Public Notice

U.S. Army Corps Of Engineers

Galveston District

Permit Application No: SWG-2016-01027

Date Issued: 29 March 2018

Comments Due: 30 April 2018

U.S. ARMY CORPS OF ENGINEERS, GALVESTON DISTRICT
AND
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

PURPOSE OF PUBLIC NOTICE: To inform you of a proposal for work in which you might be interested. It is also to solicit your comments and information to better enable us to make a reasonable decision on factors affecting the public interest. The U.S. Army Corps of Engineers (Corps) is not the entity proposing or performing the proposed work, nor has the Corps taken a position, in favor or against the proposed work.

AUTHORITY: This application will be reviewed pursuant to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA).

APPLICANT:
Dow Chemical Company
2301 North Brazosport Boulevard
Freeport, Texas 77541
POC: Ms. Yvonne Sampson
Telephone: 979-238-4814

LOCATION: The project site is located between the Brazos River and Oyster Creek, approximately eight miles northwest of the City of Angleton and abuts the Brazos River, in Brazoria County, Texas. The project can be located on the U.S.G.S. quadrangle map titled: OTEY, Texas.

LATITUDE & LONGITUDE (NAD 83):
Latitude: 29.2709860466716 Longitude: -95.543090603221

PROJECT DESCRIPTION: The proposed Project would provide additional water storage capacity by constructing an off-channel (upland) reservoir and associated infrastructure located immediately north of the existing Harris Reservoir site. The off-channel reservoir would include a 1,929-acre impoundment with a nominal storage capacity of 50,000 acre-feet, an intake and pump station to divert Dow's existing surface water rights from the Brazos River, an outlet to Oyster Creek and an emergency spillway. The Project also includes floodplain enhancements in Oyster Creek, stream restoration and temporary construction staging and laydown areas.

The Project facilities are intended to provide a reliable water supply from the Brazos River for Dow's Texas Operations in Freeport, Texas and other users of Dow's water supply system including the Brazosport Water Authority during extended periods of low stream flows and/or drought. The proposed off-channel reservoir will be operated in conjunction with the existing Brazoria and Harris reservoirs to supplement the total available storage capacity and to provide additional operational flexibility. The project components include the following:

Off-channel impoundment – An approximately 40-foot-high by 36,200-foot-long upland earthen embankment will be constructed to form the impoundment. The embankment is to be constructed of compacted soils obtained from borrow areas within the reservoir interior. The results of an initial geotechnical investigation of the site in 2013 suggest soils from borrow areas located in the reservoir interior will primarily consist of cohesive or silty soils and therefore the preliminary slope design for this embankment section are based on designs for similar soil conditions. The components of the embankment section include a stabilizing berm, soil-cement armoring, wave wall, main embankment, chimney and blanket filters and drains, perimeter toe ditch, seepage barrier wall, and a perimeter road embankment. The proposed embankment section has side slope ratios of 3 horizontal to 1 vertical on the interior slope and 3.5 horizontal to 1 vertical on the exterior slope. The 3.5 horizontal to 1 vertical ratio of the exterior slope is intended to reduce the probability of shallow slumps occurring on the slope. Such slumps are common on embankments with 3:1 (horizontal to vertical) side slopes constructed with clayey soils on the Gulf Coast because of weathering of the compacted clay that occurs because of alternating wetting and drying cycles. A stabilizing berm with a 6:1 (horizontal to vertical) slope is shown against the lower portion of the interior slope. The berm will be constructed of soils stripped from the embankment footprint and borrow areas and will mainly serve two purposes: (1) to stabilize the slope under a rapid drawdown loading condition during releases in drought conditions, and (2) to decrease the portion of the slope requiring armoring against erosion. Some materials like sand and cement will be imported to the site for construction of internal filter/drains and soil-cement armoring. The exterior slope of the embankment will be seeded with native vegetation and maintained by mowing.

River intake and pump station –The river intake will be an in-channel intake structure including a sheet pile structure with concrete head wall in the Brazos River, mechanically cleaned T-screens, inlet pipes from the screens to the pump station building and stabilization of the Brazos riverbank near the intake as needed. The pump station will be partially underground with reinforced concrete walls, will be enclosed on three sides above-ground, and have a roof. The above-ground portion will have exterior cladding and roofing of prefinished metal wall and roof panels. The design will allow for removal of equipment thru a roof opening of a size that will be determined. The pump station will contain two pumps each capable of pumping 75,000 gallons per minute (gpm) from the River to the reservoir. An electrical power line will be constructed to convey power from nearby CenterPoint Energy transmission lines to the pump station. Water will be conveyed to the reservoir via approximately 1,200 linear feet of steel discharge pipeline. Streambank stabilization measures will be installed in the immediate vicinity of the intake structure, approximately 200 feet upstream and 100 feet downstream. The streambank stabilization measures are anticipated to include riprap and/or bio-engineered measures. They will be designed to reinforce the toe and a portion of the slope of the riverbank, preventing lateral migration of the Brazos River.

Other facilities associated with the pump station include the Operations Building, Electrical Motor Control Center (MCC) Building, and Transformer area. The Operations Building is an approximately 2,000-square-foot pre-engineered metal building supported by a concrete foundation, and will include restrooms and a meeting space. The MCC will be a pre-engineered/pre-fabricated structure, which may have to be elevated above the ground surface depending on the design flood elevation. Power will be brought into the MCC/ pump station area and routed within the Project site to electrical components as needed. The transformer will be supported on a concrete foundation pad with a containment area.

Discharge line/reservoir inlet structure - The welded steel discharge lines from the pumps will run above-grade to where they exit the building and combine into the common header. The header will remain above grade upstream and immediately downstream of the flowmeter. Downstream, the discharge line will be buried with minimum cover to the reservoir. The line will be exposed up the face of the reservoir embankment and through the top portion of the embankment into the reservoir, with the invert at or above the high-water level in the reservoir to ensure no reverse flow out of the reservoir. The inlet structure will be located inside the reservoir and serve to transition the pump discharge from the steel pipe into the reservoir. When the reservoir is at or near empty the structure must provide energy dissipation from the high velocity of water flowing by gravity from the top of the embankment to the bottom of the reservoir. A U.S. Army Corps of Engineers (USACE 1963) -type stilling well at the end of the pipe is proposed to provide a structure to meet these requirements. The stilling well will be approximately 15-foot in diameter and depth.

Reservoir outlet - Water stored in the off-channel reservoir will be released into the proposed Oyster Creek flood bypass channel through the outlet works. From upstream to downstream, the proposed outlet works will consist of a reinforced concrete structure with trash rack, an upstream large-diameter pipe, reinforced concrete control structure with sluice gates in the embankment, two downstream pipes (smaller than the upstream large-diameter pipe), two U.S. Bureau of Reclamation (USBR) Type VI impact stilling basins, a concrete channel, a flume, and an armored channel leading to the Oyster Creek flood bypass channel. Buried pipes, both upstream and downstream of the control structure, will be encased in reinforced concrete.

Emergency spillway – The spillway will provide two functions. First, it will serve as an uncontrolled spillway with a fixed crest to protect the dam without requiring operations. The second function is as a gated spillway allowing for approximately 3 feet of operational drawdown or lowering the reservoir water surface elevation (WSEL) during an emergency release condition. If the second function of operational drawdown is determined to be unnecessary during final design, the spillway and the outlet works could possibly be combined. The concept for the spillway structure consists of a reinforced concrete structure at the top of the dam embankment with 3 radial gates. When operating, the radial gates will provide a capacity of approximately 600 cubic feet per second (cfs) to 1,000 cfs over the range of reservoir WSELs 65 to 68 feet, respectively. When overtopped, the radial gates will also serve to provide 20 to 30 feet of fixed spillway crest length for uncontrolled releases. The estimated spill capacity of the uncontrolled spillway is approximately 650 cfs with 4 feet of surcharge (WSEL 82). Downstream of the radial gates, a concrete chute will convey the flows down the embankment to an USBR Type III stilling basin followed by either a riprap or concrete channel leading to Oyster Creek.

Conveyance – Water will be released from the off-channel reservoir into Oyster Creek via a new bypass channel, supplementing releases from the existing Harris Reservoir discharge facilities. Existing pump stations and industrial canals will convey the water to Texas Operations for use. No new canals are proposed as part of the proposed Project. Drainage enhancement project – The proposed Harris Expansion Project is located within both Brazos River and Oyster Creek's 100-year FEMA regulatory floodplains with designated special flood hazard zones AE and AO on the Brazoria County Flood Insurance Rate Map (FIRM). The proposed storage facility will be above existing ground elevation with a constructed berm surrounding the reservoir. It will have an approximate footprint of 1,900 acres.

The reservoir embankment will be fully contained within the Oyster Creek floodplain and will not impact the Brazos River floodplain. In addition to the reservoir embankment, an intake/pumping facility will be located to the west of the reservoir within the Brazos River floodplain and the reservoir's spillway will be directed to Oyster Creek on the east.

The proposed Project includes floodplain enhancement projects along Oyster Creek that include three areas where the hydraulic capacity of the Oyster Creek channel above the Ordinary High Water Mark line will be changed. The first project (Project 1) modifies the existing channel (Oyster Creek and unnamed tributary north and west of Otey) north of the proposed reservoir and includes a 70-foot bottom width channel with 4H:1V side slopes and floodplain benches. A second project (Project 2) widens the main Oyster Creek channel starting just downstream of the Project 1 and includes an 80-foot bottom width channel with 4H:1V side slopes, followed by a 150-foot floodplain bench and buffer with 4H:1V side slopes tying to existing ground. This provides an approximate 400-foot top width. Adjustments to the existing Ramsey Bridge which provides access to the state prison will be required due to the channel widening. The last channel improvement project (Project 3) creates an overflow channel 15-foot-deep with a 100-foot bottom width and 4H:1V side slopes starting just downstream of the proposed Project 2. The Conceptual Mitigation Plan provides representative cross sections of the proposed channel improvements.

Other facilities - Access to the embankment for maintenance and inspection will be provided by a road on the embankment crest and another around the perimeter of the embankment. Eleven abandoned and plugged oil and gas wells which have been closed in accordance with Texas Railroad Commission regulations are located on the site.

Temporary construction laydown areas and work spaces – An approximate 20-acre area located to the southeast of the proposed reservoir will be utilized for construction offices, equipment and material storage and work force parking. A second area located southwest of the proposed off-channel reservoir near the intake from the Brazos River will be used as a work space during construction of the intake and pump station. Both areas will be sited to avoid impacts to wetlands and other WOUS. Additional temporary work space near the southwest corner of the embankment will be used during construction of the intake from the Brazos River and the bank stabilization. The upland portion of the temporary workspace will be sited to avoid wetlands and waters of the U.S. Additionally, some construction will occur in the Brazos River during construction of the intake facility and bank stabilization.

Storage facility operations - Operation of the existing and proposed storage facilities can generally be categorized into the following: (i) normal operations, (ii) drought conditions, and (iii) emergency release conditions. During normal, non-drought conditions, Dow's river water supply will continue to be operated in generally the same fashion as it has been for the past 60 years with the Harris and Brazoria reservoirs. The provision of additional storage will result in minor changes to operations. For example, the proposed reservoir will normally be filled and maintained at a full level until releases are required for maintenance, seasonal adjustments to operating pool level, or a drawdown in advance of a tropical storm landfall near the site. Given this normal mode of operation, the proposed river intake and pump station will only operate as necessary to fill the reservoir and maintain it in a full condition.

During drought conditions with low streamflows on the Brazos River, Oyster Creek, and Buffalo Camp Bayou, the average daily demand for Texas Operations, can't be met by pumping from the river alone. Water is released from Dow's water storage reservoirs in a manner that maximizes the benefit of the storage and yields the highest probability to refill storage during a sustained drought. The following outlines a conceptual operating plan for the storage facilities after the proposed reservoir is constructed.

1. Water releases would first be made from the proposed reservoir. Water would be released exclusively from this source or used to augment flows from the existing Harris reservoir.
2. Once the proposed reservoir water supply was exhausted, releases would then be made from the existing Harris reservoir.
3. Finally, releases from the Brazoria Reservoir would be made. The release rates would first be set to augment the diminishing flow from the existing Harris reservoir as it empties and then at the full demand rate after Harris reservoirs are depleted. Releases from the Brazoria Reservoir would be reduced to some minimum rate, identified as required to meet critical demands.

Emergency release conditions would include drawdown in advance of a tropical storm landfall near the site, or drawdown because of embankment instability. Emergency releases could also occur via the emergency spillway in a full reservoir condition.

The construction of the proposed Project is estimated to result in the loss of 12.19 acres of emergent wetlands, 4.15 acres of forested wetlands, and 20,486.3 linear feet (5.73 acres) of streams.

The applicant's project plans are enclosed in 15 sheets.

AVOIDANCE AND MINIMIZATION: Avoidance of wetland and waterbody impacts to the maximum extent possible is initially accomplished through a robust alternative project selection process. For the proposed Project, avoidance of wetland and waterbody impacts is primarily accomplished through site selection and temporary workspace siting during design iterations. Impacts to wetlands and other waters could not be completely avoided due to the nature of the proposed project which includes inundation of water bodies on the site. Conceptual design of the floodplain enhancement project includes increasing hydraulic capacity above the Ordinary High Water Mark of Oyster Creek. Impacts are also reduced by siting temporary construction workspaces to avoid sensitive wetland and other water features. In addition, wetlands outside of construction workspaces will be demarcated in the field and identified on work plans as "no work zones" to avoid impacts during construction.

Dow will avoid and minimize potential adverse impacts to wetland and WOUS by implementing the following techniques as appropriate. Other techniques may be identified during final design and construction that can be implemented in addition to or in lieu of the following:

- Install appropriate BMPs and erosion control measures to protect wetland and water resources on the subject property and adjacent areas.
- Locate equipment refueling areas away from wetlands and WOUS.
- Reduce the disturbance to the Brazos River, Oyster Creek and other waterbodies identified during delineation, and associated vegetation to the extent practical and minimize clearing of trees and other plants in temporary workspace areas to leave in place as much vegetation as possible on stream banks within the temporary workspace.
- Stabilize and restore stream banks and adjacent upland areas after construction.
- Segregate wetland topsoil and its associated seedbank and returning it to the top where applicable.
- Use of matting to protect the underlying soil and root stock, where applicable such as during restoration and re-establishment projects along Oyster Creek as proposed in the Conceptual Mitigation Plan.
- Inspect construction areas periodically during and after construction and repair any erosion controls and/or performing restoration, as needed, in a timely manner.

The applicant's alternatives analysis are enclosed in 43 sheets.

MITIGATION: The proposed mitigation strategy includes acquiring functional capacity units from an approved mitigation bank to mitigate impacts to wetlands. To mitigate impacts to potentially jurisdictional linear features within the impoundment, Dow proposes to restore and rehabilitate two segments of Oyster Creek and reestablish two ephemeral streams. Providing bankfull benching, riparian buffer and other preservation, rehabilitation, enhancement and reestablishment treatments throughout these areas will improve the physical, biological and chemical functionality of Oyster Creek.

The applicant's mitigation plan is enclosed in 38 sheets.

CURRENT SITE CONDITIONS: The diversity of the project site with respect to vegetation, soils, and available water resources provides habitat for a large number of native wildlife species such as those described in the following sections. Columbia Bottomland Hardwoods, scrub shrub uplands, forested uplands, forested wetlands, emergent wetlands, ephemeral and intermittent streams, and a series of man-made drainage ditches are present on the site.

The applicant's ecological baseline report is enclosed in 31 sheets.

This public notice is being issued based on information furnished by the applicant. This project information has not been verified by the Corps. As of the date of this public notice, the Corps has received but not yet verified the wetland delineation.

A preliminary review of this application indicates that an Environmental Impact Statement (EIS) may be required. Since permit assessment is a continuing process, this preliminary determination of EIS requirement will be changed if data or information brought forth in the coordination process is of a significant nature.

Our evaluation will also follow the guidelines published by the U.S. Environmental Protection Agency pursuant to Section 404 (b)(1) of the CWA.

OTHER AGENCY AUTHORIZATIONS:

Although the project site is not located within the Texas Coastal Zone projects that affect downstream inflow rates along the coast may require certification from the Texas Coastal Management Program. The applicant has stated that the proposed activity complies with Texas' approved Coastal Management Program goals and policies and will be conducted in a manner consistent with said program.

This project would result in a direct impact of greater than three acres of waters of the state or 1,500 linear feet of streams (or a combination of the two is above the threshold), and as such would not fulfill Tier I criteria for the project. Therefore, Texas Commission on Environmental Quality (TCEQ) certification is required. Concurrent with Corps processing of this application, the TCEQ is reviewing this application under Section 401 of the CWA and in accordance with Title 30, Texas Administrative Code Section 279.1-13 to determine if the work would comply with State water quality standards. By virtue of an agreement between the Corps and the TCEQ, this public notice is also issued for the purpose of advising all known interested persons that there is pending before the TCEQ a decision on water quality certification under such act. Any comments concerning this application may be submitted to the Texas Commission on Environmental Quality, 401 Coordinator, MSC-150, P.O. Box 13087, Austin, Texas 78711-3087. The public comment period extends 30 days from the date of publication of this notice. A copy of the public notice with a description of work is made available for review in the TCEQ's Austin office. The complete application may be reviewed in the Corps office listed in this public notice. The TCEQ may conduct a public meeting to consider all comments concerning water quality if requested in writing. A request for a public meeting must contain the following information: the name, mailing address, application number, or other recognizable reference to the application; a brief description of the interest of the requester, or of persons represented by the requester; and a brief description of how the application, if granted, would adversely affect such interest.

NATIONAL REGISTER OF HISTORIC PLACES: The staff archaeologist has reviewed the latest published version of the National Register of Historic Places, lists of properties determined eligible, and other sources of information. The following is current knowledge of the presence or absence of historic properties and the effects of the undertaking upon these properties:

> The permit area is likely to yield resources eligible for inclusion in the National Register of Historic Places. An investigation for the presence of potentially eligible historic properties is justified.

THREATENED AND ENDANGERED SPECIES: Preliminary indications are that no known threatened and/or endangered species or their critical habitat will be affected by the proposed work.

ESSENTIAL FISH HABITAT: Although the project site is not located along the Texas coast projects that affect downstream inflow rates along the coast may affect essential fish habitat. This notice initiates the Essential Fish Habitat consultation requirements of the Magnuson-Stevens Fishery Conservation and Management Act. Our initial determination is that the proposed action would not have a substantial adverse impact on Essential Fish Habitat or federally managed fisheries in the Gulf of Mexico. Our final determination relative to project impacts and the need for mitigation measures is subject to review by and coordination with the National Marine Fisheries Service.

PUBLIC INTEREST REVIEW FACTORS: This application will be reviewed in accordance with 33 CFR 320-332, the Regulatory Programs of the Corps, and other pertinent laws, regulations and executive orders. The decision whether to issue a permit will be based on an evaluation of the probable impacts, including cumulative impacts, of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefits, which reasonably may be expected to accrue from the proposal, must be balanced against its reasonably foreseeable detriments. All factors, which may be relevant to the proposal, will be considered: among those are conservation, economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs and, in general, the needs and welfare of the people.

SOLICITATION OF COMMENTS: The Corps is soliciting comments from the public, Federal, State, and local agencies and officials, Indian tribes, and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps to determine whether to issue, modify, condition or deny a permit for this proposal. To make this decision, comments are used to assess impacts on endangered species, historic properties, water quality, general environmental effects, and the other public interest factors listed above. Comments are used in the preparation of an Environmental Impact Assessment and/or an EIS pursuant to the National Environmental Policy Act. Comments are also used to determine the need for a public hearing and to determine the overall public interest of the proposed activity.

