plane was computed that would result in a sliding factor of safety greater than 1.0 (to represent a stable structure). The computed internal angle of friction of 34 degrees was confirmed to be appropriate for the assumed failure plane within the foundation of the spillway based on the original boring logs. As discussed in more detail further in this report, this value will be established or confirmed during a foundation geotechnical program prior to final design. Stability results for this condition is shown in 4.

Table 5-4: Existing Conditions – Normal Operations (Reduced Uplift) - Stability Results

Flotation	
Computed Factor of Safety	2.0
Required Factor of Safety	1.3
Overturning	
Computed Location of Resultant	Middle 1/3
Required Location of Resultant	Middle 1/3
Bearing	
Computed Bearing Pressure	456 psf
Allowable Bearing Pressure	3,000 psf
Sliding	
Computed Factor of Safety	1.06
Required Factor of Safety	2.0

As a final evaluation of the existing structure, the USACE provides guidelines on evaluating existing structures with drains in place [2]. The guidelines allow up to a 50% reduction in uplift between headwater and tailwater at the first line of drains. Under this condition, uplift varies from full headwater at the upstream edge of the spillway, to a reduced uplift at the first line of drains, to tailwater pressure at the downstream end of the spillway. Tailwater pressure starts at the end of the gated portion of the spillway, as it is assumed that the stilling basin drains are still effective over the full length of the stilling basin. Figure 4-3 depicts this uplift profile.

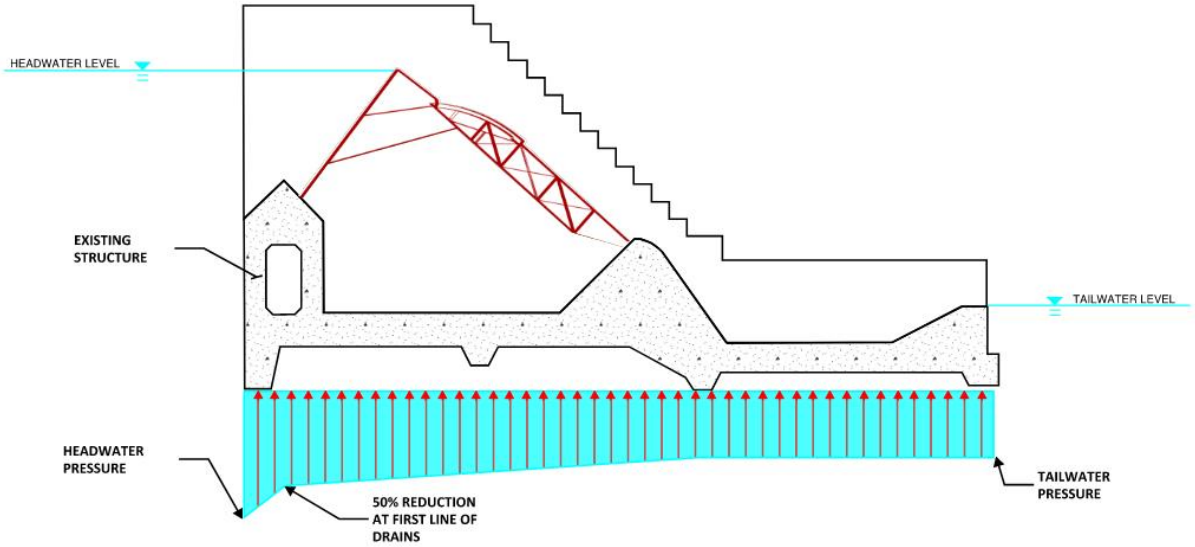

Figure 5-3: Existing Spillway – USACE Uplift Diagram

For this condition, under the usual load case, the resultant force along the base of the spillway falls outside of the middle third of the base, which indicates a cracked base. This result is considered unacceptable for a usual load condition.

5.4.2 Future Conditions

Due to the current age of the spillway (specifically the underdrain system and upstream and downstream sheetpile cutoffs), and the fact that the spillway will need to continue to remain in service for many years to come, the final stability evaluation considered the current drain system and sheetpile cutoffs ineffective. As previously mentioned, the existing condtion of the underdrain system and sheetpile cutoffs is unknown; and it is a reasonable assumption that at some point, the drains could fully clog, the drain pipes collapse, or the sheetpiling corrode to a point they are no longer useful. Under this situation, the uplift profile would vary from full headwater to tailwater under the length of the spillway.