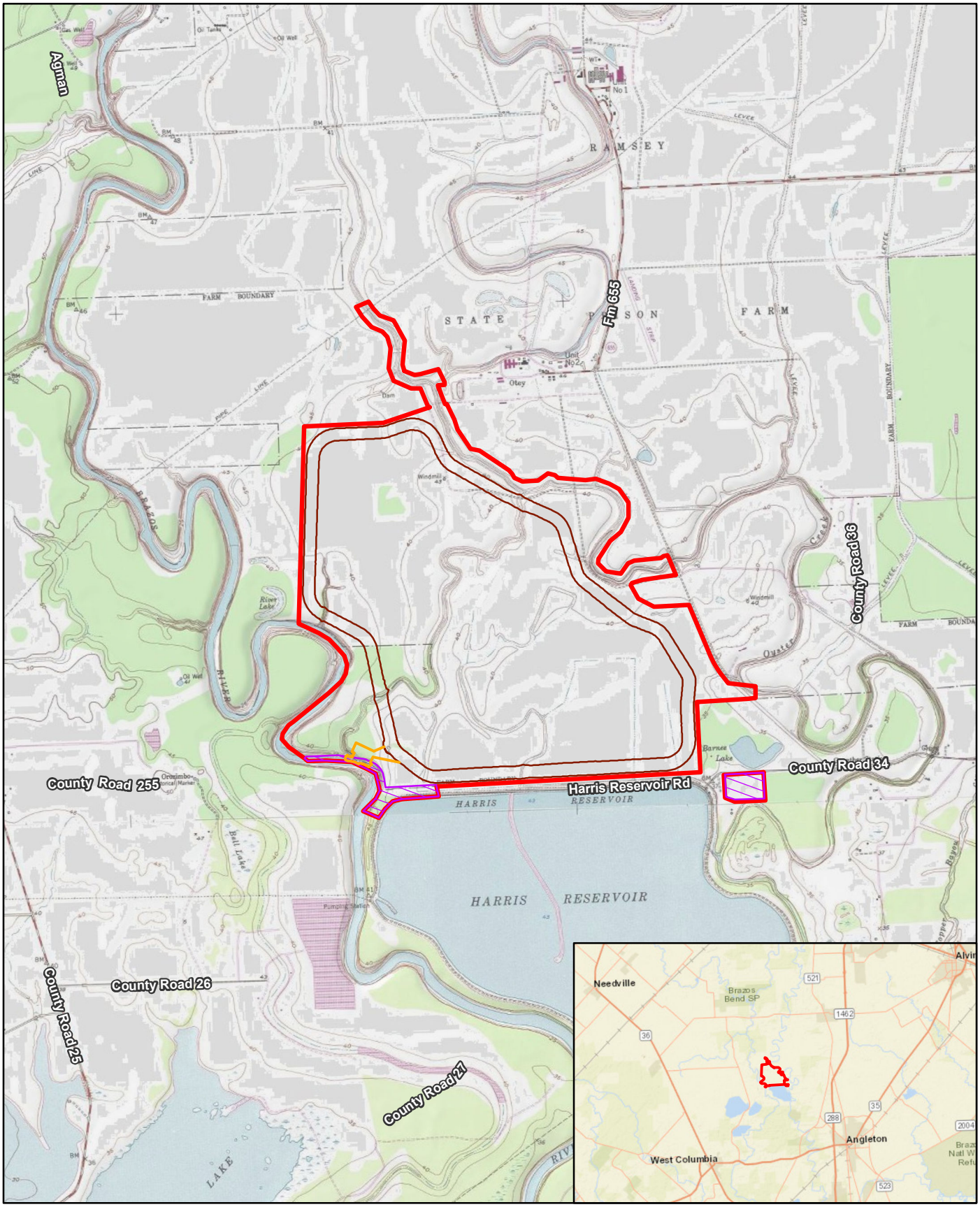
This public notice is being distributed to all known interested persons in order to assist in developing facts upon which a decision by the Corps may be based. For accuracy and completeness of the record, all data in support of or in opposition to the proposed work should be submitted in writing setting forth sufficient detail to furnish a clear understanding of the reasons for support or opposition.

PUBLIC HEARING: The purpose of a public hearing is to solicit additional information to assist in the evaluation of the proposed project. Prior to the close of the comment period, any person may make a written request for a public hearing, setting forth the particular reasons for the request. The District Engineer will determine if the reasons identified for holding a public hearing are sufficient to warrant that a public hearing be held. If a public hearing is warranted, all known interested persons will be notified of the time, date, and location.

CLOSE OF COMMENT PERIOD: All comments pertaining to this public notice must reach this office on or before **30 April 2018**. Extensions of the comment period may be granted for valid reasons provided a written request is received by the limiting date. **If no comments are received by that date, it will be considered that there are no objections**. Comments and requests for additional information should reference our file number, **SWG-2016-01027**, and should be submitted to:

Policy Analysis Branch
Regulatory Division, CESWG-RD-P
U.S. Army Corps of Engineers
P.O. Box 1229
Galveston, Texas 77553-1229
409-766-3869 Phone
409-766-6301 Fax
swg_public_notice@usace.army.mil

DISTRICT ENGINEER
GALVESTON DISTRICT
CORPS OF ENGINEERS



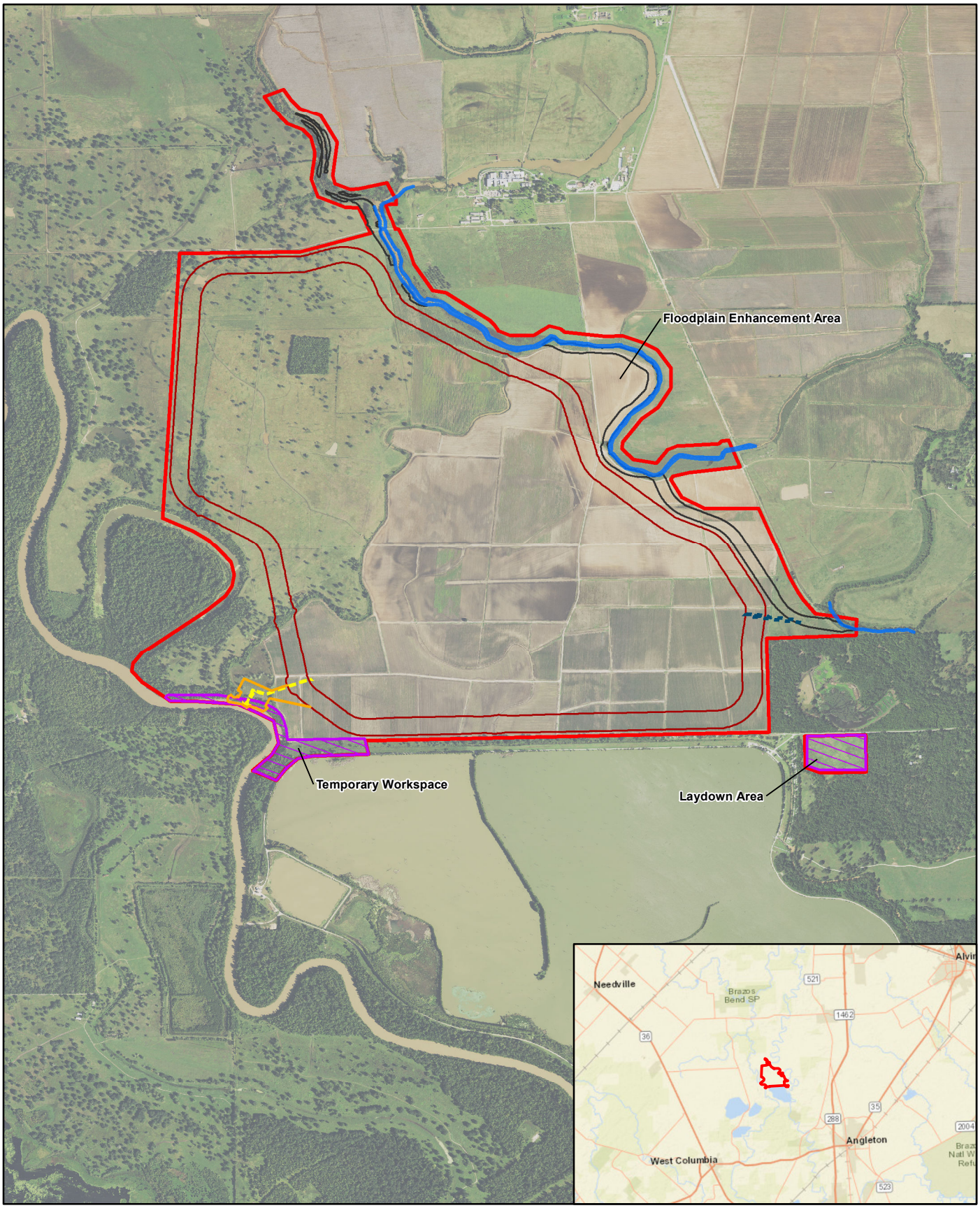
LEGEND

- Temporary Workspace Area
- Project Boundary
- Pump Station
- Embankment Limits

BASE MAP SOURCE
USGS 7.5-minute Topographic Quadrangle
Otey, TX (published, 1981)

0 2,000 4,000
Feet

FIGURE 1
Harrison Expansion Project:
Vicinity Map
The Dow Chemical Company
Brazoria County, Texas



LEGEND

- Embankment Limits
- Pump Station
- Inlet Pipe
- Spillway
- Oyster Creek
- Grading Boundary
- Temporary Workspace Area
- Project Boundary

BASE MAP SOURCE: NAIP Imagery, 2014

N

0 1,500 3,000

Feet

FIGURE 2

Harrison Expansion Project:
Project Components Map
The Dow Chemical Company
Brazoria County, Texas

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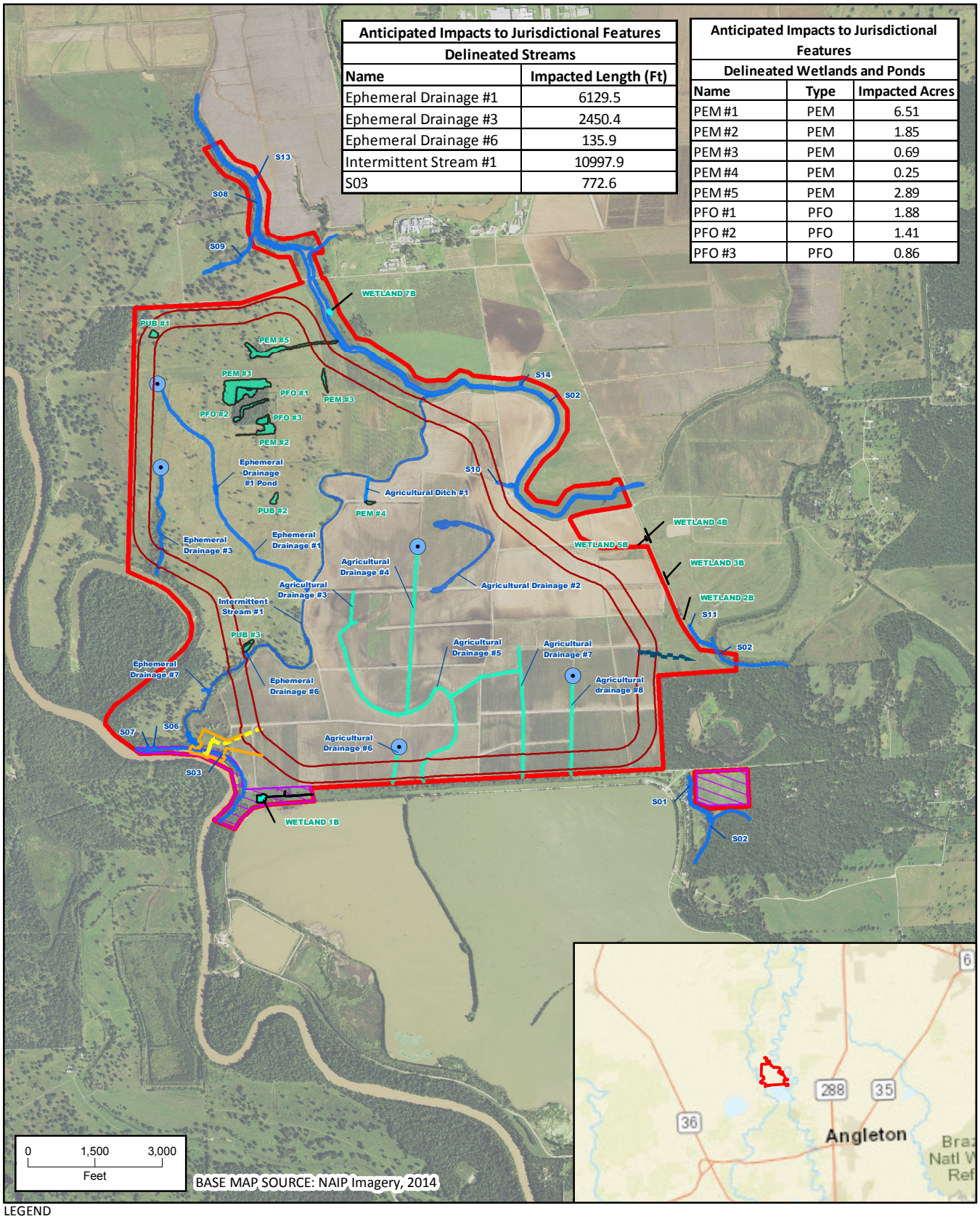

Anticipated Impacts to Jurisdictional Features	
Delineated Streams	
Name	Impacted Length (Ft)
Ephemeral Drainage #1	6129.5
Ephemeral Drainage #3	2450.4
Ephemeral Drainage #6	135.9
Intermittent Stream #1	10997.9
S03	772.6

Anticipated Impacts to Jurisdictional Features		
Delineated Wetlands and Ponds		
Name	Type	Impacted Acres
PEM #1	PEM	6.51
PEM #2	PEM	1.85
PEM #3	PEM	0.69
PEM #4	PEM	0.25
PEM #5	PEM	2.89
PFO #1	PFO	1.88
PFO #2	PFO	1.41
PFO #3	PFO	0.86

LEGEND

- Embankment Limits
- Pump Station
- Inlet Pipe
- Spillway
- Temporary Workspace Area
- Project Boundary

Delineation Data

- Open Ended Point
- Delineated Wetland
- Non-Jurisdictional Agricutlural Drainages
- Delineated Jurisdictional Stream

N

FIGURE 3
Harrison Expansion Project:
Wetlands & Waters of U.S. Impact Figure
The Dow Chemical Company
Brazoria County, Texas

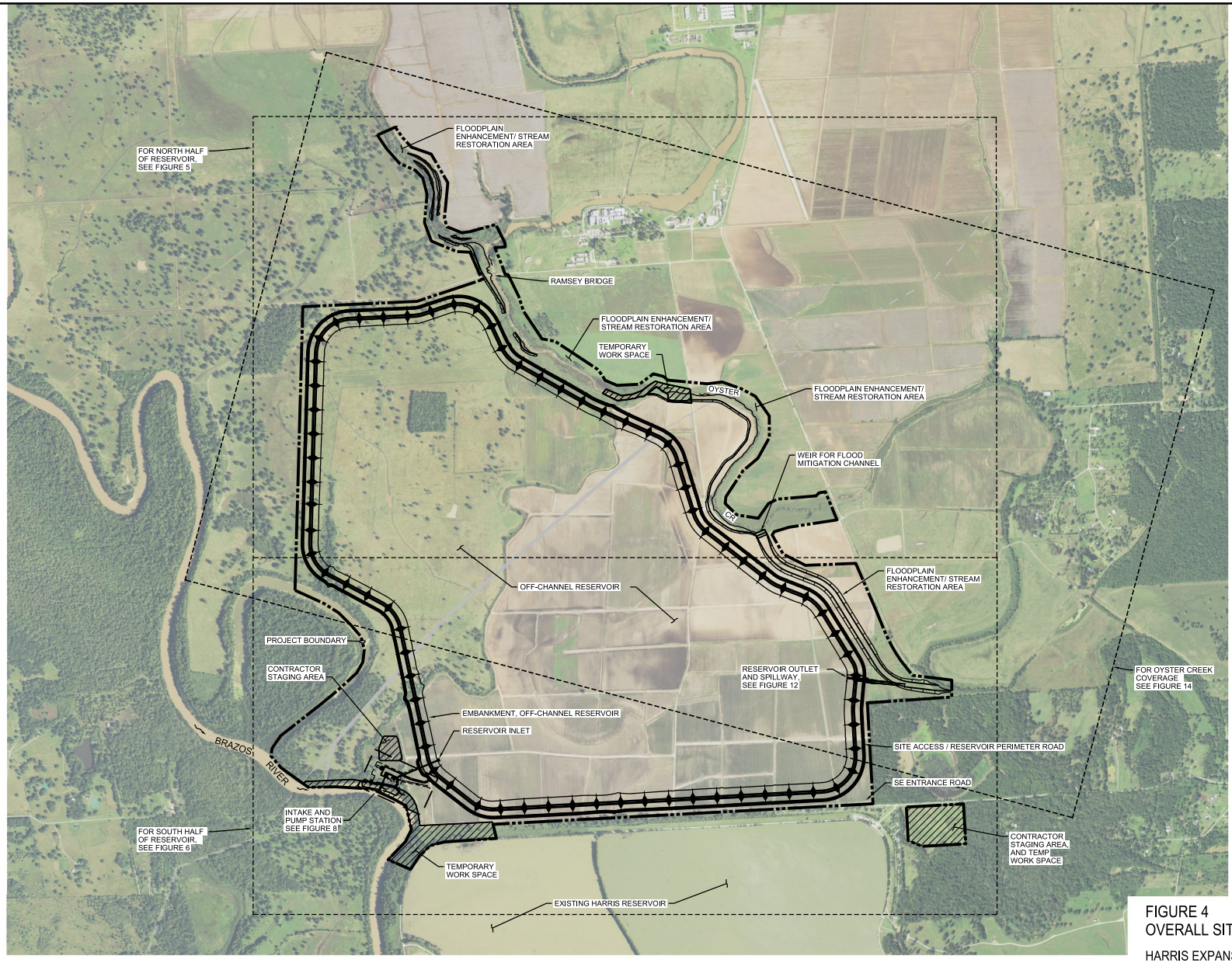

FIGURE 4
OVERALL SITE PLAN AND KEY MAP

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

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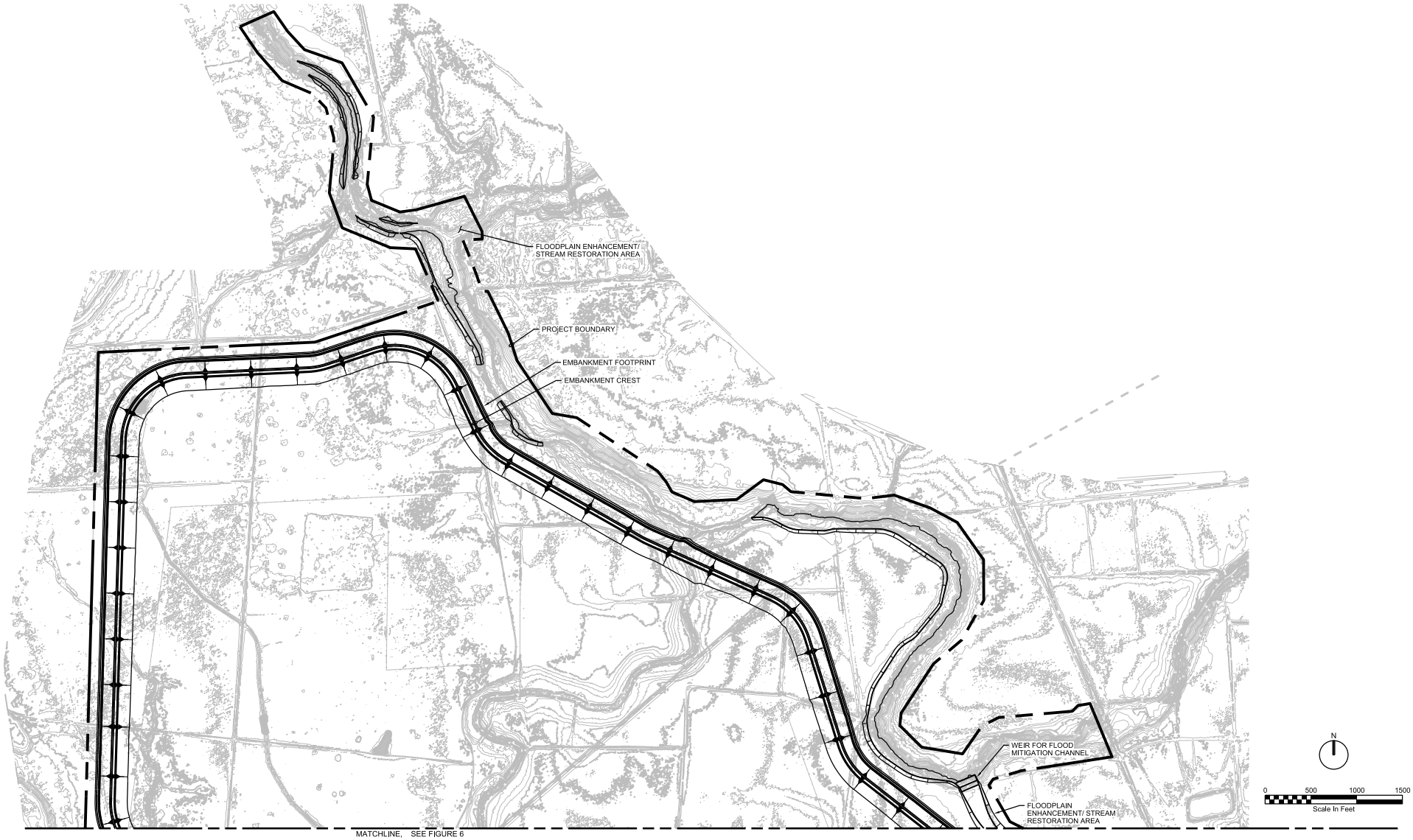