To improve stability and satisfy stability criteria, remedial measures most appropriate for this spillway would be adding supplemental drains to better manage uplift pressures long-term and anchoring into the foundation. It was first considered to add vertical drains near the upstream end of the spillway, installing them from within the existing 3'-0" x 6'-0" intake port. This would result in the previously described allowable reduction at the line of drains. However, this option was not progressed due to the challenges of installing vertical drains within such a small working area and potential dangers related to control of high headwater uplift pressures. Installing vertical relief wells through the stilling basin slab is relatively straight forward and would result in a reduced uplift along the downstream portion of the spillway, equal to tailwater pressure. Anchoring of the spillway into the foundation would involve installation of post-tensioned anchors through the thickened portion of the spillway slab, inclined upstream with penetration into clay. The proposed vertical relief wells, anchors and assumed uplift profile are depicted in Figure 4-

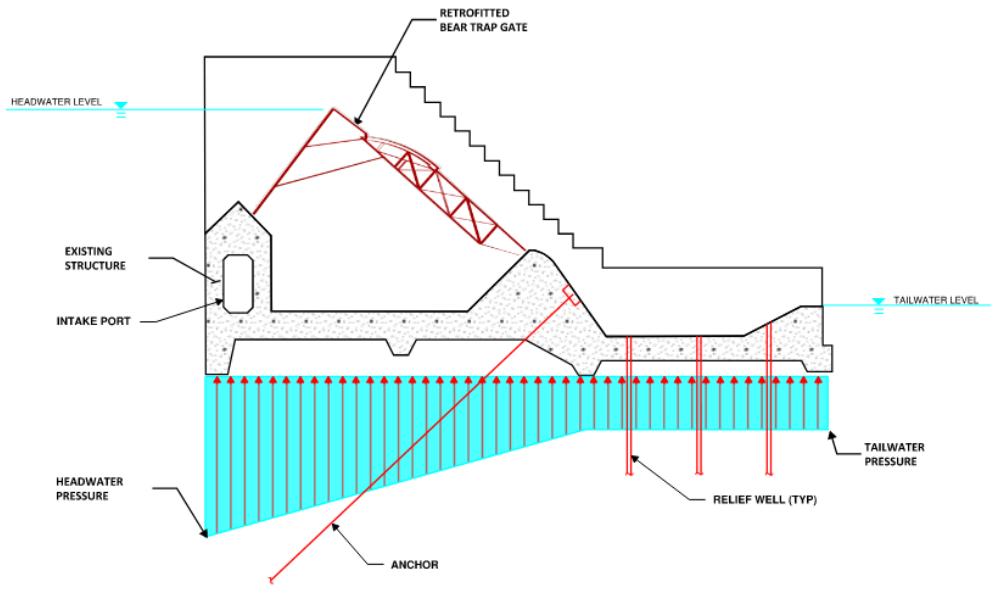

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Figure 5-4: Future Spillway – Remedial Measures to Satisfy Stability

Table 5-5 below indicates the the factors of safety obtained for the retrofitted bear trap gates and proposed remedial measures including relief wells and anchors.

Table 5-5: Improved Spillway Stability Results

Loading Condition	Normal Operations	Flood
Flotation		
Computed Factor of Safety	1.69	3.10
Required Factor of Safety	1.3	1.2
Overturning		
Computed Location of Resultant	Middle 1/3	Middle ¼
Required Location of Resultant	Middle 1/3	Middle ¼
Bearing		
Computed Bearing Pressure	926 psf	420 psf
Allowable Bearing Pressure	3,000 psf	3,000 psf
Sliding		
Required Anchor Force	25 kips/ft	0 kips/ft
Computed Factor of Safety	2.59	6.10
Required Factor of Safety	2.0	1.7

For normal operating conditions an externally applied anchor resistance of 25 kips per foot is required to meet the required factors of safety for overturning and sliding. If anchors are installed at 5 foot intervals along the width of the spillway, an anchor resistance of 150 kips is required per anchor. Without anchors sliding factor of safety falls below minimum requirements. Additionally, the resultant would be located outside of the middle third of the base. This results in a cracked base which is unacceptable for normal operations.