FIGURE 5
PLAN - NORTH HALF OF RESERVOIR

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

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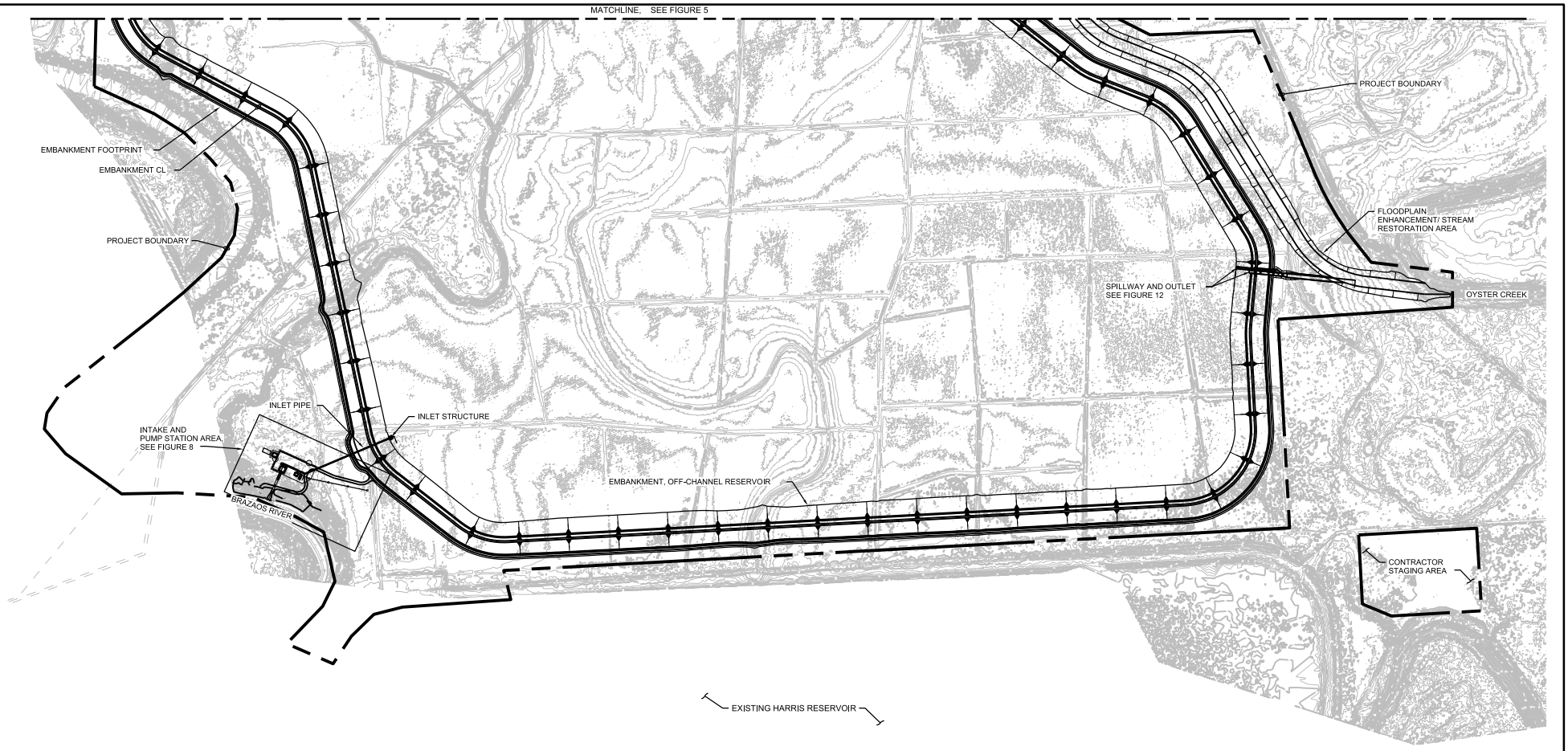

FIGURE 6
PLAN - SOUTH HALF OF RESERVOIR

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

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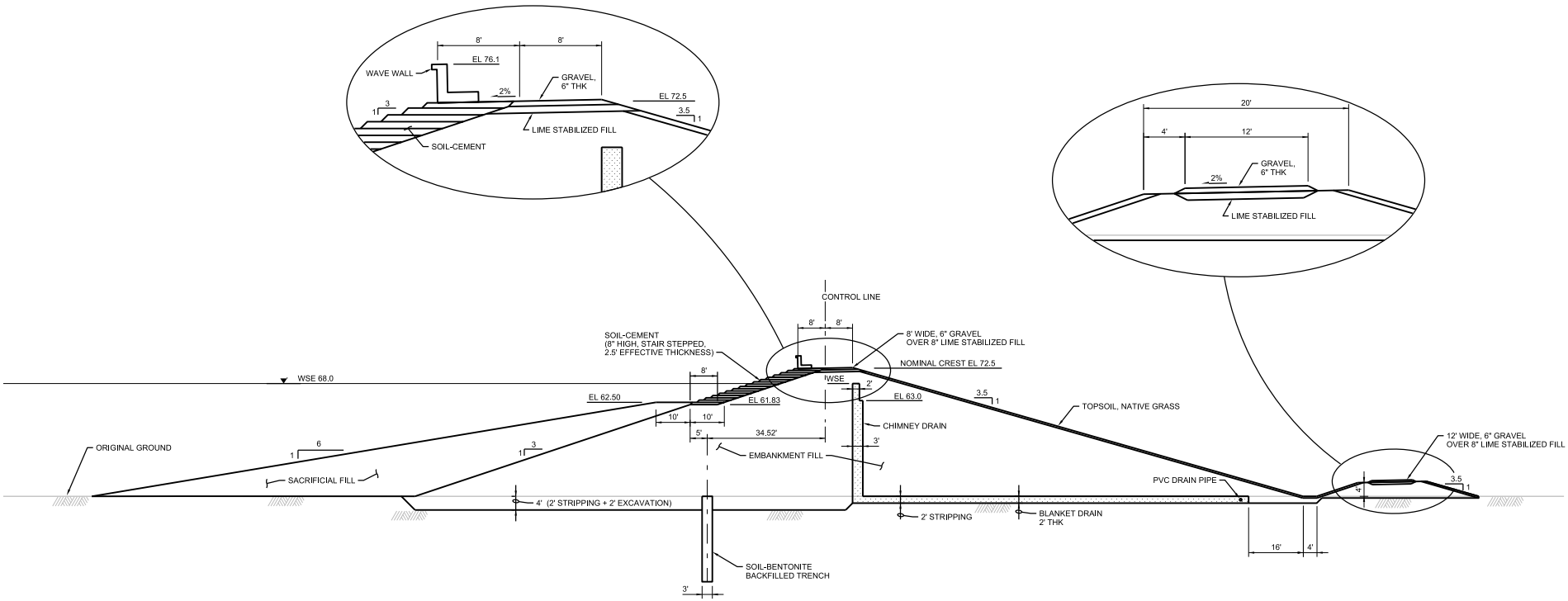

TYPICAL EMBANKMENT SECTION

1"=15'

FIGURE 7
TYPICAL EMBANKMENT SECTION

HARRIS EXPANSION PROJECT
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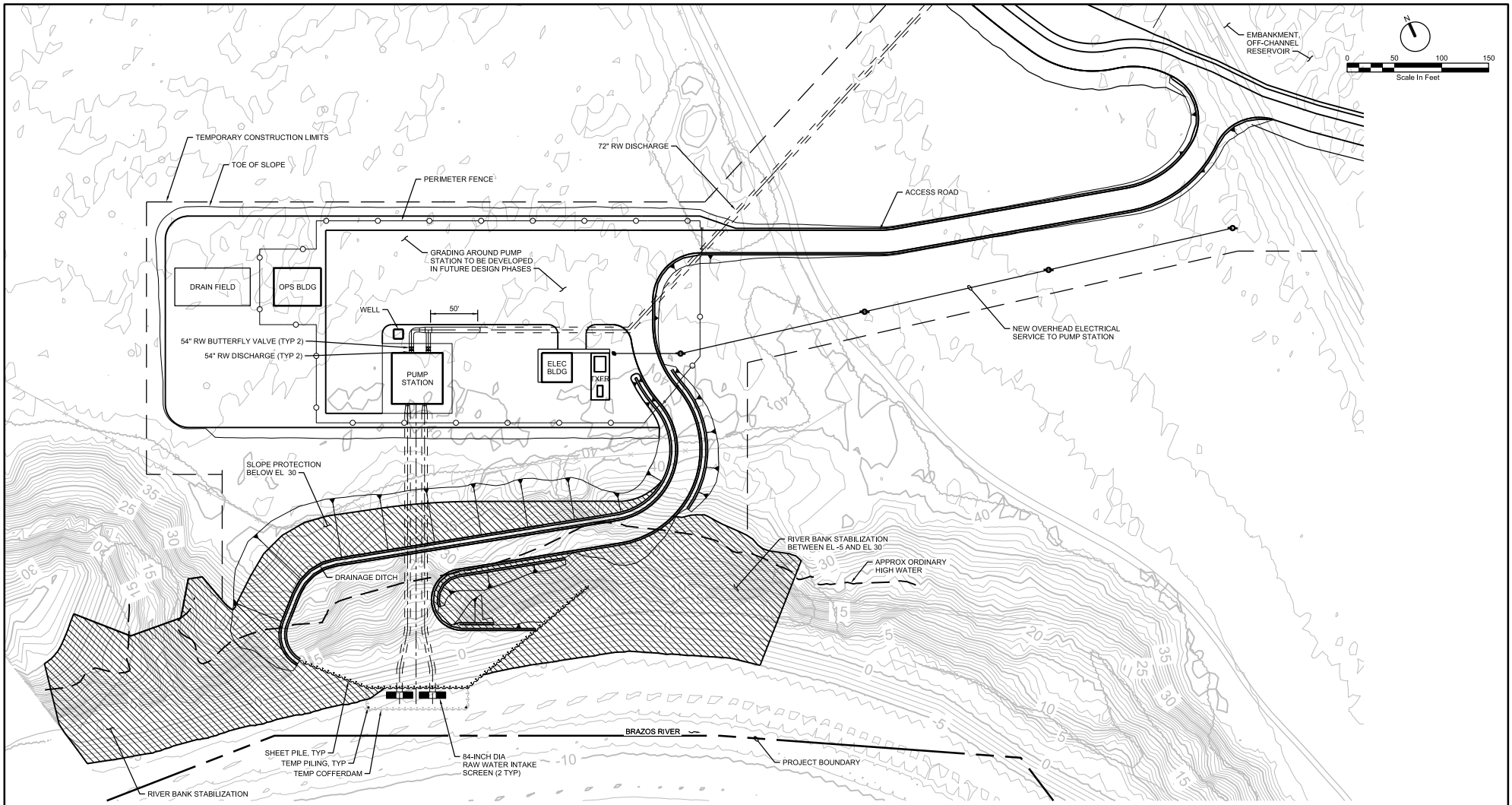

FIGURE 8
INTAKE AND PUMP STATION - SITE PLAN

HARRIS EXPANSION PROJECT
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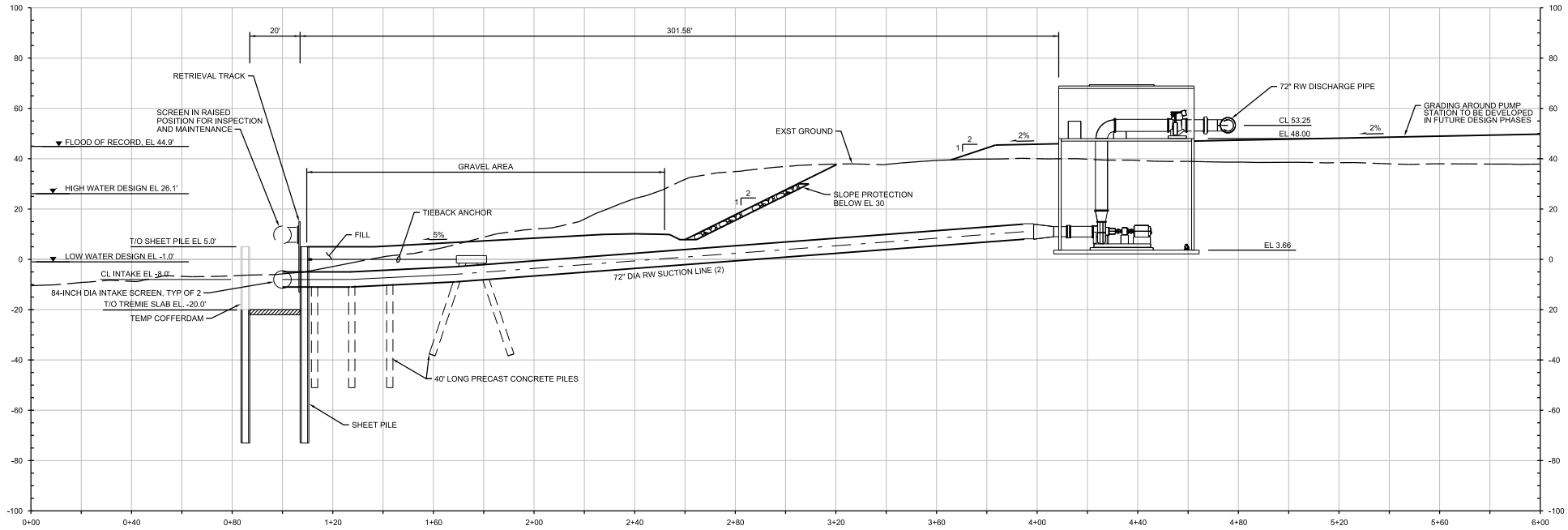

INTAKE SECTION

1"=20'

0 20 40 60

Scale In Feet

FIGURE 9
INTAKE AND PUMP STATION - SECTION

HARRIS EXPANSION PROJECT
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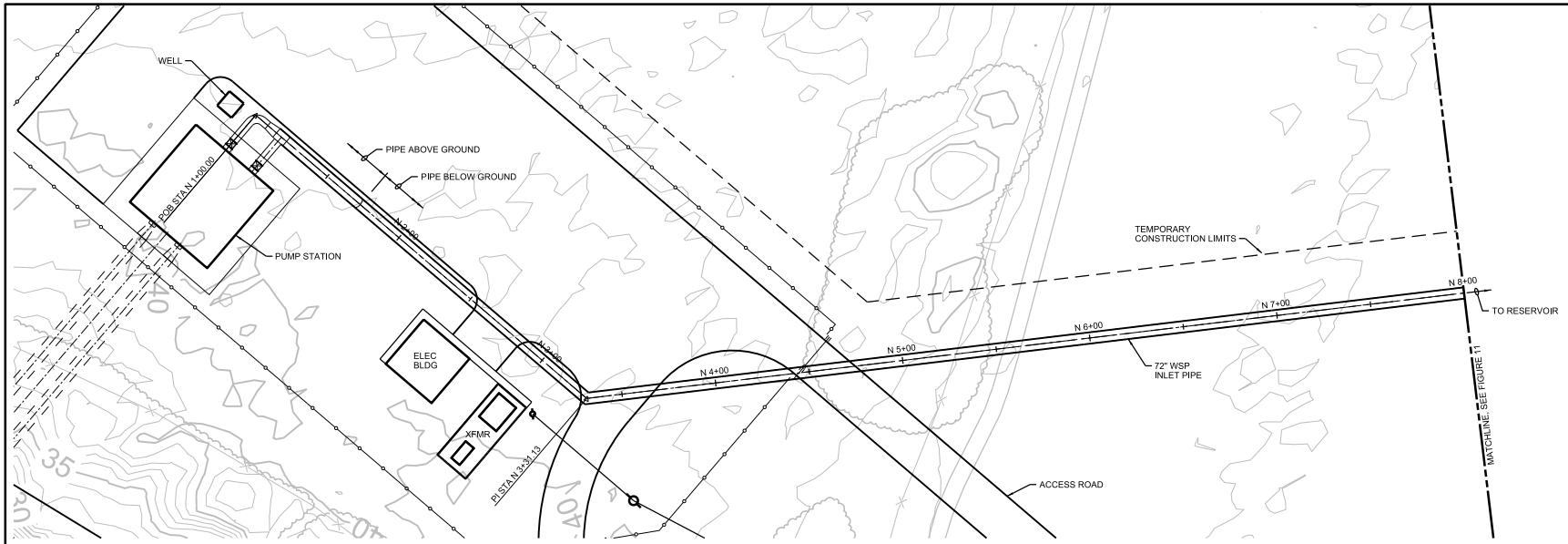
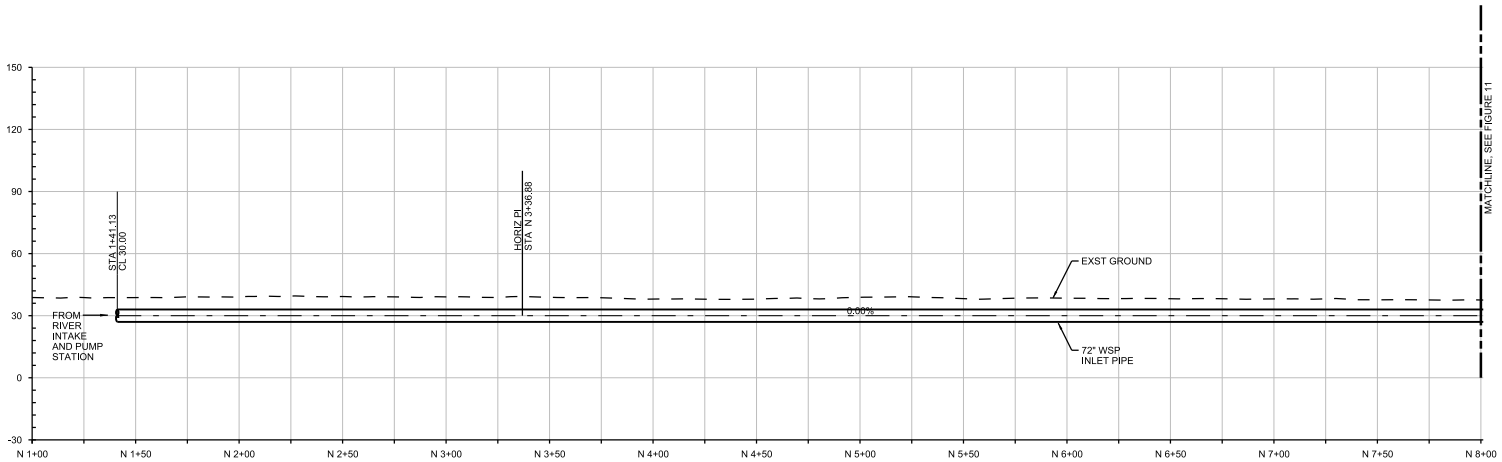


INLET PLAN
1"=30'



INLET PROFILE
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FIGURE 10
RESERVOIR INLET - PLAN AND PROFILE

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

672534

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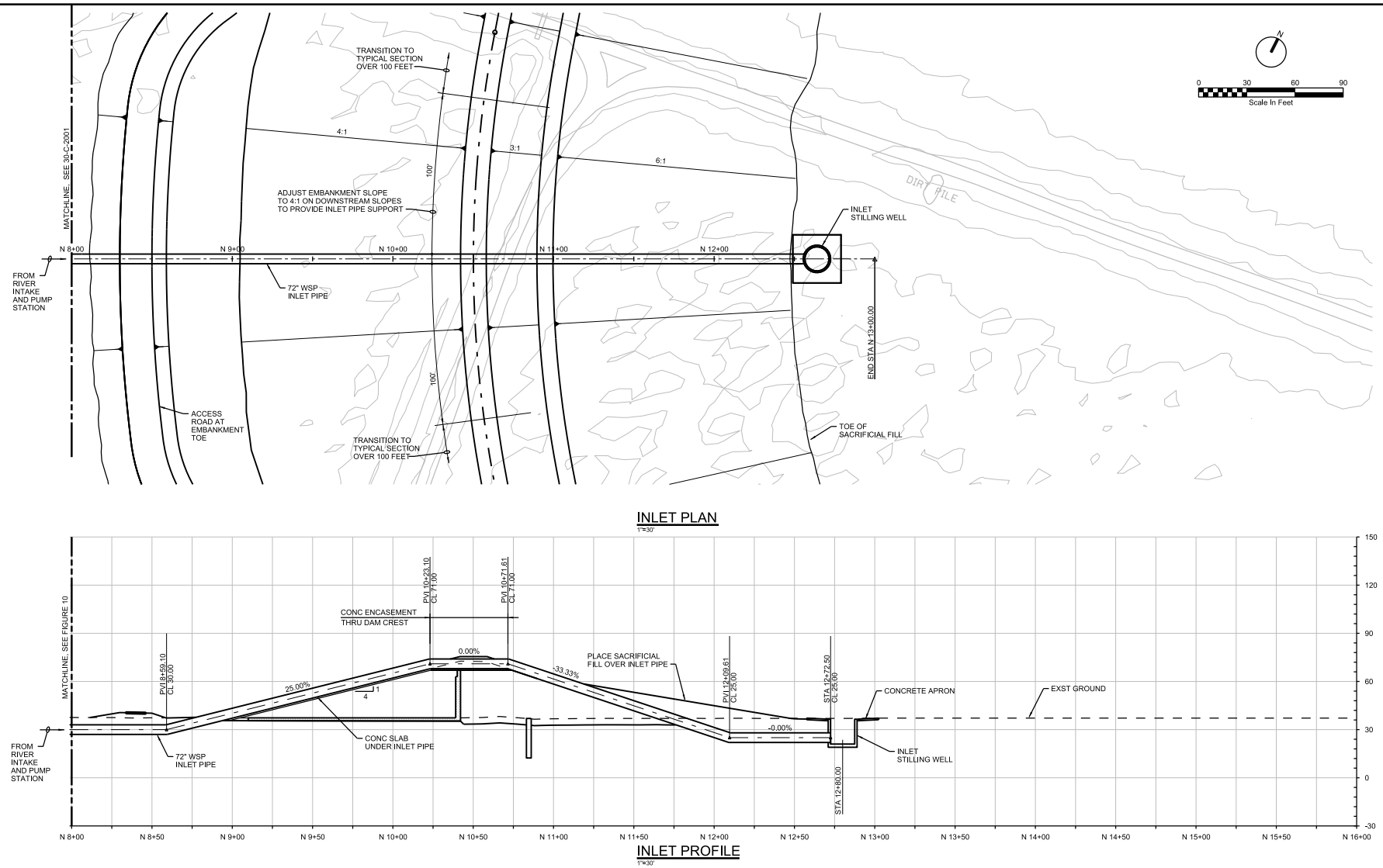

INLET PLAN

1"=30'

INLET PROFILE

1"=30'

FIGURE 11
RESERVOIR INLET AT EMBANKMENT

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

672534

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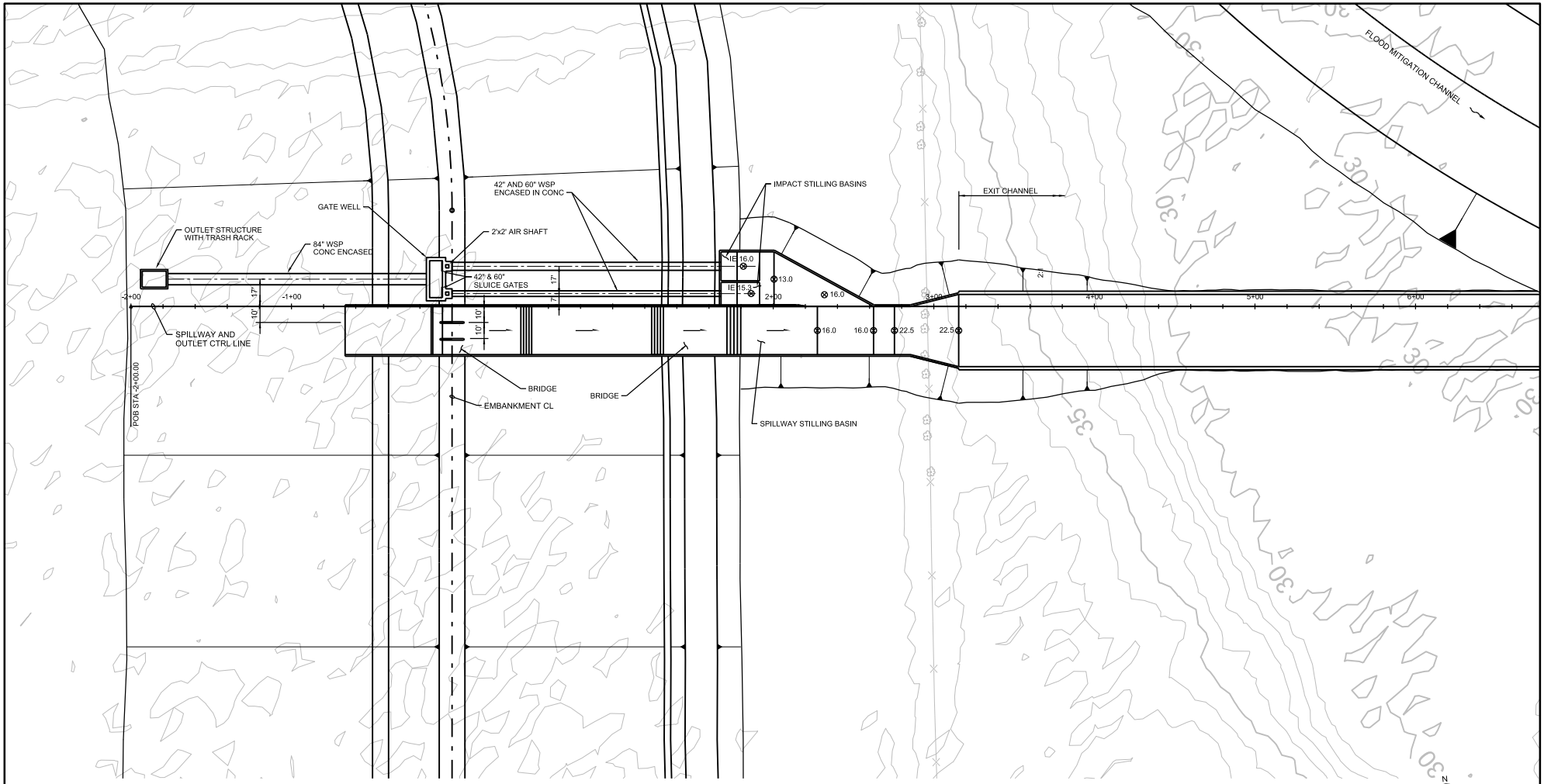

OUTLET AND SPILLWAY PLAN

1"=30'

FIGURE 12
OUTLET AND SPILLWAY - PLAN

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

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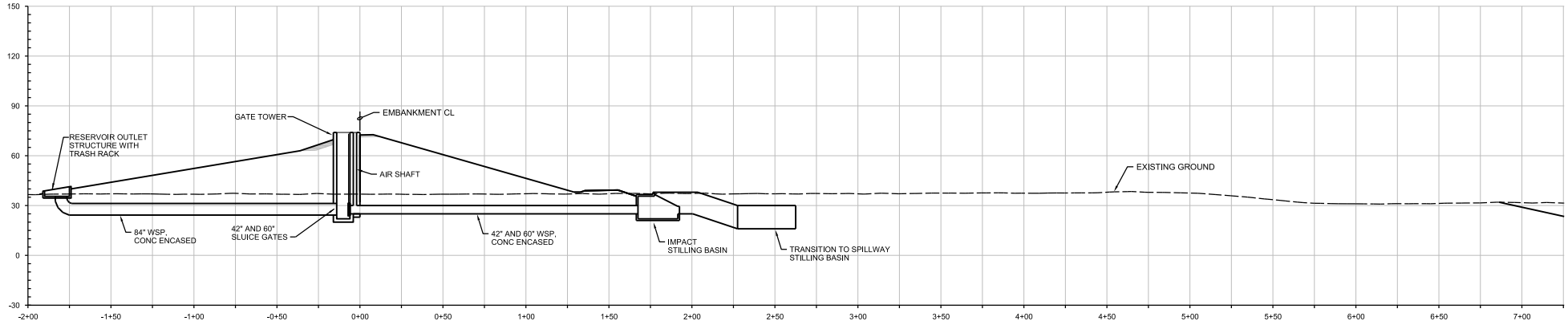
FILENAME: 404-fig12_672534.dgn PLOT DATE: 12/21/2017 PLOT TIME: 1:24:30 PM



PROFILE AT OUTLET
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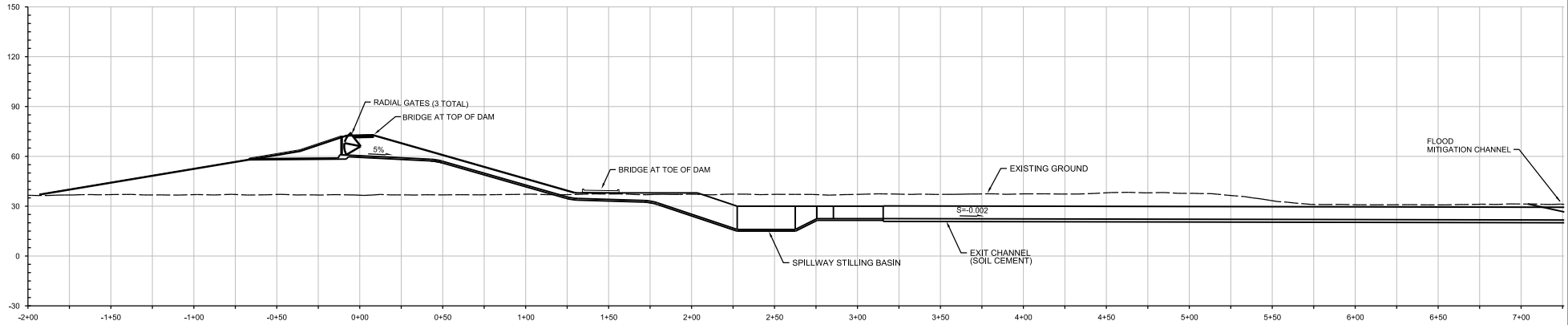

PROFILE AT SPILLWAY
1"=30'

FIGURE 13
OUTLET AND SPILLWAY - PROFILES

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

672534

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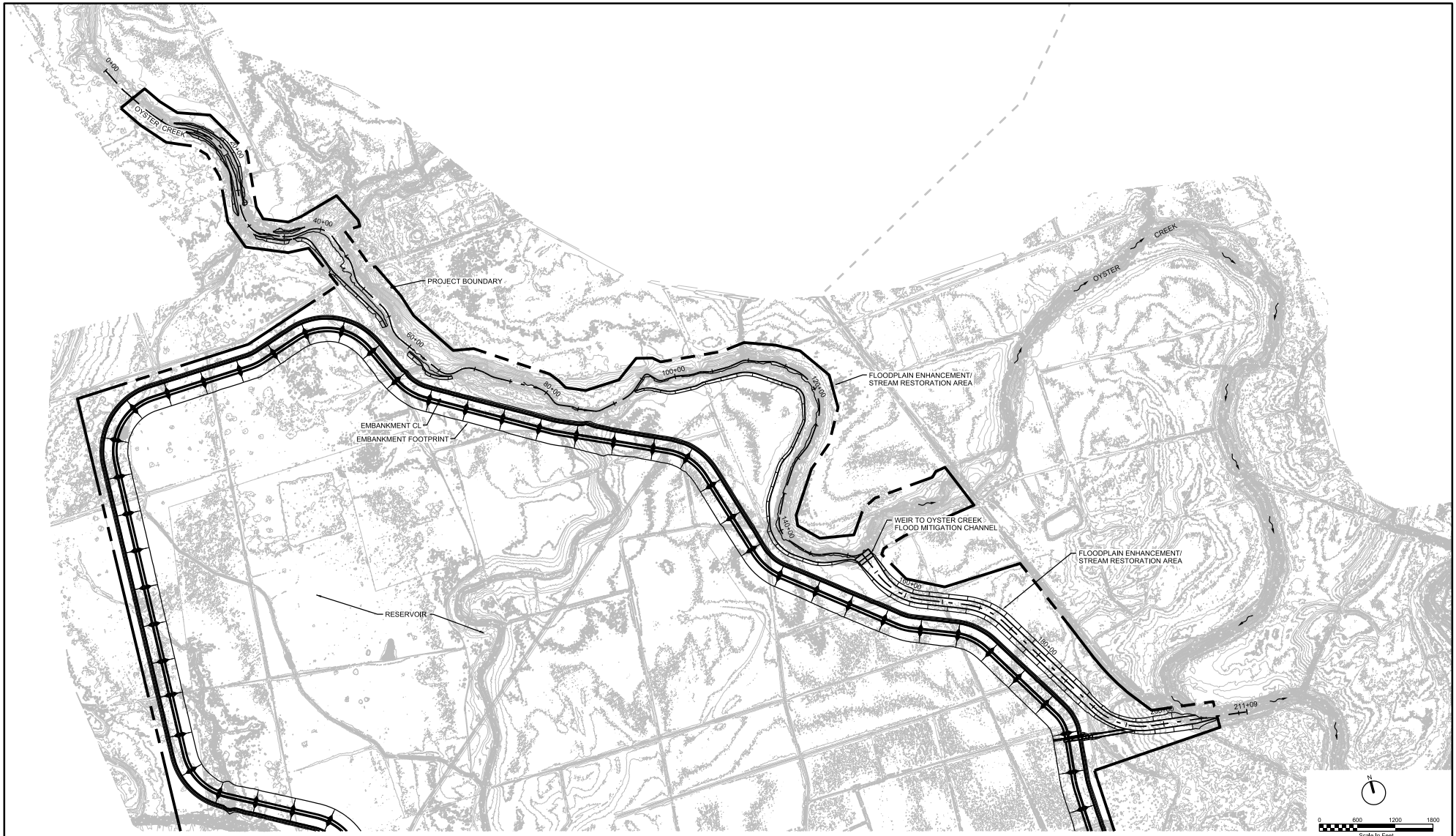

FIGURE 14
OYSTER CREEK - OVERALL PLAN

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

672534

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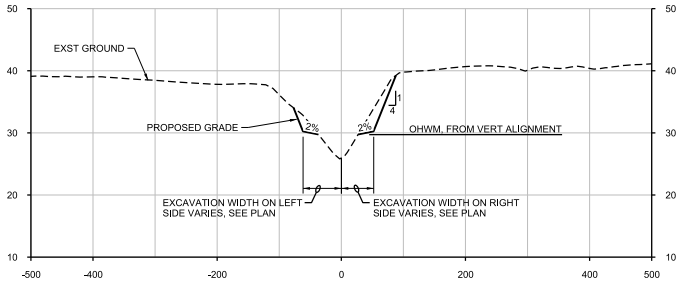

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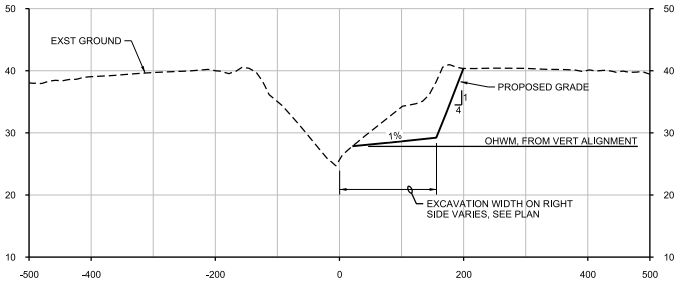

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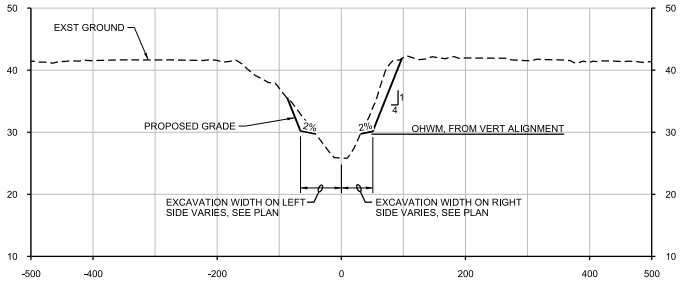

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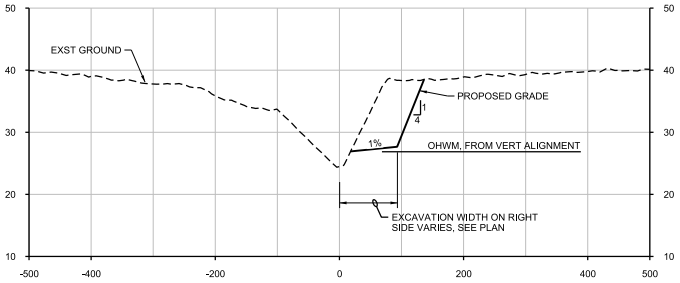

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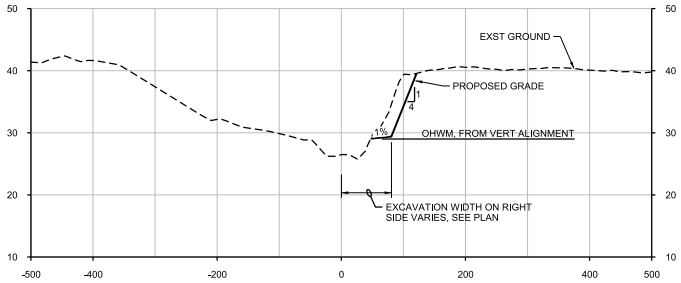

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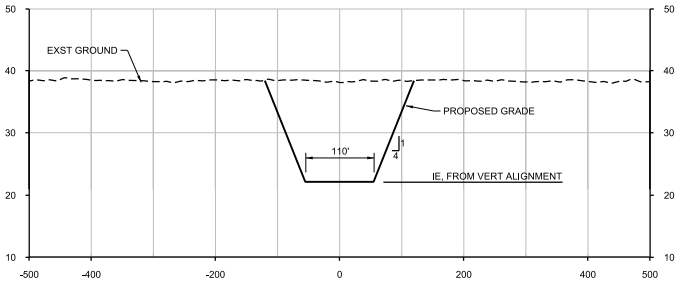

STA 158+00± TO STA 202+50±
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FIGURE 15
OYSTER CREEK - CROSS SECTIONS

HARRIS EXPANSION PROJECT
404 PERMIT APPLICATION

672534

FILENAME: 404-fig15_672534.dgn PLOT DATE: 12/21/2017 PLOT TIME: 1:26:17 PM

Attachment I

Biological Resources

Contents

Tables

Figures

Biological Resources

This material is being provided in support of compliance with the federal Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and Section 68.002 and 68.015 Texas Parks and Wildlife Code. The purpose of this report is to present field data, habitat descriptions, and other pertinent information to document compliance with the regulations referenced above.

1.1 Vegetation and Habitat

This section provides information on water bodies and upland habitats within the project area. This section also confirms that the project area lies outside the Coastal Management Zone.

1.1.1 Wetlands and other Waters of the U.S., Riparian Area, and Aquatic Habitats

See Attachments B and C for detailed discussion of these resources.

1.1.2 Coastal Zone

The project area is not within a coastal zone management area (Texas General Land Office 2016).

1.1.3 Upland Habitats

Generally, Texas is divided into 10 natural regions or ecoregions: the Piney Woods, the Gulf Prairies and Marshes, the Post Oak Savanah, the Blackland Prairies, the Cross Timbers, the South Texas Plains, the Edwards Plateau, the Rolling Plains, the High Plains, and the Trans-Pecos. The project is located within the Gulf Prairies and Marshes, which includes barrier islands along the coast, salt grass marshes surrounding bays and estuaries, remnant tallgrass prairies, oak parklands and oak mottes scattered along the coast, and tall woodlands in the river bottomlands. Native vegetation consists of tallgrass prairies and live oak woodlands. Brush species such as mesquites (*Prosopis* spp.) and acacias (*Senegalia* spp. and *Vachellia* spp.) are more common now than in the past. Although much of the native habitat has been lost to agriculture and urbanization, the region still provides important habitat for migratory birds and spawning areas for fish and shrimp (TPWD 2016g).

Specifically, the proposed project is located within the Western Gulf Coastal Plain-Floodplains and Low Terraces ecoregion. The principal distinguishing characteristics of the region are its relatively flat topography and mainly grassland potential natural vegetation. Inland from this region the plains are older, more irregular, and have mostly forest or savanna-type vegetation potentials. Largely because of these characteristics, a higher percentage of the land is in cropland than in bordering ecological regions. Rice, grain sorghum, cotton, and soybeans are the principal crops. Urban and industrial land uses have expanded greatly in recent decades, and oil and gas production is common. Bottomland forests of pecan (*Carya illinoinensis*), water oak (*Quercus nigra*), southern live oak (*Quercus virginiana*), and elm (*Ulmus* spp.), are typical, with some bald cypress (*Taxodium distichum*) on larger streams. The Brazos River floodplains are a broad expanse of alluvial sediments. Soils include vertisols, mollisols, and entisols. Large portions of floodplain forest have been removed and land cover is now a mix of forest, cropland, and pasture (Griffith et.al. 2004).

Within the project area the eastern two-thirds of the property were converted to farmland and were used historically for corn and cotton production. The western third of the project area was historically maintained as grazed pastureland for the production of cattle. Typically, grazed areas within this

ecoregion may be invaded by exotic or native weedy grasses that will dominate the site. Bermudagrass (*Cynodon dactylon*), King Ranch bluestem (*Bothriochloa ishaemum*), Gordo bluestem (*Dichanthium aristatum*), Kleberg bluestem (*Dichanthium annulatum*), smutgrass (*Sporobolus indicus*), Johnsongrass (*Sorghum halepense*), and others are primary invaders. Some native grasses and shrubs remain, including are Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), Eastern gammagrass (*Tripsacum dactyloides*) and Florida paspalum (*Paspalum floridanum*). Cool-season species are present in lesser amounts in the more open savannah type areas and are more abundant in areas with greater canopies.

The major cool-season grass species present included Canada (*Elymus canadensis*) and Virginia (*Elymus virginicus*) wildrye, Texas wintergrass (*Nassella leucotricha*) and sedges (*Carex* spp.). Very narrow corridors of wooded areas remain along surface waters throughout the property. Due to the erosion, there is limited vegetation on the river banks in the project area. Some early growth of black willow (*Salix nigra*) and cottonwood (*Populus deltoides*) occurs along portions of the river bank (HDR 2014).

1.1.4 Columbia Bottomlands

The Columbia Bottomlands is an ecologically-rich, 700,000-acre region that is a mix of native grasslands, hardwood forests, and coastal wetlands. The area covers most of Fort Bend and Brazoria counties and portions of Matagorda and Wharton counties (Nature Conservancy 2017).

Approximately half of the project site is mapped as Columbia Bottomlands by the Ecological Mapping System of Texas (EMST) (TPWD 2017). The majority of the area mapped as Columbian Bottomlands consists of grasslands. Smaller areas of deciduous shrubland, evergreen shrubland, hardwood forest and woodland, and live oak forest and woodland are mapped within the project site. The area mapped by the Ecological Mapping System of Texas as Columbia Bottomlands within the project site is shown on Figure I-1.

The majority of the area within in the project site corresponds with the Columbia Bottomlands habitat types as described in TPWD's EMST. Although not mapped as Columbia Bottomlands Herbaceous Wetlands by the EMST, the PEM wetlands identified within the project site support species described under the Columbia Bottomlands Herbaceous Wetlands habitat type. The PFO wetlands identified within the project site support many species described under the Columbia Bottomlands Hardwood Forest and Woodlands habitat type.