Generally, the most critical loading condition was found to occur at normal operations in which the largest head differential occurs between the upstream and downstream ends of the spillway. Higher tailwater levels during flood events results in higher uplift pressures, but these pressures are offset by the weight of water within the stilling basin.

5.4.3 Training Wall Stability

Review of existing FNI reports on the training wall stability at Nolte Dam was performed as part of this scope of work. The most recent report was submitted to GBRA on August 26, 2015 and is titled “Technical Memorandum Dunlap, McQueeny, Nolte, and TP-4 Dams – Training Wall Stability – Updated Analysis Results”. The findings from the previous study indicated that the walls are stable for both usual and unusual loading conditions. A summary of the results obtained from the previous stability analysis is presented in Table 4-6 below.

Table 5-4: Training Wall Stability Results

Loading Condition	Usual
Computed Location of Resultant	Middle 1/3
Required Location of Resultant	Middle 1/3
Computed Factor of Safety	3.1
Required Factor of Safety	1.5

For unusual loading conditions, the wall was analyzed by back calculating the required undrained shear strength of the backfill soil given the undrained strength of the foundation material in order to meet current stability criteria. It was found that a required cohesion of 600 psf is needed for training wall stability. Laboratory results from the unconsolidated undrained test on the clay fill material at Nolte Dam indicate that the minimum tested strength value of the backfill material is 1,096 psf which is greater than the required cohesion. Therefore, the training walls satisfied stability requirements for unusual loading conditions.

The findings of the previous stability analyses are still applicable and the stability of the walls satisfy code requirements. Further laboratory testing prior to final design, in addition to the spillway foundations investigations, will be performed to verify previous testing results.

5.4.4 Hydraulic Inadequacy

Hydraulic inadequacy of the dam will be addressed during final engineering. Results from engineering will enable a solution to be developed. The solution could vary from justifying the dam as low risk and not needing to address any further to partial or full hardening over the length of the embankments. Results will drive the solution and a long term solution will be developed to address.

6.0 OPINION OF PROBABLE PROJECT COST (OPCC)

This section covers the background, methodology, and limitations associated with the OPCC for this project at the present level of development. Included in this section are costs for replacement with modernized bear trap gates.

6.1 LEVEL OF PROJECT DEFINITION

AACE International (formerly the Association for the Advancement of Cost Engineering) defines five levels of cost estimates for a project in their Recommended Practice No. 17R-97 [4]. AACE classifications are a widely-accepted guideline within the cost-estimating community for defining level of project maturity and expected range of accuracy for associated project cost estimates. AACE classifications range from Level 5 to Level 1 for the lowest to highest level of project definition. The purpose of the AACE classifications is to "improve communication among stakeholders involved with preparing, evaluating, and using project cost estimates." The guidelines are intended to help avoid inappropriate decisions caused by misunderstandings of cost estimates and what they are expected to represent.

The united States Society on Dams (USSD) also provides guidelines for construction cost estimations for reservoir projects [5]. USSD recommends classifications for cost estimates which correspond directly to the AACE classifications. Per USSD, generally only a bidding contractor would expend the effort necessary to develop an AACE Class 1 estimate.

This memorandum presents AACE Class 3 cost estimates for the gate replacement. Per AACE, a Class 3 estimate corresponds to a project maturity level of between 10 and 40 percent completeness. A Class 3 OPCC is suitable for budget authorization but should be refined during final design for budget control of the project. The true project construction cost would be expected to fall within -5 to +20 percent of the Class 3 OPCC. Summarizes the AACE cost estimate classifications with the Expected Accuracy Ranges recommended by USSD. The OPCC includes line items of the most significant construction costs for the major project components.

6.2 UNIT PRICES

Preparation of an OPCC involves the use of data derived from a number of sources, with an overall goal of obtaining a reasonable and defensible expectation of costs for a specific level of project maturity. Sources of data used in preparation of the OPCC include but are not limited to the following:

1. Construction data aggregation services
2. Publicly-available construction data
3. Similar past projects performed by owner and/or engineer
4. Professional experience and engineering judgement

Unit prices shown in the OPCC are assumed to include direct project costs, overhead, and profit for each line item. In other words, unit prices reflect the total unit cost of that line item to the owner. Except where

explicitly noted, indirect project costs (e.g. bonds, safety program, quality control, surveying, insurance, warranties, taxes, etc.) are assumed to be subsidiary to the major construction work items listed in the OPCC.