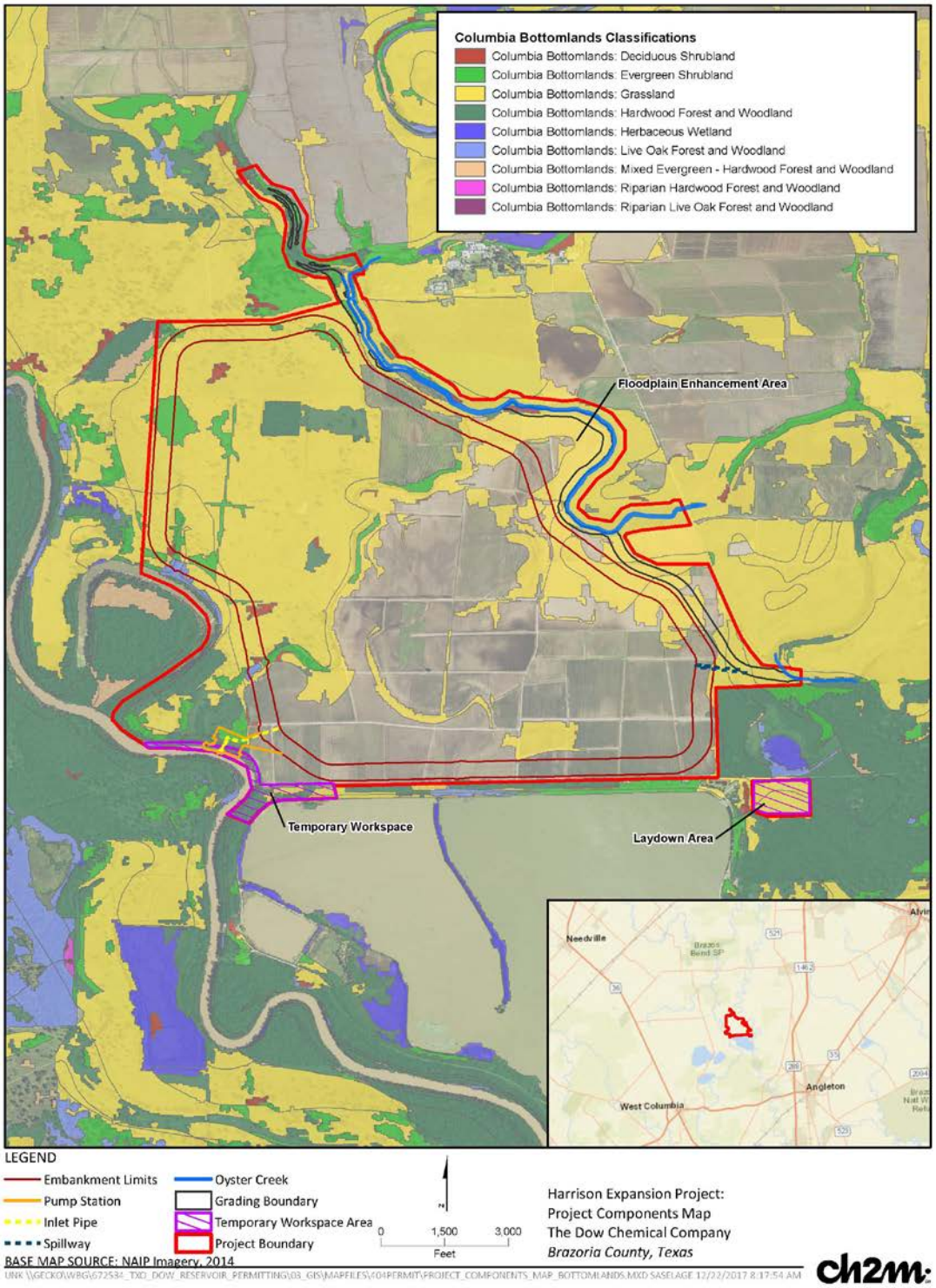

Figure I-1. Ecological Mapping Systems of Texas
Harris Expansion Project Individual Permit Application

1.2 Wildlife and Fisheries

This section describes wildlife and fisheries in the area including recreationally and economically important species, avian species, fisheries, freshwater mussel and other wildlife.

The proposed project is located within the Western Gulf Coastal Plain (Level III) and Floodplains and Low Terraces (Level IV) ecoregion (Griffith et al. 2004). Many of the most common fauna occurring in the Floodplains and Low Terraces ecoregion are opportunistic and are capable of survival in a variety of habitats.

The diversity of the project site with respect to vegetation, soils, and available water resources provides habitat for a large number of native wildlife species such as those described in the following sections. Scrub shrub uplands, forested uplands, forested wetlands, emergent wetlands, ephemeral and intermittent streams, and a series of man-made drainage ditches are present on the site.

1.2.1 Recreationally and Economically Important Species

No recreational public hunting grounds have been identified in the project area. Nearby counties allow public and private hunting of dove, quail, waterfowl, wild turkey, and white-tailed deer. All these species that are hunted in nearby counties for recreation may occur in the project area. Non-consumptive recreation, such as wildlife viewing and birdwatching, are not known to occur in the project area. Because the land is private and is used for agriculture and grazing, it is not considered a high quality recreation, viewing, or birding area. The only commercially valuable species identified in the project area is domestic cattle, which graze in parts of the project area.

No public recreational fishing grounds have been identified in the project area. However, the project area is bordered by three waterbodies used for recreational fishing: Brazos River, Harris Reservoir (limited access), and Oyster Creek. Recreationally important game fish species known to occur within these waterbodies include: blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), and white crappie (*Pomoxis annularis*) (Linam and Kleinsasser 1987). Threatened or endangered species are described in Section 1-3.

1.2.2 Resident and Migratory Birds

Avian species that may occur in the project site include year-round residents and many migratory species. The project site is located within the Central Flyway, a migration route that generally follows the Great Plains states. The scrub shrub and forested habitats of the project site provide shelter, food, and nesting protection for a variety of upland birds. Bird species that can occur in these habitats include a wide assortment of song birds, hawks, owls, and game birds. These birds rely on the areas with dense vegetation for cover and the abundant food source of fruits and insects common to these habitats.

The project site is located on the Brazos River floodplain, where wetland habitats and aquatic resources are common. Aquatic habitats, such as bottomland hardwood forests, emergent wetlands, intermittent, and ephemeral ditches are present throughout the site. Ducks and migratory birds use wetlands for resting areas on migration routes and for nesting. However, portions of the project area have had agricultural activities for a number of years which would result in resident and migratory birds avoiding these areas.

1.2.3 Fisheries

Game and non-game fish species in Texas are regulated and protected by the USFWS and the TPWD in accordance with the *U.S. Fish and Wildlife Conservation Act of 1980* (16 USC 2901-2911) and the *U.S. Fish and Wildlife Coordination Act of 1958*.

As discussed in Section 3.7, several ephemeral streams, intermittent streams, man-made ponds, and a series of man-made drainage ditches were identified within the proposed project site. The project site is also bordered by the Brazos River to the southwest, Harris Reservoir to the south, and Oyster Creek to the northeast. A representative list of common game and non-game fish species known to occur in the surrounding waterbodies and that likely occur in the project site is presented in Table I-1.

Table I-I. Fish Species Potentially Occurring in the Project Site
Harris Expansion Project Individual Permit Application

Common Name	Scientific Name
Blackstripe topminnow	*Fundulus notatus*
Blacktail shiner	*Cyprinella venusta*
Blue catfish	*Ictalurus furcatus*
Bluegill sunfish	*Lepomis macrochirus*
Bullhead minnow	*Pimephales vigilax*
Channel catfish	*Ictalurus punctatus*
Gizzard shad	*Dorosoma cepedianum*
Golden shiner	*Notemigonus crysoleucas*
Golden topminnow	*Fundulus chrysotus*
Goldfish	*Carassius auratus*
Green sunfish	*Lepomis cyanellus*
Largemouth bass	*Micropterus salmoides*
Longear sunfish	*Lepomis megalotis*
Mosquitofish	*Gambusia affinis*
Orangespotted sunfish	*Lepomis humilis*
Pirate perch	*Aphredoderus sayanus*
Pugnose minnow	*Opsopoeodus emiliae*
Red shiner	*Cyprinella lutrensis*
Sailfin molly	*Poecilia latipinna*
Silverband shiner	*Notropis shumardi*
Slough darter	*Etheostoma gracile*
Smallmouth buffalo	*Ictiobus bubalus*
Spotted gar	*Lepisosteus oculatus*
Tadpole madtom	*Noturus gyrinus*
Threadfin shad	*Dorosoma petenense*
Tidewater silverside	*Menidia peninsulae*
White crappie	*Pomoxis annularis*
Yellow bullhead	*Ameiurus natalis*

Source: Linam and Kleinsasser 1987; NatureServe Explorer 2016

1.2.4 Freshwater Mussels

There are approximately 300 freshwater mussel species recognized in the United States. Of these, 53 species are native to Texas. Fifteen species of mussels maintain a state status of threatened in Texas; of which one is a candidate for federal protection, and 11 others are currently petitioned for listing under the U.S. Endangered Species Act (ESA) (Winemiller et al. 2010). The smooth pimpleback

(*Quadrula houstonensis*) and Texas fawnsfoot (*Truncilla macrodon*), both state listed threatened species, are restricted to the Colorado and Brazos River drainages.

The smooth pimpleback typically occurs in mud, sand, or gravel substrates in small to moderate-sized rivers with slow to moderate flows. Surveys conducted from 1980 to 2006 have noted steep declines in the number of extant populations of smooth pimpleback in both river systems (TPWD 2009). In the Brazos River drainage, scattered groups or individuals have been found alive in the Brazos from the Waco area to the mouth of the Navasota River and in the Little Brazos River, Leon River, and other tributaries (Howells 2002). The nearest known location of smooth pimpleback is approximately 85 miles upstream of the project site.

Little is known about habitat requirements for the Texas fawnsfoot. It probably prefers sand, gravel, and perhaps sandy-mud bottoms in moderate flow rivers and streams (NatureServe Explorer 2016). A recently discovered population in the Brazos River between Possum Kingdom and the mouth of the Navasota River represents the only known surviving population (TPWD 2009). The nearest known location of Texas fawnsfoot is located more than 85 miles upstream of the project site.

A 2012 mussel survey conducted approximately 3,970 feet downstream of the project site found no evidence of live mussel, shell, or shell fragments. Substrate appeared to be the primary limiting factor affecting the presence of mussels within this section of the river. The shallow shoreline areas were virtually devoid of fine substrates, but instead were composed of very dense, hard-packed clay, which may be unsuitable for mussel colonization (HDR 2012).

1.2.5 Mammals

Mammal species in the project area are those associated with Forest/Cropland/Pasture mosaics (Griffith et al. 2004). A representative list of common mammals known to occur in the Floodplains and Terraces ecoregion and that likely occur in the project site is presented in Table I-2.

Table I-2. Mammal Species Potentially Occurring in the Project Site
Harris Expansion Project Individual Permit Application

Common Name	Scientific Name
Baird's pocket gopher	*Geomys breviceps*
Bobcat	*Lynx rufus*
Common raccoon	*Procyon lotor*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Eastern cottontail	*Sylvilagus floridanus*
Eastern fox squirrel	*Sciurus niger*
Eastern gray squirrel	*Sciurus carolinensis*
Eastern harvest mouse	*Reithrodontomys humulis*
Eastern mole	*Scalopus aquaticus*
Eastern red bat	*Lasiurus borealis*
Eastern spotted skunk	*Spilogale putorius*
Evening bat	*Nycticeius humeralis*
Fulvous harvest mouse	*Reithrodontomys fulvescens*
Hispid cotton rat	*Sigmodon hispidus*
Least shrew	*Cryptotis parva*
Nine-banded armadillo	*Dasypus novemcinctus*
Red fox	*Vulpes*

Table I-2. Mammal Species Potentially Occurring in the Project Site
Harris Expansion Project Individual Permit Application

Common Name	Scientific Name
Striped skunk	*Mephitis*
Virginia opossum	*Didelphis virginiana*
White-footed mouse	*Peromyscus leucopus*
White-tailed deer	*Odocoileus virginianus*

Source: NatureServe Explorer 2016; USFWS 2016a

1.2.6 Amphibians and Reptiles

Amphibian and reptile species occupying the project area are typically limited by their specific habitat requirements. Many species use different habitat types at different times of the year or at different life stages. Specific habitat needs for reptiles and amphibians vary widely by species and their life stage. The habitat types found throughout the project area provide suitable habitat for various amphibian and reptile species. Common amphibian and reptile species that are likely to occur within the project site are summarized in Table I-3.

Table I-3. Amphibian and Reptile Species Potentially Occurring in the Project Site
Harris Expansion Project Individual Permit Application

Common Name	Scientific Name
Amphibians	
Blanchard's cricket frog	*Acris crepitans blanchardi*
Bullfrog	*Lithobates catesbeianus*
Bronze frog	*Lithobates clamitans*
Central newt	*Notophthalmus viridescens louisianensis*
Cope's gray tree frog	*Hyla chrysoscelis*
Dwarf American toad	*Anaxyrus americanus charlesmithi*
Eastern gray tree frog	*Hyla versicolor*
Eastern narrow-mouth toad	*Gastrophryne carolinensis*
Great plains narrow-mouthed toad	*Gastrophryne olivacea*
Green tree frog	*Hyla cinerea*
Gulf coast toad	*Incilius valliceps*
Hurter's spadefoot	*Scaphiopus hurterii*
Marbled salamander	*Ambystoma opacum*
Northern spring peeper	*Pseudacris crucifer*
Small-mouthed salamander	*Ambystoma texanum*
Southern crawfish frog	*Lithobates areolatus*
Southern leopard frog	*Lithobates sphenocephala*
Spotted chorus frog	*Pseudacris clarkii*
Squirrel tree frog	*Hyla squirella*
Strecker's chorus frog	*Pseudacris streckeri*
Upland chorus frog	*Pseudacris feriarum*
Reptiles	
Bloctched water snake	*Nerodia erythrogaster transversa*
Broad-banded water snake	*Nerodia fasciata confluens*

Table I-3. Amphibian and Reptile Species Potentially Occurring in the Project Site
Harris Expansion Project Individual Permit Application

Common Name	Scientific Name
Broad-headed skink	*Plestiodon laticeps*
Canebrake rattlesnake	*Cratalus horridus*
Checkered garter snake	*Thamnophis marcianus*
Common musk turtle	*Sternotherus odoratus*
Common snapping turtle	*Chelydra serpentina*
Diamondback water snake	*Nerodia rhombifer*
Eastern garter snake	*Thamnophis sirtalis*
Eastern hognose snake	*Heterodon platirhinos*
Eastern yellow-bellied racer	*Coluber constrictor flaviventris*
Glossy crayfish snake	*Regina rigida*
Graham's crayfish snake	*Regina grahamii*
Green anole	*Anolis carolinensis*
Ground skink	*Scincella lateralis*
Gulf coast ribbon snake	*Thamnophis proximus orarius*
Mississippi map turtle	*Graptemys pseudogeographica kohnii*
Mississippi mud turtle	*Kinosternon subrubrum hippocrepis*
Prairie kingsnake	*Lampropeltis calligaster*
Red-eared slider	*Trachemys scripta elegans*
Rough earth snake	*Virginia striatula*
Rough green snake	*Opheodrys aestivus*
Southern copperhead	*Agkistrodon contortrix*
Speckled kingsnake	*Lampropeltis holbrooki*
Texas coral snake	*Micrurus tener*
Texas rat snake	*Pantherophis obsoletus lindheimeri*
Texas river cooter	*Pseudomys texana*
Western coachwhip	*Coluber flagellum testaceus*
Western cottonmouth	*Agkistrodon piscivorus leucostoma*
Western slender glass lizard	*Ophisaurus attenuatus*
Yellow mud turtle	*Kinosternon flavescens*

Source: NatureServe Explorer 2016; USFWS 2016b

1.3 Threatened and Endangered Species

Any federal action, including permits, requires compliance with the federal ESA. Protection of critical habitat for federal listed endangered and threatened species is a regulatory requirement under the ESA. Critical habitat is defined within Section (3) (5) (A) of the ESA as:

> *"areas within a listed species' current (at time of listing) range that contain the physical or biological features that are essential to that species' conservation or that for some reason require special management; and areas outside the species' current range that the secretary determines to be essential to its conservation."*

Additionally, Texas statute and TPWD regulations prohibit the taking, possession, transportation, or sale of any of the animal species designated by state law as endangered or threatened without the issuance of a permit.

1.3.1 Federal

The U.S. Fish and Wildlife Service (USFWS) endangered species list includes nine federally-listed species: piping plover (*Charadrius melodus* – threatened), red knot (*Calidris canutus rufa* – threatened), whooping crane (*Grus americana* – endangered), West Indian manatee (*Trichechus manatus* – endangered), green sea turtle (*Chelonian mydas* – threatened), hawksbill sea turtle (*Eretmochelys imbricata* – endangered), leatherback sea turtle (*Dermochelys coriacea* – Endangered), Kemp's Ridley sea turtle (*Lepidochelys kempii* – Endangered), and loggerhead sea turtle (*Caretta caretta* – threatened); and two Candidate species: smooth pimpleback (*Quadrula houstonensis*) and Texas fawnsfoot (*Truncilla macrodon*), with the potential to occur in the project area. Table I-4 identifies and provides additional detail on these species.

Table I-4. Federally Listed Species Having Potential to Occur Within or in the Vicinity of the Project Area
Harris Expansion Project Individual Permit Application

Species (Latin Name)	Federal Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Birds				
Whooping Crane (*Grus americana)*	Endangered	A bi-annual migrant, traveling between its summer habitat in central Canada, and its wintering grounds on the Texas coast. Whooping cranes occupy winter areas for almost half a year. Prefer sites with minimal human disturbance. Whooping cranes primarily use shallow, seasonally, and semi-permanently flooded palustrine wetlands for roosting, and various cropland and emergent wetlands. Wintering habitat in the Aransas National Wildlife Refuge, Texas, includes salt marshes and tidal flats on the mainland and barrier islands.	Whooping cranes migrate through the Great Plains in April to mid-May and mid-September to October, occupying their wintering grounds along the Texas coast for more than half the year.	Moderate
Piping Plover (*Charadrius melodus)*	Threatened	In Texas, piping plovers inhabit barren sand and gravel shores of rivers and gulf beaches. In addition, they use barren river sandbars. Plovers avoid dense vegetation. Beaches used by piping plovers generally are 10 to 40 yards wide.	Texas is the wintering home for 35 percent of the known population of piping plovers. They begin arriving in late July or early August, and will remain for up to 9 months.	Low

Table I-4. Federally Listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Individual Permit Application

Species (Latin Name)	Federal Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Red Knot (*Calidris canutus rufa*)	Threatened	The Red Knot prefers the shoreline of coasts and bays and also uses inland mudflats. Primarily utilized seacoasts on tidal flats and beaches, herbaceous wetland, and Tidal flat/shore. Primary prey items include coquina clam (*Donax spp*.) on beaches and dwarf surf clam (*Mulinia lateralis*) in bays, at least in the Laguna Madre.	Wintering Range includes: Aransas, Brazoria, Calhoun, Cameron, Chambers, Galveston, Jefferson, Kennedy, Kleberg, Matagorda, Nueces, San Patricio, and Willacy counties.	Low
Mollusks				
Smooth Pimpleback *(Quadrula houstonensis)*	Candidate	Utilizes mud, sand, and gravel substrates in as little as 3 to 4 centimeters of water, but appears susceptible to dramatic water level fluctuations, scoured bedrock, and shifting sand substrates. Able to tolerate very slow to moderate stream flow velocities (NatureServe 2016).	The smooth pimpleback is endemic to central Texas and historically occurred throughout the Colorado and Brazos River basins, but is now found only in nine distinct locations, mostly in the Brazos River basin (Federal Register 2012).	Low
Texas Fawnsfoot *(Truncilla macrodon)*	Candidate	Rivers and large streams with sand, gravel, and perhaps sandy-mud bottoms with moderate flows. No specimens have been documented in reservoirs. As with other freshwater mussel species, the Texas fawnsfoot would be susceptible to dramatic water level fluctuations, scoured bedrock, shifting sand substrates, and dewatering (NatureServe 2016).	The Texas fawnsfoot is endemic to central Texas and historically occurred in the Trinity, Brazos, and Colorado River basins. More recently, the fawnsfoot have only been found in five locations, and only the three populations in the Brazos River basin appear to be sustainable (Federal Register 2012).	Low
Mammals				

Table I-4. Federally Listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Individual Permit Application

Species (Latin Name)	Federal Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
West Indian Manatee (*Trichechus manatus*)	Endangered	Occupies marine, brackish, and fresh water systems where they feed on submerged, emergent, and floating vegetation, preferring shallow sea grass beds with access to deep channels. Often use canals, creeks, and lagoons associated with coastal rivers and sloughs in which to feed, rest, mate, and calving. Critical habitat was designated in Florida in 1976 (USFWS 2001).	Historic distribution is thought to be very similar to the manatee's current distribution concentrating in the warm waters of Florida, with some seasonal migration west to Texas. Seasonal movements are dependent on water temperatures and seasonal availability of plant species (USFWS 2001). Individuals seen along the Texas Gulf Coast may be wanders from populations along the Mexican Gulf Coast (NatureServe 2016).	Low
Reptiles				
Green Sea Turtle (*Chelonia mydas*)	Threatened	A global species in tropical and subtropical seas with water temperatures above 20 degrees Celsius. Feed in shallow sea grass and algae beds. Known to rest on shallow rocky bottoms and coral reefs, sometimes out of the water (NMFS and USFWS 1998a).	Nest in tropical beach habitats around the world and adult females return to their natal beach to lay eggs. There are no green sea turtle nesting beaches in Texas, but individuals are seen along the Texas coast during migration (TPWD 2012a).	Low
Hawksbill Sea Turtle (*Eretmochelys imbricata*)	Endangered	Occurs throughout the world in tropical and subtropical regions, spending the majority of their lifecycle in the ocean, only coming to shore to lay eggs. Generally, juvenile and adult hawksbill are benthic in their feeding nature, consuming a variety of sponges and invertebrates.	Occur in the Gulf of Mexico and juveniles and hatchlings have been recorded along the Texas coast, believed to have originated from Mexican nesting beaches. No nesting beaches are known along the Texas coast (USFWS 2016c).	Low

Table I-4. Federally Listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Individual Permit Application

Species (Latin Name)	Federal Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	Endangered	Lay eggs on coastal beaches, hatchlings leave the coast for deeper water and grow before returning to near shore habitats as juveniles and adults. Adults primarily occur in the Gulf of Mexico, and utilize shallow near-shore and inshore bay habitats. Are primarily carnivorous, feeding on a variety of crustaceans, including various crab species (NMFS, USFWS, and SEMARNAT 2011).	Kemp's ridley sea turtles have a much more restricted distribution than other sea turtles, nesting primarily in Mexico, Texas, and a few other states in the United States (NMFS, USFWS, and SEMARNAT 2011).	Low
Leatherback Sea Turtle (*Dermochelys coriacea*)	Endangered	Unlike other sea turtle species, the leatherback sea turtle is a pelagic species, foraging on jellyfish, squid, fish, and crustaceans. They are highly migratory and only use the deep waters of the Gulf of Mexico for foraging, rarely coming close to shore following schools of prey.	Occurs throughout the world's oceans. Designated critical habitat has been established in the U.S. Virgin Islands (Federal Register 1979). There are no known nesting beaches in the continental United States. The majority of known nest beaches are located in the eastern Pacific, western Pacific, and Indian Ocean (NMFS and USFWS 1998b).	Low
Loggerhead Sea Turtle (*Caretta caretta*)	Threatened	Terrestrial habitats of coastal beaches are utilized for egg laying and incubation. Near shore habitat is utilized by juveniles and adults for feeding. Open ocean habitat is used for migration. Loggerheads occasionally nest on beaches in estuarine zones with coarse sandy beaches between the high tide line and the dunes (NMFS and USFWS 2008)	In Texas, loggerhead sea turtles do inhabit the Gulf of Mexico, occasionally are documented along the Texas coast, and only minor solitary nesting activity has been recorded along the Gulf coast.	Low

1.3.1.1 State

TPWD's county lists includes several species that are federally listed under the ESA but are not considered by the USFWS as potentially occurring in Brazoria County. A brief description, including status, habitat requirement, and range, of the federal and state listed species that TPWD indicates have the potential to occur in Brazoria County are provided in Table I-5. Figure I-2 presents known occurrences of federal- and state-listed species and native plant communities within 10 miles of the project site.

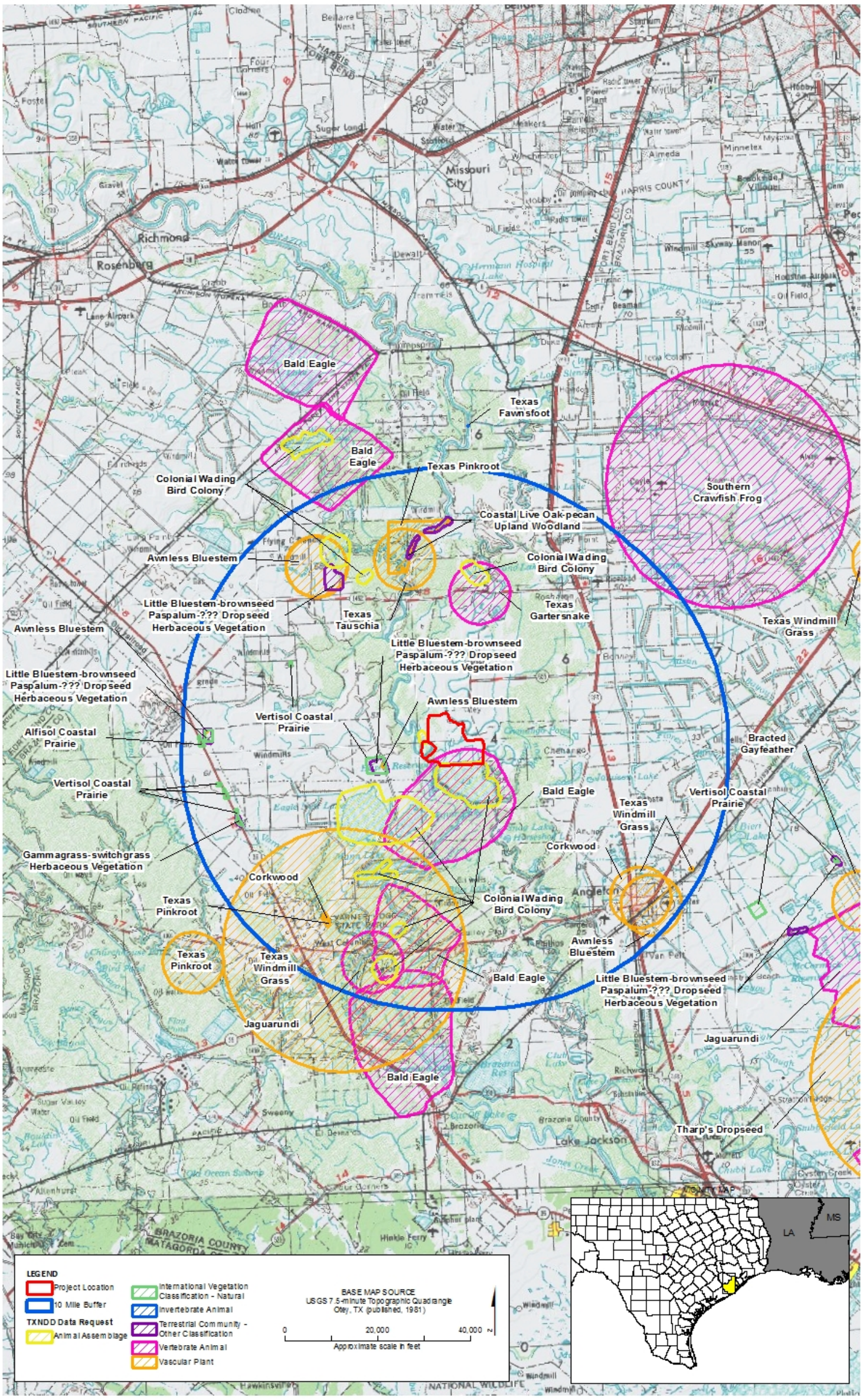

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Figure I-2. Texas Natural Diversity Database Results within 10 Miles of the Project Area
Harris Expansion Project Individual Permit Application

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
BIRDS				
American Peregrine Falcon *(Falco peregrinus anatum)*	Threatened	Year-round resident and local breeder in west Texas, nests in tall cliff eyries. Occupies wide range of habitats during migration, including urban, concentrations along coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands.	Migrant across state from more northern breeding areas in United States and Canada, winters along coast and farther south.	Low
Bald Eagle (*Haliaeetus leucochephalus*)	Threatened	Occurs primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds.	Present year-round throughout Texas as spring and fall migrants, breeders, or winter residents. The population in Texas is divided into two populations: breeding birds and nonbreeding or wintering birds. Breeding populations occur primarily in the eastern half of the state and along coastal counties from Rockport to Houston. Nonbreeding or wintering populations are located primarily in the Panhandle, Central, and East Texas, and in other areas of suitable habitat throughout the state (TPWD 2016b).	High
Eskimo Curlew (*Neumenius borealis*)	Endangered	Is a tundra nesting species that migrates through the prairies of the U.S., and is thought to winter in the Pampas lowlands, in South America (USFWS 2011).	The Eskimo curlew is so rare the last record of physical evidence was collected in 1963 in Barbados (USFWS 2011). Since that time, 39 potential sightings have occurred, but these reports were not able to be confirmed by physical evidence. Surveys of breeding territories, migration routes, and wintering grounds over the last few decades have not detected the species (USFWS 2011).	Low

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Peregrine Falcon (*Falco peregrinus anatum*)	Threatened	Occupies wide range of habitats during migration, including shores, coastlines, and barrier islands as well as urban areas.	Migrates across the state from more northern breeding areas in US and Canada to winter along coast and farther south. Resident breeder in west Texas. Another sub species, *F.p. tundrius*, is no longer listed in Texas.	Low
Piping Plover (*Charadrius melodus*)	Threatened	Beaches and bayside mud or salt flats.	Wintering migrant along the Texas Gulf Coast.	Low
Reddish Egret (*Egretta rufescens*)	Threatened	Utilizes brackish marshes and shallow salt ponds and tidal flats; nests on ground or in trees or bushes, on dry coastal islands in brushy thickets of yucca and prickly pear.	Occurs along the Gulf Coast of Texas and some parts of Louisiana and southern Florida. It is rare along the Gulf Coast of Mexico, West Indies and Baja California (TPWD 2016c).	Low
Sooty Tern (*Sterna fuscata*)	Threatened	Predominately "on the wing"; does not dive, but snatches small fish and squid with bill as it flies or hovers over water; breeding April through July. Breed along the coast on small islands. These terns prefer to nest in small colonies above flood tides, in flat, sparsely vegetated, and fairly open areas (Texas A&M AgriLife Extension 2016a).	Breeding sites for sooty terns along the central and south sections of the Texas coast in the Coastal Prairies, Coastal Sand Plain, and South Texas Brush Country regions (Texas A&M AgriLife Extension 2016a).	Low
White-faced Ibis (*Plegadis chihi*)	Threatened	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.	It nests in isolated colonies from Oregon to Kansas, but its center of greatest abundance seems to be in Utah, Texas, and Louisiana. In Texas, they breed and winter along the Gulf Coast and may occur as migrants in the Panhandle and West Texas (TPWD 2016d).	Low
White-tailed Hawk (*Buteo albicaudatus*)	Threatened	Near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral.	Breeding locations in Texas typically occur within Coastal Sand Plain, Coastal Prairies, and South Texas Brush Country regions (Texas A&M AgriLife Extension 2016b).	Low

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Whooping Crane (*Grus americana*)	Endangered	A bi-annual migrant, traveling between its summer habitat in central Canada, and its wintering grounds on the Texas coast. Whooping cranes occupy winter areas for almost half a year. Prefer sites with minimal human disturbance. Whooping cranes primarily use shallow, seasonally, and semi-permanently flooded palustrine wetlands for roosting, and various cropland and emergent wetlands. Wintering habitat in the Aransas National Wildlife Refuge, Texas, includes salt marshes and tidal flats on the mainland and barrier islands.	Whooping cranes migrate through the Great Plains in April to mid-May and mid-September to October, occupying their wintering grounds along the Texas coast for more than half the year. Whooping cranes have been observed at Brazoria National Wildlife Refuge as recent as November 2015 (USFWS 2013).	Moderate
Wood Stork (*Mycteria americana*)	Threatened	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e., active heronries).	Breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960. Wood storks are federally listed AL, FL, GA, MS, NC, and SC.	Moderate
Fishes				

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Smalltooth Sawfish (*Pristis pectinata*)	Endangered	Young occur very close to shore in muddy and sandy bottoms, seldom descending to depths greater than 32 feet (10 meter); in sheltered bays, on shallow banks, and in estuaries or river mouths. Adult sawfish occur in various habitat types (mangrove, reef, seagrass, and coral), in varying salinity regimes and temperatures, and at various water depths; feed on a variety of fish species and crustaceans.	Gulf of Mexico, Caribbean, western Atlantic, Pacific and Indian Oceans, with a core distribution in the United States in the coastal lagoons, reefs, mangroves, and bays of south Florida. Many individuals documented from Texas to the Atlantic coast of the United States are believed to originate from this breeding population (Federal Register 2001). In decades prior to 1970, the sawfish were considered "not uncommon" along the Texas coast, but since 1971 only three published or museum reported captured smalltooth sawfish have been documented from this region (Federal Register 2001).	Low
Mammals				
Jaguarundi (*Herpailurus yagouaroundi*)	Endangered	Jaguarundi occur in dense, thorny shrublands.	South Texas brush country and lower Rio Grande valley. Jaguarundis also occur in northern Mexico and central and south America (TPWD 2016e).	Low
Louisiana Black Bear (*Ursus americanus luteolus*)	Threatened	Typically inhabits bottomland hardwood forest habitat. Additional habitat types occasionally used include brackish and freshwater marshes, levees along canals and bayous, and agricultural fields.	Current breeding populations are concentrated in northeast and south central Louisiana within the Tensas and Atchafalaya River basins, which were designated Critical Habitat in 2009 (Federal Register 2009)	Low

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Ocelot (*Leopardus pardalis*)	Endangered	Utilizes areas with a dense shrub layer (95% cover) in a variety of forested and savanna habitats. In Texas, ocelots prefer shrub communities with greater than 95% shrub cover, and avoid areas with less than 75% shrub cover (USFWS, 2010).	Restricted to extreme southern Texas and southern Arizona. Two breeding populations are thought to exist in southern Texas, one located in Kennedy, and Willacy Counties and the second in Cameron County on the Laguna Atascosa National Wildlife Refuge (USFWS 2010). No additional breeding populations are thought to exist.	Low
Red Wolf (*Canis rufus*)	Endangered	Extirpated; formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies.	Historically ranged throughout the southeastern U.S., from the Atlantic coast to central Texas, and from the Gulf Coast to central Missouri and southern Illinois. Were extirpated from most of the eastern portion of their range. A small number persisted in the wild in southeastern Texas and southwestern Louisiana until the late 1970s; however, by 1980, the species was declared extinct in the wild (NatureServe 2016).	Low
West Indian Manatee (*Trichechus manatus*)	Endangered	Occupies marine, brackish, and fresh water systems where they feed on submerged, emergent, and floating vegetation, preferring shallow sea grass beds with access to deep channels. Often use canals, creeks, and lagoons associated with coastal rivers and sloughs in which to feed, rest, mate, and calving. Critical habitat was designated in Florida in 1976 (USFWS 2001).	Historic distribution is thought to be very similar to the manatee's current distribution concentrating in the warm waters of Florida, with some seasonal migration west to Texas. Seasonal movements are dependent on water temperatures and seasonal availability of plant species (USFWS 2001). Individuals seen along the Texas Gulf Coast may be wanders from populations along the Mexican Gulf Coast (NatureServe 2016).	Low
Mollusks				

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Smooth Pimpleback (*Quadrula houstonensis*)	Threatened	Utilize mud, sand, and gravel substrates in as little as 3 to 4 centimeters of water, but appears susceptible to dramatic water level fluctuations, scoured bedrock, and shifting sand substrates. Able to tolerate very slow to moderate stream flow velocities (NatureServe 2016).	The smooth pimpleback is endemic to central Texas and historically occurred throughout the Colorado and Brazos River basins, but is now limited to nine distinct locations, mostly in the Brazos River basin (Federal Register 2012).	Low
Texas Fawnsfoot (*Truncilla macrodon*)	Threatened	Prefer rivers and large streams with sand, gravel, and perhaps sandy-mud bottoms with moderate flows. No specimens have been documented in reservoirs. As with other freshwater mussel species, the Texas fawnsfoot would be susceptible to dramatic water level fluctuations, scoured bedrock, shifting sand substrates, and dewatering (NatureServe 2016).	The Texas fawnsfoot is endemic to central Texas and historically occurred in the Trinity, Brazos, and Colorado River basins. More recently, the fawnsfoot have only been found in five locations, and only three populations in the Brazos River basin appear to be sustainable (Federal Register 2012).	Low
Reptiles				
Alligator Snapping Turtle (*Macrochelys temminckii*)	Threatened	Perennial waterbodies; deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation.	Native to the southeastern region of the United States. They are confined to the river systems that drain into the Gulf of Mexico.	High
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	Endangered	Occurs throughout the world in tropical and subtropical regions, spending the majority of their lifecycle in the ocean, only coming to shore to lay eggs. Generally, juvenile and adult hawksbill are benthic in their feeding nature, consuming a variety of sponges and invertebrates.	Occur in the Gulf of Mexico and juveniles and hatchlings have been recorded along the Texas coast, believed to have originated from Mexican nesting beaches. No nesting beaches are known along the Texas coast (USFWS 2016c).	Low

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area

Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Green Sea Turtle (*Chelonia mydas*)	Threatened	A global species found in tropical and subtropical seas with water temperatures above 20 degrees Celsius. Feed in shallow sea grass and algae beds. Known to rest on shallow rocky bottoms and coral reefs, sometimes out of the water (NMFS and USFWS 1998a).	Nest in tropical beach habitats around the world and adult females return to their natal beach to lay eggs. There are no green sea turtle nesting beaches in Texas, but individuals are seen along the Texas coast during migration (TPWD 2012a).	Low
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	Endangered	Lay eggs on coastal beaches, hatchlings leave the coast for deeper water and grow before returning to near shore habitats as juveniles and adults. Adults primarily occur in the Gulf of Mexico, and utilize shallow near-shore and inshore bay habitats. Are primarily carnivorous, feeding on a variety of crustaceans, including various crab species (NMFS, USFWS, and SEMARNAT 2011).	Kemp's ridley sea turtles have a much more restricted distribution than other sea turtles, nesting primarily in Mexico, Texas, and a few other states in the United States (NMFS, USFWS, and SEMARNAT 2011).	Low
Leatherback Sea Turtle (*Dermochelys coriacea*)	Endangered	Unlike other sea turtle species, the leatherback sea turtle is a pelagic species, foraging on jellyfish, squid, fish, and crustaceans. They are highly migratory and only use the deep waters of the Gulf of Mexico for foraging, rarely coming close to shore following schools of prey.	Occurs throughout the world's oceans. Designated critical habitat is located in the U.S. Virgin Islands (Federal Register 1979). There are no known nesting beaches in the continental United States. The majority of known nest beaches are located in the eastern Pacific, western Pacific, and Indian Ocean (NMFS and USFWS 1998b).	Low

Table I-5. State-listed Species Having Potential to Occur Within or in the Vicinity of the Project Area
Harris Expansion Project Environmental Resource Document

Species (Latin Name)	State Status	Habitat	Distribution	Potential to Occur Within the Project Area (Low, Moderate, High)
Loggerhead Sea Turtle (*Caretta caretta*)	Threatened	Terrestrial habitats of coastal beaches are utilized for egg laying and incubation. Near shore habitat is utilized by juveniles and adults for feeding. Open ocean habitat is used for migration. Loggerheads occasionally nest on beaches in estuarine zones with coarse sandy beaches between the high tide line and the dunes (NMFS and USFWS 2008)	In Texas, loggerhead sea turtles do inhabit the Gulf of Mexico, occasionally are documented along the Texas coast, and only minor solitary nesting activity has been recorded along the Gulf coast.	Low
Texas Horned Lizard (*Phrynosoma cornutum*)	Threatened	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky.	Texas horned lizards range from the south-central United States to northern Mexico, throughout much of Texas, Oklahoma, Kansas and New Mexico	Low
Timber Rattlesnake (*Crotalus horridus*)	Threatened	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e., grapevines or palmetto.	Timber rattlesnakes occur in upland woods, swamps, floodplains, and riparian zones in the eastern United States; the eastern third of Texas (TPWD 2016f).	High

1.4 Survey Results

A reconnaissance-level biological survey and habitat assessment of the Project area was conducted April 11 through April 14, 2016 and April 13 through April 27, 2017 (Cardno Entrix 2017). No federally or state listed threatened or endangered species were observed near or within the Project area during the field surveys.

1.4.1 Federally Listed Species

The palustrine emergent wetlands and extensive croplands within the Project area could provide suitable foraging habitat for the federally endangered whooping crane. Whooping cranes have been documented on the Brazoria National Wildlife Refuge located approximately 20 miles southeast of the Project area (USFWS 2013). No whooping cranes were observed during the field surveys; however, based on the presence of suitable foraging habitat and the proximity of the Project area to the Brazoria National Wildlife Refuge, there is a moderate potential for the whooping crane to occur within the Project area.

The Brazos River and its tributaries could provide suitable habitat for the smooth pimpleback and Texas fawnsfoot, both of which are candidates for federal listing as well as state-listed species. These species are discussed in greater detail in Section 1.2.4. A 2012 mussel survey conducted in the Brazos River approximately 3,970 feet downstream of the project site found no evidence of live mussel, shell, or shell fragments (HDR 2012). The last known observed location of the smooth pimpleback was documented approximately 85 miles upstream of the project site at the confluence of the Navasota and Brazos Rivers (Howells 2002). The last known observed location of the Texas fawnsfoot was documented greater than 85 miles upstream of the project site between Possum Kingdom Lake and the mouth of the Navasota River (TPWD 2009). Therefore, there is a low potential for these species to occur within Oyster Creek and other tributaries within the Project area.

All other federally listed species were identified as having a low potential to occur within the project area due to a lack of suitable habitat.

1.4.2 State Listed Species

The federally and state listed whooping crane, smooth pimpleback, and Texas fawnsfoot are discussed in Section 1.4.1.

Bald eagles nest in tall trees near water, primarily rivers and large lakes. Harris Reservoir and the Brazos River provide suitable nesting and foraging habitat for bald eagles; however, no eagles or their nests were observed near these waterbodies or within other portions of the Project area during the field surveys. Based on the availability of suitable nesting and foraging habitat within and near the vicinity of the Project area, there is a high potential for bald eagles to occur within the Project area.