Table 5-1: AACE Generic Cost Estimate Classification Matrix

Estimate Class	Level of Project Definition (as a % of completion)	End Use	Expected Accuracy Range	Preparation Effort (Degree of effort relative index of 1)
Class 5	0% to 2%	Screening or feasibility	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Concept study or feasibility	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget authorization	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 75%	Control or bid/tender	L: -5% to -15% H: +5% to +20%	5 to 20
Class 1	65% to 100%	Check estimate or bid/tender	L: -3% to -10% H: +3% to +15%	10 to 100

6.3 RISKS AND CONTINGENCY

An OPCC is an approximation based on available records at a present time to represent a prediction of conditions at some point in the future. As such, an OPCC is necessarily an approximation, and thus has an inherent level of uncertainty. At a feasibility design level, the OPCC is subject to considerable risk which is reflected in the expected accuracy ranges provided in . Major risks to the OPCC identified for the gate replacement project include, but are not limited to the following:

1. **Economic conditions:** The construction industry has seen major fluctuations in bidding climate during the recently year. Commodity prices fluctuate with market conditions, which can affect unit prices on critical construction line items (e.g. cement, aggregates and sand, diesel fuel, steel, etc.). Similar construction projects occurring simultaneously can raise bid prices due to shortages in specialized contractors. Additionally, major regional events (e.g. Hurricane Katrina) can cause sharp increases or decreases in material and labor prices.
2. **Unforeseen Conditions:** Rehabilitation projects inherently experience unforeseen conditions during construction. For this project, we would consider foundation conditions the biggest unknown. A geotechnical field investigation will be required to better understand material properties and overall foundation conditions within the footprint of the existing spillway.
3. **Schedule risks:** Many costs in the OPCC are related to the project schedule and duration of construction. A number of factors can affect the project schedule including floods and weather delays during construction.

USSD recommends a total project contingency of between 25 and 40 percent for a feasibility-level estimate to address uncertainty and risk factors. Contractor overhead and profit (OH&P) at 15 percent has been included in this OPCC.

6.4 PRICE BASE

Unless otherwise stated, all dollar values presented in this memorandum can be assumed to be nominal values with a price base of March 2023. If values are to be used in a year other than 2023, they should be adjusted for factors which affect nominal prices over time as appropriate (e.g. inflation, construction cost index, etc.).

6.5 EXCLUDED COSTS

The OPCC presented in this memorandum does not include material sales tax or non-constructions costs, including the following:

- Project financing costs
- Easement and right-of-way acquisition
- Legal costs
- Public outreach
- Owner administration and project management costs
- Ongoing costs, including operation and maintenance

Table 6-2 shows the opinion of probable project cost for the installation of three new bear trap gates and required improvements at Nolte Dam.

Table 6-2: Opinion of Probable Construction Cost

ITEMS					
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Performance and Payment Bonds and Insurance	1	LS	$ 179,727	$ 179,727
2	Mobilization and Demobilization	1	LS	$ 419,363	$ 419,363
3	Site Preparation and Access	1	LS	$ 75,000	$ 75,000
4	Care of Water/Temporary Facilities	1	LS	$ 500,000	$ 500,000
5	Removal and Disposal of Existing Gates	3	EA	$ 128,700	$ 386,100
6	Fabrication of Dewatering System	1	LS	$ 150,000	$ 150,000
7	Fabrication of New Bear Trap Gates	3	EA	$ 400,000	$ 1,200,000
8	Bear Trap Gate Installation	3	EA	$ 386,100	$ 1,158,300
9	Splined Wood Decking	10,500	SF	$ 10	$ 105,000
10	Hinge Anchorage (including Orkot Bushings & Pin)	72	EA	$ 5,000	$ 360,000
11	Gate Controls Package (by Sorenson)	1	LS	$ 460,000	$ 460,000
12	Side Sealing (Epoxy Coating)	6	EA	$ 18,000	$ 108,000
13	Gate Seals	3	EA	$ 25,000	$ 75,000
14	Strand (or Bar) Anchors	1	LS	$ 678,000	$ 678,000
15	Relief Wells	1	LS	$ 240,500	$ 240,500
16	Instrumentation	9	LS	$ 10,000	$ 90,000
17	Flood Cleanup Allowance	3	EA	$ 35,000	$ 105,000
18	Standby Time Delays	30	DAY	$ 10,000	$ 300,000
			SUBTOTAL:		**$ 6,590,000**
			OH&P:	15%	**$ 989,000**
			AACE CLASS 3 RANGE	-5%	**$ 7,200,050**
				20%	**$ 9,094,800**
			CONSTRUCTION TOTAL		**$ 7,579,000**