Wood storks use a variety of freshwater and estuarine wetlands for nesting, feeding, and roosting sites. Typical foraging sites throughout the species' range include freshwater marshes and stock ponds, shallow, seasonally flooded roadsides or agricultural ditches, narrow tidal creeks or shallow tidal pools, and managed impoundments (USFWS 1997). The palustrine emergent wetlands and numerous agricultural ditches within the Project area as well as Harris Reservoir provide suitable foraging habitat for wood storks; however, no wood storks were observed during the field surveys. Based on the assessment conducted, there is a moderate potential for wood storks to occur within the Project area.

Alligator snapping turtles inhabit deep water of rivers, canals, lakes, and oxbows, all of which are located within the Project area. No alligator snapping turtles were observed during the field surveys, however, there is a high potential for the species to occur within the Project area given the variety of deep water habitats present within the Project area.

Timber rattlesnakes prefer dense groundcover in swamps, floodplains, deciduous woodlands, riparian zones, and abandoned farmland. Several of these habitat types are present within the Project area and provide suitable habitat for the timber rattlesnake. No timber rattlesnakes were observed during the field surveys; however, there is a high potential for the species to occur within the Project area based on the presence of suitable habitat and the relatively undisturbed nature of these habitats.

All other state listed species were identified as having a low potential to occur within the project area due a lack of suitable habitat.

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Attachment D
Alternatives Analysis

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ATTACHMENT D

Alternatives Analysis

The Alternatives Analysis details the full range of alternatives considered by Dow prior to pursuing a Section 404 permit for the Harris Expansion Project, and includes the framework used to analyze these alternatives and the evaluation criteria applied to identify those practicable[1] alternatives that meet the project purpose and need. This attachment also presents an analysis of alternative projects selected for further evaluation and the potential environmental consequences of those alternatives. The alternatives analysis presented herein demonstrates that:

1) There is not a practicable alternative to the proposed work, which would have less adverse impact on the aquatic ecosystem (so long as the alternative will not have other significant adverse environmental consequences);
2) It [the proposed project] does not violate a State water quality standard, violate a toxic effluent standard, jeopardize the continued existence of a threatened or endangered species, or violate protective requirements of a federal marine sanctuary;
3) It [the proposed project] will not result in significant degradation of waters of the U.S.; and
4) Appropriate and practicable steps will be taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (USACE 2003).

The amount of information needed to make such a determination and the level of scrutiny required by the U.S. Army Corps of Engineers' (USACE) Alternatives Analysis Guidance (USACE 2003) is commensurate with the severity of the environmental impact (as determined by the functions of the aquatic resource and the nature of the proposed activity) and the scope/cost of the project.

Alternative Analysis Framework

Dow used a rigorous analysis framework to determine that there is not a readily apparent practicable alternative to the Harris Expansion Project which would meet the project purpose and need while having a less adverse impact on the aquatic ecosystem when other environmental impacts are considered. The analysis framework includes the following evaluation process:

- Identifies the full range of alternatives considered and screens out those alternatives found to be not practicable.
- Defines the criteria for evaluation of alternatives used to identify the least environmentally damaging practicable alternative to meet the project purpose and need.
- Provides a preliminary public interest review in which the comparison of public interest benefits verses detriments is framed with "yes" and "no" determinations with "yes" meaning public interest benefits accrued outweigh or are reasonably balanced against foreseeable detriments, and "no" meaning benefits accrued do not outweigh or are not reasonably balanced against foreseeable detriments.
- Those alternatives that have two or more of the following four screening factors were considered to be not practicable:
    - does not meet the purpose and need

[1] Practicable alternatives are those alternatives that are "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." (40 C.F.R. §230.3 (l))

- does not result in a discernible difference from other alternatives
- has "other significant adverse environmental consequences"
- is a Special Aquatic Site[2]

Full Range of Alternatives

Dow identified a full range of (15) potential alternatives that were evaluated to meet the purpose and need for the project and that might be practicable. In addition, the No Action Alternative was evaluated. The 15 alternatives studied included non-structural and structural projects located near the Texas Operations site in Freeport and at more remote locations. **Figure D-1** shows the location of the 15 alternatives evaluated. These 16 alternatives (including the No Action Alternative) were initially screened to identify practicable projects that met the overall purpose of and need for the project. The full range of alternatives and initial screening to select alternatives for detailed evaluation are summarized in **Table D-1**.

[2] Special Aquatic Sites are afforded a higher level of scrutiny and protection. Special aquatic sites include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and stream riffle and pool complexes.

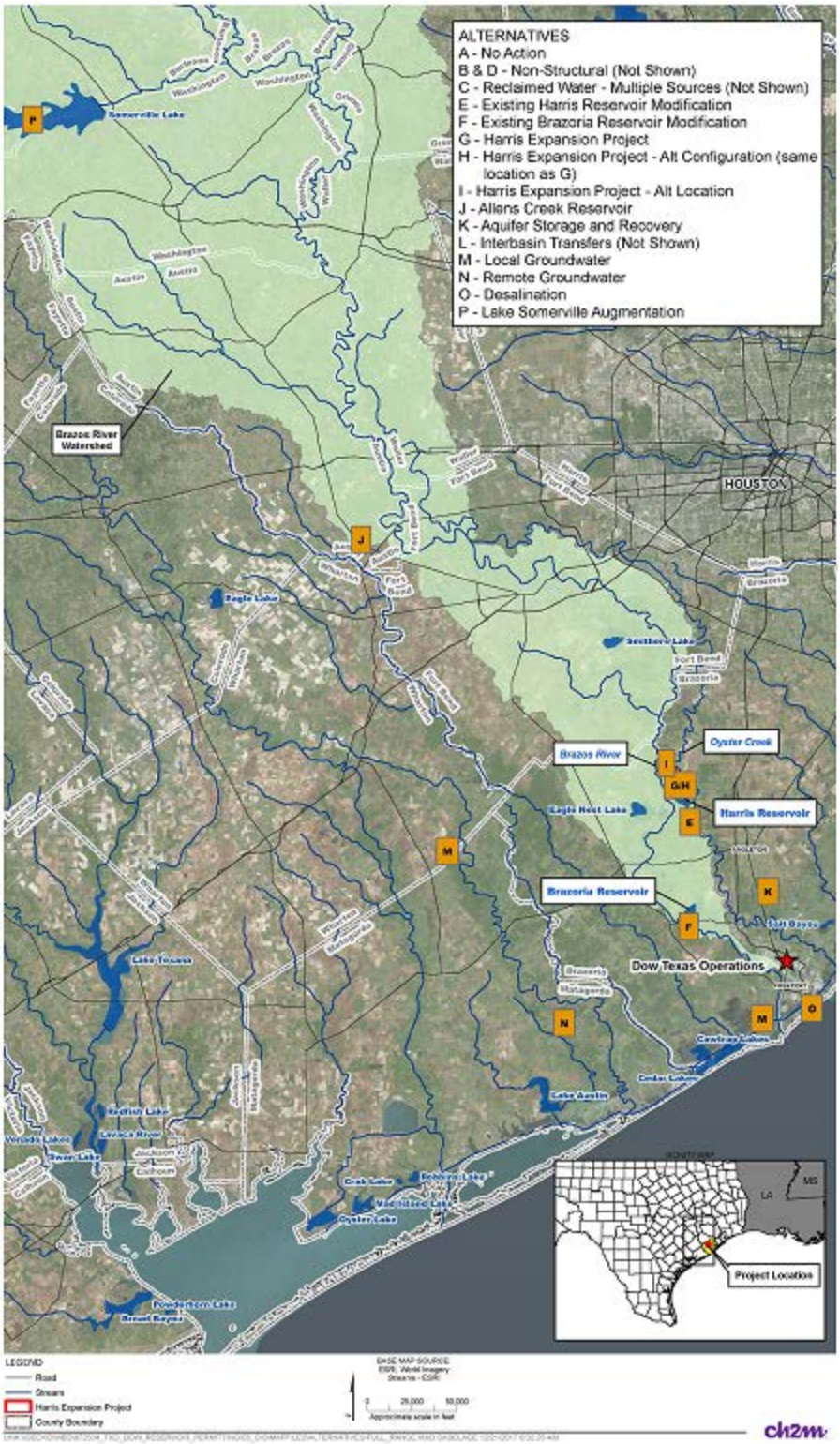


Figure D-1. Location of Full Range of Alternatives
Harris Expansion Project Individual Permit Application

Table D-1. Full Range of Water Supply Alternatives and Initial Screening

Harris Expansion Project Individual Permit Application

Alternative Letter	Name	Description	Practicable	Meets Project Need	Special Aquatic Site [1]	Carried Forward for Alternative Analysis
Alternative A	No Action	The "No Action" alternative means that no additional water storage would be constructed and that the proposed activity would not take place and Dow would continue to operate their water supply system as is currently done. The No Action alternative would include Dow's current water conservation and water reclamation projects. The expiration of the stored water purchase agreement with the Brazos River Authority in 2021 is included.	N/A	No	N/A	Yes
Alternative B	Enhanced Conservation	The Enhanced Conservation alternative includes capital projects or operational changes within the Texas Operations site that would reduce water consumption by an additional 10 percent (approximately 20,000 acre-feet) per year. This alternative was not carried forward since it would not reduce risk associated with long-term average water storage capacity during extended drought nor meet the identified need for the project.	Yes	No	No	No
Alternative C	Expanded Reclaimed Water Use	The Expanded Reclaimed Water Use alternative includes use of municipal reclaimed water from the cities of Alvin and Freeport delivered via the bed and banks of Oyster Creek or via pipeline to the Texas Operations distribution system. The projected water demand in 2020 for the cities is 4,644 acre-feet and 1,283 acre-feet, respectively (*2016 Region H Regional Water Plan*). Assuming that 70 percent of water used is treated and discharged, up to approximately 4,150 acre-feet per year might be available for Dow's use. This volume is substantially below Dow's weekly water demand of approximately 3,000 acre-feet *per week*. This alternative was not carried forward since it would not provide sufficient volume to meet the identified need for the project, nor address storage during drought or water curtailment.	No	No	Potentially (conveyance system)	No

Table D-1. Full Range of Water Supply Alternatives and Initial Screening

Harris Expansion Project Individual Permit Application

Alternative Letter	Name	Description	Practicable	Meets Project Need	Special Aquatic Site [1]	Carried Forward for Alternative Analysis
Alternative D	Utilize Existing Stored Water or Under-utilized Run-of River Rights in Brazos River	The "Utilize Stored Water or Underutilized Run-of-River Rights in the Brazos River" alternative includes executing contract(s) with the Brazos River Authority (BRA) to purchase additional stored water from upstream reservoirs through an Interruptible Water Availability Agreement (IWAA) and supplementing with water rights acquisition or lease from other water right holders in the basin (Reddy, et al 2015). Available BRA storage reserves are fully contracted, it's reservoirs fill less frequently than lower basin storage alternatives and the BRA interruptible water policy no longer allows multiyear agreements (BRA 2017). Annual contracts of this nature do not provide long-term reliability and would have limited availability during drought. Due to the lack of available surface water rights that are reliably available during drought does not meet the purpose and therefore, this alternative was not carried forward.	No	No	No	No
Alternative E	Modification of Existing Harris Reservoir	The "Modification of the Existing Harris Reservoir" alternative includes activities such as dredging, deepening or raising the embankment of the existing Harris Reservoir to expand the storage capacity. This alternative was not carried forward because these activities cannot be performed at Harris Reservoir without disrupting the existing supply and thus the ongoing functionality of the Texas Operations during construction. There are also dam safety concerns with raising the existing embankment heights. For these reasons, the project was not carried forward.	No	No	No	No
Alternate F	Modification of Existing Brazoria Reservoir	The "Modification of the Existing Brazoria Reservoir" alternative includes activities such as dredging, deepening or raising the embankment of the existing Brazoria Reservoir to expand the storage capacity. This alternative was not carried forward because the salt water wedge prevents diversion at Brazoria Reservoir during low flow conditions and these activities cannot be performed without disrupting the existing supply and thus the ongoing functionality of the Texas Operations during construction. There are also dam safety concerns with raising the existing embankment heights. For these reasons, the project was not carried forward.	No	No	No	No
Alternative G	Harris Expansion Project	The "Harris Expansion Project" alternative includes construction of an off-channel reservoir north of the existing Harris Reservoir to add approximately 50,000 acre-feet of additional storage capacity. This is the proposed project.	Yes	Yes	Yes	Yes

Table D-1. Full Range of Water Supply Alternatives and Initial Screening

Harris Expansion Project Individual Permit Application

Alternative Letter	Name	Description	Practicable	Meets Project Need	Special Aquatic Site [1]	Carried Forward for Alternative Analysis
Alternative H	Harris Expansion Project – Alternate Embankment Configuration	The "Harris Expansion Project –Alternate Embankment Configuration" includes an alternate site layout for the construction of an off-channel reservoir north of the existing Harris Reservoir to add approximately 56,760 acre-feet of additional storage capacity (*2016 Region H Regional Water Plan*).	Yes	Yes	Yes	Yes
Alternative I	Harris Expansion Project – Alternate Location	The "Harris Expansion Project – Alternate Location" alternative is the result of Dow's site selection evaluation of 6 sites. While not carried forward to detailed design, it is assumed that it would provide a storage capacity comparable to Alternative G (approximately 50,000 acre-feet). Four of the six sites identified were not suitable due to technical, availability or cost considerations; Alternative G, the proposed project, and this alternative location were the only two deemed to be feasible (Dow 2015).	Yes	Yes	Yes	Yes
Alternative J	Allens Creek Reservoir	The "Allens Creek Reservoir" alternative includes construction of a proposed reservoir with storage capacity of up to 145,533 acre-feet and an approximate annual yield of 99,650 acre-feet in Austin County (*2016 Region H Regional Water Plan*). The alternative would include buying water from the Brazos River Authority and/or the City of Houston, if available, and releasing it downstream to Dow's diversion structures.	Yes	Yes	Yes	Yes
Alternative K	Aquifer Storage and Recovery	The "Aquifer Storage and Recovery (ASR)" alternative includes an ASR well field(s) (either 10 million gallons per day (MGD) or 14 MGD) in central Brazoria County near Brazosport Water Authority facilities that could be operated to store treated water during low demand months for retrieval and distribution during summer months. This would provide operational flexibility to maintain storage water in the existing Dow water system reservoirs. In addition to the wellfield, the alternative would include conveyance facilities to transport water to the Texas Operations distribution system and potentially a water treatment plant (HDR 2013). Assuming a 6-month fill and storage period and a 6-month recovery period, a 14 MGD facility would provide approximately 7,841 acre-feet per year. Because the yield is less than that needed for the project, this option was not carried forward.	Yes	No	Potentially – (conveyance system)	No

Table D-1. Full Range of Water Supply Alternatives and Initial Screening

Harris Expansion Project Individual Permit Application

Alternative Letter	Name	Description	Practicable	Meets Project Need	Special Aquatic Site [1]	Carried Forward for Alternative Analysis
Alternative L	Surface Water from Adjacent Basins	The "Surface Water from Adjacent Basins" alternative includes an interbasin transfer of water from the Colorado River to the west or the Trinity River to the east. Such interbasin transfers would include amending water rights, diversion and conveyance facilities and additional storage in the basin of origin (Colorado or Trinity River basin) or additional storage capacity near Texas Operations to create a reliable water supply that could be delivered at needed rates during drought conditions. This project was not carried forward due to the lack of surface water rights available for transfer and logistical reasons related to amending water rights, obtaining interbasin transfer authorizations and acquiring necessary rights-of-way or easements. Additionally, the potential for negative impacts to instream flows or freshwater inflows to bays and estuaries in the basin of origin is possible. This project has the potential to impact aquatic habitat in both the basin of origin and the receiving basin. Further, the complexity of surface water interbasin transfer authorizations would be expected to delay implementation beyond the project implementation timeframe. For these reasons, the project was not carried forward.	No	Yes	Yes	No
Alternative M	Local Groundwater Supply	The "Local Groundwater Supply" alternative includes construction of a well field in Brazoria or Matagorda counties to produce groundwater from the Chicot and Evangeline Aquifers and conveyance facilities to transport water to the Texas Operations distribution system (HDR 2013). This alternative was not carried forward because the current groundwater production in Brazoria and Matagorda counties is already equal to the established regulatory limit as determined by the "Modeled Available Groundwater (MAG)" volume and because of concerns about subsidence. Issued permits exceed the MAG; therefore, long-term production is not reliable. Due to the potential for subsidence and regulatory constraints, this alternative was not carried forward.	Yes	No	No	No
Alternative N	Remote Groundwater Supply	The "Remote Groundwater Supply" alternative includes construction of a well field in southeast Wharton County to produce up to 17,500 acre-feet/year of new water from the Chicot and Evangeline Aquifers in southeast Wharton County. Conveyance to the Texas Operations distribution system would be accomplished by pipelines and conveyance via the bed and banks of the Brazos River where it would be diverted into Dow's reservoirs and existing water supply system (HDR 2013). Because the yield is less than that needed for the project, this option was not carried forward.	Yes	No	Potentially – (conveyance system)	No

Table D-1. Full Range of Water Supply Alternatives and Initial Screening

Harris Expansion Project Individual Permit Application

Alternative Letter	Name	Description	Practicable	Meets Project Need	Special Aquatic Site [1]	Carried Forward for Alternative Analysis
Alternative O	Seawater Desalination	The "Seawater Desalination" alternative includes construction of a reverse osmosis treatment plant to produce 33,600 acre-feet per year of desalinated seawater water from the Gulf of Mexico and conveyance facilities to transport treated water to the Texas Operations water distribution system (2*011 Region H Regional Water Plan*, TWDB 2016). The project would include diversion of seawater using an existing intake facility, a reverse osmosis plant, an existing outfall to discharge brine concentrate into the Gulf of Mexico via the Brazos River and raw water and treated water conveyance facilities. To meet the project need, a desalination project would need to be expanded significantly from the representative projects previously studied. Note that this alternative presents an updated location for a potential desalination facility because the conceptual location of the 10 MGD alternative studied by the Region H Water Planning Group is no longer available.	Yes	Yes	Potentially–(conveyance system)	Yes
Alternative P	Lake Somerville Augmentation	The "Lake Somerville Augmentation" alternative includes construction of a pump station and pipeline to deliver high flows from the Brazos River to increase the firm yield up to an additional 22,800 acre-feet per year in the existing Lake Somerville located in Burleson, Lee and Washington counties (*2016 Region H Regional Water Plan*). The alternative would include buying water from the BRA and/or the City of Houston, if available and releasing water downstream to Dow's diversion structures. Due to uncertainty regarding availability of firm water supply, implementation schedule and the ability to meet Dow's water volume and delivery rates, this is not a practicable alternative to meet the purpose of and need for the project and was not carried forward for further evaluation	No	No	Yes	No

Notes:

[1] Special aquatic sites include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and stream riffle and pool complexes (USACE, 2003. Alternative Analysis Guidance Date: 23 October 2003.

[2] There are a few water rights in Texas that include the explicit authorization for interbasin transfer without loss of seniority; however, those are not the standard water right.

Alternative Evaluation Criteria

The alternatives carried forward for further analysis after the initial screening are those that are feasible to be implemented and that meet the need for the project. To the extent that readily available and comparable information exists, **Table D-2** outlines the 3-tiered system based on assigning value assessments of low (least favorable), medium and high (most favorable) to criteria used to evaluate and select those alternatives considered practicable[3] and selected for further analysis. The initial screening criteria used to determine the avoidance, minimization, and ecological impact extent to which an alternative is practicable include:

- The ability to meet the project's overall purpose of providing reliable water supply during drought
- The ability to meet the project's overall purpose of using existing Dow-owned surface water rights within the authorized diversion segment (at or near the existing Harris Reservoir)
- The relative logistical coordination needed to construct and operate the project
- The ability to meet the project purpose with existing technology
- The relative cost

The criteria for each factor are specific to achieving the need for and purpose of the project and were developed to facilitate comparison between a diverse range of alternatives. The results of applying the criteria in **Table D-2** to the 6 alternatives carried forward for detailed review are presented in **Table D-5** in the following section**.**

[3] As defined in 40 C.F.R. § 230.3, “practicable” alternatives are those alternatives that are "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes."