OTHER BUDGET ITEMS					
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	Engineering Feasibility Report	1	LS	$ 165,000	$ 165,000
2	Engineering Design & Site Investigations	1	LS	$ 600,000	$ 600,000
3	Construction Oversight and Quality Assurance	1	LS	$ 350,000	$ 350,000
4	Resident Representation	16	Month	$ 35,000	$ 560,000

7.0 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to further progress the design and construction considerations for replacement of the three existing bear trap gates with modernized bear trap gates at Nolte Dam.

Stability of the spillway, with the modernized bear trap gates, was evaluated. It was determined that the proposed spillway configuration does not satisfy stability requirements under sliding conditions and corrective measures are required in conjunction with the spillway gate replacement. As the basis for preliminary design estimates, the improvements consist of installing post-tensioned anchors through the existing slab and into the foundation, as well as installation of relief wells in the stilling basin slab to reduce uplift pressures under the structure. In order to design the anchors and relief wells and verify foundation bearing capacity, it will be necessary to perform a geotechnical foundation investigation to best define foundation conditions and material properties beneath the spillway. The details of this recommended investigation is discussed further in this section.

Stability of the left and right training walls was re-evaluated. It was determined that the findings of the previous stability analyses are still applicable and stability of the walls satisfy code requirements. Further laboratory testing prior to final design will be performed to verify previous testing results.

Care of water and dewatering during construction was also futher evaluated. It is recommeneded to provide a means to provide a dry work area on a daily basis for critical construction activities, including gate demolition, installation of the new gates, and installation of the relief wells. This would ideally involve protection of the work area upstream, downstream, and along the sides of each spillway bay. In addition to protection of the work area on a daily basis, consideration must be given to how the contractor will handle flood events, which will very likely inundate the work area, resulting in temporary removal of equipment and materials, work shutdown, clean up and restart of work.

The following considerations and efforts related to care of water should be evaluated and collected as part of the final design effort:

- Determine if a reservoir level of four feet above upstream hinge pins will be acceptable to manage risk throughout the anticipated construction duration of approximtely two years. If four feet of cofferdam around surrounds the gate under construction, reservoir pool will be about 7-8 feet less than full reservoir.
- Evaluate if work sequencing should be limited to replacement of one spillway gate at a time.
- Evaluate if adjacent gates will be able to throttle flows or will there be insufficient head to raise the gates from at rest position.
- Evaluate the possibility of modifying the existing gates with buoyancy tubes to allow functioning in lower reservoir heads during the construction period.
- Evaluate if maintenance flows must be maintained during construction. This could influence sequence of construction.

- Determine discharge capacity of the spillway during the construction of the proposed improvements. Final design activites may include developing rating curves for one gate down and two gates down scenarios.
- Determine how much freeboard the cofferdam needs to be able to handle during rapidly changing river flows.
- Better charactize typical flow conditions along this reach of the Guadalupe River for use in evaluating construction risk.
- River flow verus tailwater curves will be required to assess needs and extent of required downstream cofferdam.

As previously mentioned, specific foundation material properties beneath the spillway were estimated due to a lack of testing data available. Prior to final design, further site investigations are required to verify the assumptions or establish final foundation material and strength properties. This will specifically consist of collecting and testing of materials beneath the existing spillway for use in final stability calculations and relief well and anchor design.

The proposed geotechnical scope of work should consist of field exploration, laboratory testing, engineering analysis, and reporting as described below.

Field Exploration:

1. Select appropriate locations for exploratory borings within the vicinity of the dam. Coordinate with Client and notify Texas 811 of the planned borings prior to commencement of the field exploration activities in order to locate existing underground utilities within the area. It is assumed the boring locations will be accessible using a truck-mounted drill rig. If clearing is required to access the selected site or if an all-terrain drill rig is required to access the boring locations, these activities will be included as Additional Services.
2. Subcontract with a drilling contractor to drill six borings, two upstream of the dam, two near the dam centerline and two downstream of the dam. It is anticipated that there will be three borings on the left bank and three borings on the right bank. Four borings will be drilled to an approximate depth of 75 feet and two borings to a depth of approximately 60 feet.
    a. The borings will be advanced using standard rotary drilling equipment with continuous-flight augers (solid or hollow stem) or rotary wash methods. Subsurface samples will be collected using 3-inch diameter push tubes for cohesive soils and a 2-inch diameter split-spoon sampler in conjunction with the Standard Penetration Test (SPT) for intermediate and non-cohesive soils. Rock and rock-like materials will be cored and/or tested *in situ* using the Texas Cone Penetration (TCP) Test or the SPT, as appropriate for the material.
    b. Groundwater observations within the borings will be recorded at the time of drilling and at the completion of drilling and sampling.
    c. The borings will be backfilled with cement-bentonite grout upon completion of drilling and sampling.

   d. Due to the uncertainly in the current condition of the underdrain system and sheetpile cutoffs, it is recommended to install piezometers through the spillway slab to quantify the uplift pressure beneath the slab during the upcoming foundation geotechnical investigation. A total of 9 piezometers is recommended to be installed with 3 piezometers provided per gate bay and placed near the upstream face (downstream of sheet pile cutoff), between the gate sills, and in the stilling basin (upstream of sheet pile cutoff).

3. Conduct a site visit prior to drilling to locate and mark the boring locations, coordinate with the Client, and determine accessibility, as required.
4. An Engineer or Geologist experienced in logging borings will direct the drilling, log the borings, and handle and transport the samples. Visual classification of the subsurface stratigraphy shall be provided according to ASTM D2488 and the Unified Soil Classification System (USCS) during drilling and sampling.

Laboratory Testing:

1. Testing shall be performed on samples obtained from the borings to determine soil classification and pertinent engineering properties of the subsurface materials.
2. FNI will select samples for laboratory testing, assign tests, and review the test results. Testing will be performed by a geotechnical testing subcontractor.
3. Laboratory tests will be appropriately assigned for the specific subsurface materials encountered during exploration, but are expected to include:
   a. Atterberg limits – 25 tests
   b. Percent passing the no. 200 sieve – 20 tests
   c. Gradation tests – 5 tests
   d. Moisture content – 25 tests
   e. Unit dry weight – 10 tests
   f. Unconfined compressive strength – soil: 20 tests; rock – 20 tests
   g. Triaxial tests – 3 tests
   h. Direct shear tests – 4 tests

Geotechnical Engineering Analysis and Reporting

1. FNI will perform the geotechnical engineering analysis and prepare a Geotechnical Investigation Report summarizing the investigation. The report will include the following:
   a. Appendix with the boring locations, boring logs, laboratory test results, and a key to the symbols used.
   b. Discussion of subsurface conditions and soil properties indicated by the field and laboratory work and the implications for design.

c. Anchor design recommendations for the spillway and stilling basin and lateral and overturning resistance, etc. applicable for the loading conditions on the spillway.
d. General discussion of expected construction related issues.
e. Earthwork related recommendations for use during development of plans and specifications.

Based on the results and findings of the preliminary engineering study for replacement of the existing spillway gates, it was verified that modernized bear trap gates are an effective option for Nolte Dam to meet modern dam safety and regulatory standards. Therefore, it is recommended to proceed with the final design and development of construction documents for the construction of the modernized bear trap gates and proposed remedial improvements to the dam.

8.0 REFERENCES

1. Dam Safety Program, Texas Commission on Environmental Quality, August 2009. Design and Construction Guidelines for Dams in Texas.
2. US Army Corps of Engineers, December 2005, Stability Analysis of Concrete Structures.
3. Freese and Nichols, Inc. March 2018. H-5 Gate Replacement Evaluation Technical Memo.
4. AACE International. 2011. Recommended Practice No. 17R-97, Cost Estimate Classification System.
5. U.S. Society on Dams. May 2012. Guidelines for Construction Cost Estimating for Dam Engineers and Owners.