Table D-2. Evaluation Criteria for Practicability of Alternative Projects

Harris Expansion Project Individual Permit Application

3- tiered Rating System	**Low**	**Moderate / Limited**	**High**
Rating Symbol	○	◒	●
Overall Project Purpose Factors			
Ability to provide reliable water supply for Texas Operations during extended drought (reliable is defined as: 1) available during a drought, and 2) able to deliver supply at rates equal to water demand to Dow and those they serve on a daily/weekly basis)	No	When combined with other sources	Yes
Ability to use existing Dow-owned surface water rights diverted within the authorized diversion segment	No	With loss of seniority of water rights.	Yes
Logistical Factors			
Ability to be operational within five years	Extended or uncertain schedule	Potentially operational, but uncertain	Highly likely for substantial completion within five years
Property rights / # of property owners affected	More than 5 property owners and / or unwilling to sell.	Fewer than 5 property owners and / or willing to sell.	Not Applicable or Single Owner
Conveyance distance to existing conveyance system (greater distances reduce reliability due to main breaks)	Long distance (>20 miles)	Medium distance (>5 and <20 miles)	Reasonably close (< 5 miles)
Water availability/ water right availability to Dow (either new permits or through agreement/ acquisition)	Less than 17,500 acre-feet	Between 17,500 - 47,000 acre-feet	47,000 acre-feet or more
Technology Factors			
Project capable of high delivery rates (e.g., 3000 acre-feet per week) with reasonably-sized capital facilities	No	Limited	Yes
Project capable of being constructed with existing water supply system (Harris and Brazoria reservoirs) remaining in operation	No	Potentially, but with difficulty and at a high construction cost	Yes
Relative Cost Factors			
Annualized unit cost per acre-foot per year (capital and operations & maintenance)	Annualized unit cost per acre-foot per year (capital and operations & maintenance)	Annualized unit cost per acre-foot per year (capital and operations & maintenance)	Annualized unit cost per acre-foot per year (capital and operations & maintenance)
Unit capital cost per acre-foot	Unit capital cost per acre-foot	Unit capital cost per acre-foot	Unit capital cost per acre-foot
Availability of suitable land for project at reasonable cost	Availability of suitable land for project at reasonable cost	Availability of suitable land for project at reasonable cost	Availability of suitable land for project at reasonable cost

After the screening to select which projects could potentially and practicably achieve the purpose and need for the project (summarized in Table D-1), the 6 project alternatives carried forward for detailed analysis were evaluated using the environmental impact criteria in **Table D-3**, again following a 3-tiered system based on value assessments with low (most favorable), medium and high (least favorable) to identify the least environmentally damaging practicable alternative. Qualitative values were used for the environmental impact analysis because quantified data were not available for all alternatives.

Table D-3. Evaluation Criteria for Environmental Impact Factors
Harris Expansion Project Individual Permit Application

3- tiered Rating System for Impacts	**Low**	**Moderate**	**High**
Rating Symbol	○	◒	●
Potential for impacts to critical habitat or listed threatened or endangered fish and aquatic species	No effect	May affect, but not likely to adversely affect	May affect, and is likely to adversely affect
Potential impacts to surface water quality (or violation of State water quality standards)	No impacts	Temporary, indirect, and short-term impacts	Adverse, direct, and long-term impacts
Potential for impacts to wetlands and other Waters of the U.S.	No impacts to wetlands or other WOUS	Impacts to <50 acres of wetlands or other WOUS	Impacts to ≥50 acres of wetlands or other WOUS
Potential for impacts to aquatic ecosystem/ instream flows	No impacts	Temporary, indirect, and short-term impacts	Adverse, direct, and long-term impacts
Potential for impacts to land (e.g. subsidence and impacted area not owned by Dow)	No impacts	Temporary, indirect, and short-term impacts	Adverse, direct, and long-term impacts
Potential for impact to cultural resources	No undertaking/no potential to cause effects	Undertaking might affect cultural resources	Undertaking may adversely affect cultural resources
Potential for impacts related to energy requirements (e.g., greenhouse gas and impacts of locating sufficient energy supply to meet peak delivery rates)	No impacts	Temporary, indirect, and short-term impacts	Adverse, direct, and long-term impacts

Alternatives Carried Forward for Detailed Evaluation

Of the 16 alternative projects identified, 6 alternatives, including the No Action and Preferred Alternative (the proposed project), were selected for detailed analysis. A detailed description of these alternatives and their anticipated environmental consequences are presented herein. **Table D-4** summarizes the 6 alternatives carried forward for detailed evaluation and **Figure D-2** shows their locations. (Please note that the alternative projects carried forward were given new identification numbers (as shown in **Table D-4**) to avoid reader confusion of missing alphabetically identified project alternatives in the detailed analysis.)

This section presents the alternatives in comparative form, defining the differences between each alternative and providing a clear basis for choice among options. For the proposed project, a comparison of options for the project components (e.g., type and size of the pump station, intake facilities and impoundment) was also conducted. A description of each alternative, summary of practicability factors and the potential environmental consequences associated with the alternative are presented. The results of the evaluation for practicability using the ranking system and criteria presented in **Table D-2** for the 6 alternatives carried forward for detailed review are presented in **Table D-5** followed by and a summary of environmental consequences presented in **Table D-6**.

Table D-4. Alternatives Carried Forward for Detailed Analysis
Harris Expansion Project Individual Permit Application

Alternative #	Name	Practicable	Meets Project Need	Special Aquatic Site [1]	Preliminary Alternative Letter
1	No Action	N/A	No	N/A	A
2	Harris Expansion Project	Yes	Yes	Yes	F
3	Harris Expansion Project –Alternate Embankment Configuration	Yes	Yes	Yes	H
4	Harris Expansion Project – Alternate Location	Yes	Yes	Yes	I
5	Allens Creek Reservoir	Yes	Yes	Yes	J
6	Seawater Desalination	Yes	Yes [2]	Yes	M

Notes:

[1] Special aquatic sites include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and stream riffle and pool complexes (USACE, 2003) Alternative Analysis Guidance Date: 23 October 2003).

[2] At the yield evaluated, the seawater desalination project would not meet the project need; however, it is assumed in this analysis that the plant could be upsized to provide the necessary water supply.

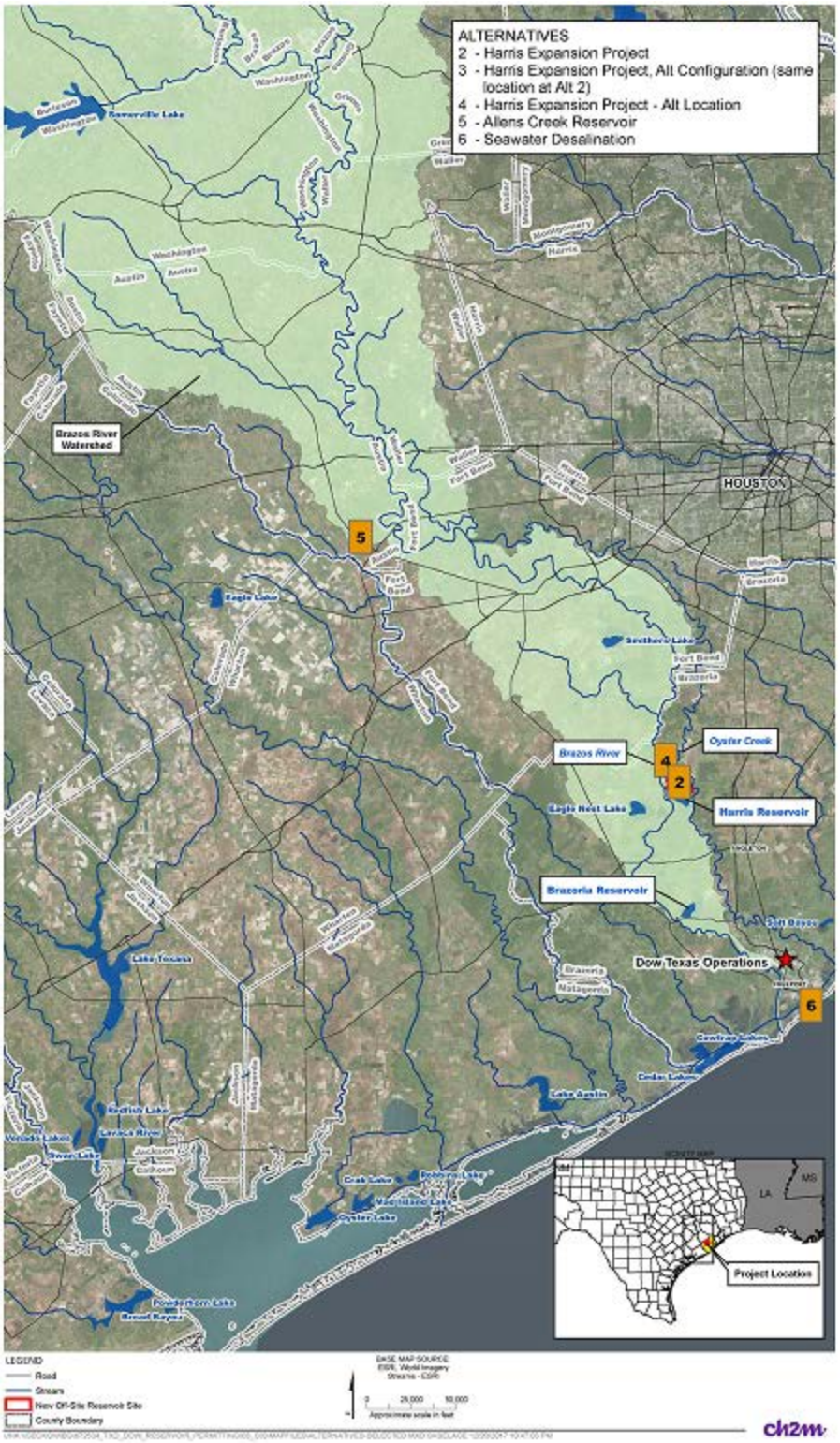


Figure D-2. Location of Alternatives Carried Forward for Detailed Analysis
Harris Expansion Project Individual Permit Application

Alternative 1 - No Action Alternative

Description

Under the No Action alternative, Dow's Texas Operations would continue to provide water supply for the facilities and other customers that rely on the water supply from Dow's current system. Dow would not construct the Harris Expansion Project and would, therefore, not have required storage capacity to sustain operations during an extended drought. The project goals would not be met.

The "No Action" alternative means that no additional water storage would be constructed and Dow would continue to operate their water supply system as they are currently. It includes Dow's existing water conservation and reclaimed water projects as well as a stored water purchase agreement for an annual average volume of 16,000 acre-feet with the Brazos River Authority that expires within 5 years. Therefore, this alternative will not achieve the project's purpose and need.

Practicability Factors

The practicability factors do not apply to this alternative.

Consequences

The No Action alternative does not meet the purpose of and need for the project.

Failure to provide a reliable water supply during drought for the Texas Operations site in Freeport and the other industries and municipalities that rely on Dow's water storage system could result in slowing production or shutting down operations for some period. This would have significant negative consequences on the 3,300 employees and 3,200 contract employees employed at the Texas Operations and the local and state economy. Dow pays an estimated $186.3 million in state taxes and an estimated $73.8 million in taxes to Brazoria County. Further, Dow contributes to the private sector economy with an approximate $685 million and $2.6 billion in purchases within Brazoria County and Texas, respectively (Dow 2016).

Given the reliance of industries and businesses across the country and internationally on products produced at the Texas Operations site, the negative consequences of potential materials and product shortages could impact the national and global economy. Combined with the local and state impacts, not meeting the water needs at Dow's Texas Operations site in Freeport would have severe negative socioeconomic consequences.

The no action alternative could potentially result in negative environmental consequences if the plant had to shut down on an emergency basis.

Alternative 2 – Harris Expansion Project (Proposed Project/ Preferred Alternative)

Description

The "Harris Expansion Project" alternative includes construction of expanded water storage capacity in an off-channel reservoir located north of the existing Harris Reservoir to add approximately 50,000 acre-feet of additional storage capacity and estimated annual yield of approximately 80,000 acre-feet.

Figure D-3 presents the proposed location of and site lay-out for the Harris Expansion Project.

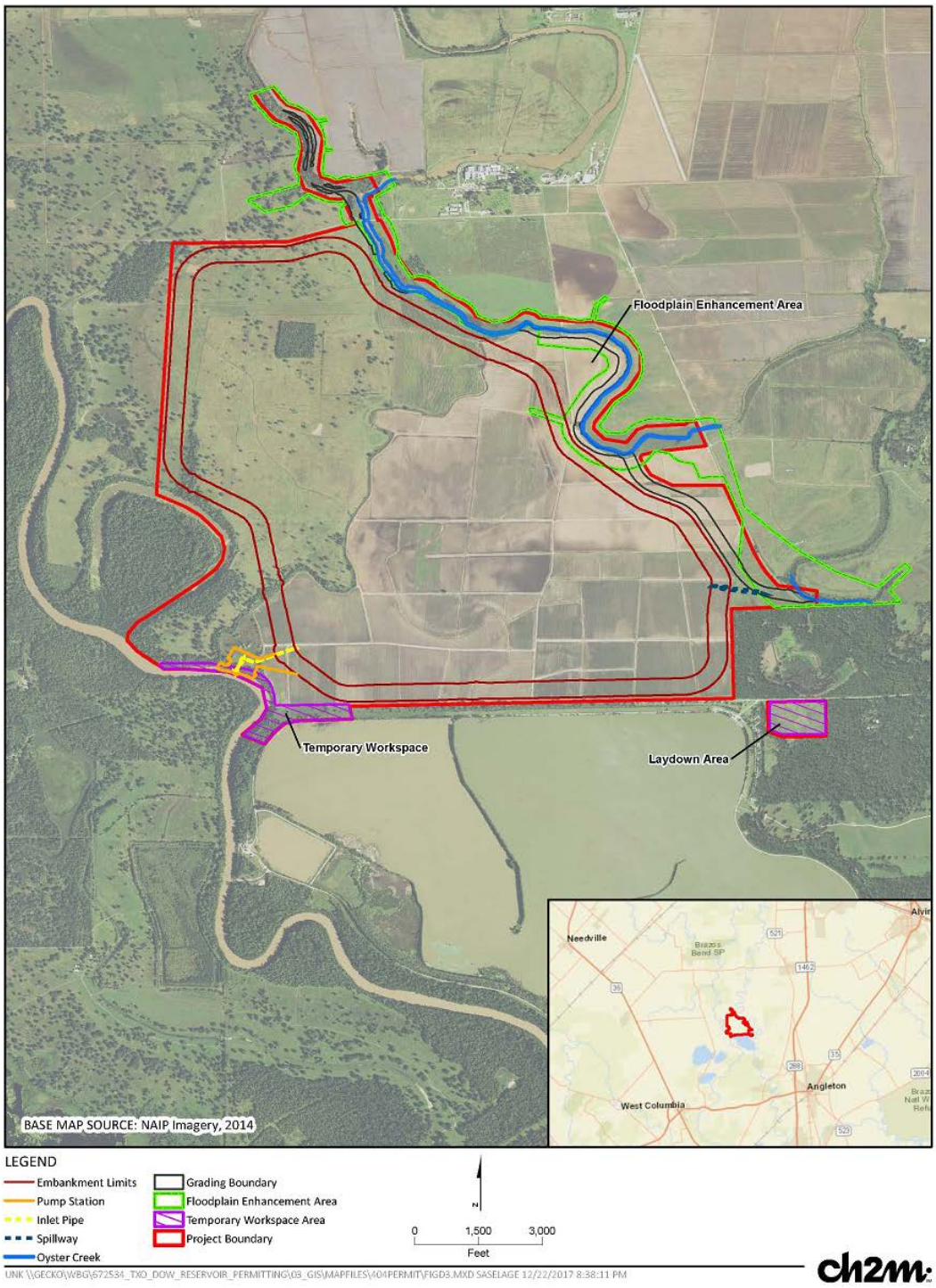


Figure D-3. Harris Expansion Project
Harris Expansion Project Individual Permit Application

Practicability Factors

Logistical Factors: Because land acquisition and concept-level design have been completed, it is estimated that the project could be operational within five years. Furthermore, Dow currently owns sufficient surface water rights authorized for diversion, storage and use for the project. The outlet works would discharge water directly into Oyster Creek. This alternative received a high rating for the 4 logistical factors.

Technology Factors: The project is capable of delivering water for the Texas Operations at the high rates required and can be constructed while the current storage and conveyance system is in operation. This alternative received a high rating for the 2 technology factors.

Relative Cost Factors: Planning level costs estimates prepared by the Region H Regional Water Planning Group indicate that the annualized capital and operational costs for the proposed project would be slightly more than $300/acre-foot/ year and capital costs would be approximately $2,810 per acre-foot (one-time cost not annualized over time). Dow currently owns the 2,200-acre site for the impoundment. This alternative received a high rating for the 3 relative cost factors.

The proposed project is a practicable alternative to meet the need for the project.

Consequences

Threatened and Endangered Species: No federally or state listed species were observed at the site during field investigation surveys conducted in 2012 and 2016. Construction for the proposed project would result in the permanent inundation of emergent and forested wetlands, which could provide marginal habitat for the state-threatened timber rattlesnake (*Crotalus horridus*). However, no timber rattlesnakes were observed during the site visits and best management practices (BMPs) will be implemented during construction to ensure no potential adverse impacts to the species. Construction of the proposed project would impact agricultural and heavily grazed areas which do not provide suitable habitat for protected species. A review of the Texas Natural Diversity Database (TXNDD) identified occurrences of bald eagles (*Haliaeetus leucocephalus*) and colonial wading bird colonies within the southern portion of the proposed project area. However, no bald eagles or their nests and no colonial wading bird colonies were observed during the site visits. Construction BMPs will be implemented to avoid impacts to migratory species.

No designated critical habitat, as defined by the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended, ESA), is in or near the project area. There would be no impacts to critical habitat.

No impacts to threatened and endangered species are anticipated as a result of the proposed project.

Water Quality: Minor, short-term impacts to water quality may occur during or after construction as a result of the proposed project. Surface water quality in the Brazos River and Oyster Creek could be temporarily impacted as a result of the construction of the pump station, reservoir outlet works, spillway and bank stabilization near those facilities. All practicable steps, including the use of BMPs, would be taken to minimize these impacts. Potential discharges to the impaired stream segment of Oyster Creek as a result of the proposed project could provide long-term, beneficial impacts to the stream by providing flow during low flow conditions.

For land-disturbing activities greater than 5 acres in size, a Large Construction Storm Water Permit (General Permit TXR150000), is required and will be obtained from the Texas Department of Environmental Quality (TCEQ) prior to initiation of clearing and grading activities associated with construction of the proposed project (TCEQ 2016a). Appropriate BMPs to minimize impacts associated with erosion would be implemented in accordance with TXR150000 and the Stormwater Pollution Prevention Plan (SWPPP) prepared for the project.

Permanent erosion controls and stormwater management measures will be implemented as permanent features to manage onsite runoff from the embankment as needed on the site.

Water Quality Certification as required under Section 401 of the CWA will be requested from the TCEQ as part of the Individual Permit application. See Section F for the Tier II questionnaire and checklist.

Wetlands and waters of the U.S.: Direct impacts to waters of the U.S. caused by the proposed project would include inundation of wetlands and streams located within the embankment areas. The

construction of the proposed project would result in the loss of 12.19 acres of emergent wetlands, 4.15 acres of forested wetlands, and 20,486.3 linear feet (5.73 acres) of streams. Compensatory mitigation would be required as a result of adverse impacts to wetlands and waters of the U.S. Using the criteria established in Table 2-3, moderate impact to wetlands and streams would result. After mitigation, impacts are expected to be minor.

Aquatic Habitat: Impacts to aquatic habitat as a result of the preferred alternative would be minor. The proposed project is not located within or adjacent to Essential Fish Habitat (EFH). Construction of the pump station could negatively impact mussel species (if present) as a result of decreased water quality during the construction phase of the project. However, a 2012 freshwater mussel survey conducted approximately 3,970 feet downstream of the project site found no evidence of live mussel, shell, or fragment (HDR 2012). The conversion of free-flowing streams within the impoundment boundary to an impoundment would alter the type and quality of aquatic habitat within the proposed reservoir site. However, the majority of the streams are low quality, ephemeral streams that provide little to no fish habitat, and aquatic life is limited. Construction of the proposed project would result in long-term beneficial impacts on aquatic habitats by creating a large waterbody that would provide suitable habitat for fish, migratory birds and colonial wading birds that is expected to provide ecological benefits greater than current low quality wetlands and drainage ditches.

Land Resources: Minor impacts to land resources would be anticipated as a result of the proposed project. The proposed site is not subject to local/regional zoning or land use development regulations, so there would be no impacts related to incompatible zoning. The proposed alternative would inundate approximately 1,900 acres of open space. Construction of the electrical, pump station, and operations buildings and associated facilities would result in the development of approximately 8.7 acres of open space.

Cultural Resources: One prehistoric archaeological site, two historic archaeological sites, one surface scatter of historic artifacts, found out of context, and one isolated artifact were identified within the 2,200-acre property of proposed project area. The prehistoric archaeological site (PS-1) and a historic residence (HS-1) could be considered eligible for listing on the National Register of Historic Places. Identification of site HS-1 resulted in a reconfiguration of the proposed embankment to ensure this historic site would not be impacted. PS-2 and a second historical site (HS-2) will be inundated by the reservoir (Griggs 2018).

A second archaeological investigation was conducted within the drainage enhancement area along Oyster Creek. Two historic archaeological sites, four surface scatters of historic artifacts found out of context, and a subsurface scatter were identified within the project area. The two sites could be considered eligible for listing on the National Register of Historic Places (Griggs 2017). These sites lie outside of the proposed floodplain enhancement projects and will not be impacted.

Impacts from the preferred alternative would be moderate; mitigation may be required in consultation with the Texas Historical Commission (THC).

No impacts to Native American Traditional Cultural Properties would be expected from implementation of the preferred alternative.

Attachment G includes detailed cultural resources reports presenting the results of intensive investigations of the properties.

Energy Use/ Green House Gas Contribution: The preferred alternative would contribute to minor short-term increases in greenhouse gas (GHG) emissions. Vehicle and equipment used during construction would be expected to create dust and fugitive emissions.

In the case of a newly formed reservoir, there tends to be a peak in emissions during the first two to three years following inundation as flooded vegetation decomposes. However, after a period of time, a

reservoir can reach a steady state that is similar to that of surrounding natural waterbodies (Soumis et al. 2005).

Impacts from the preferred alternative to greenhouse gas emissions would be minor.

Alternative 3 – Harris Expansion Project –Alternate Embankment Configuration

Description

The "Harris Expansion Project –Alternate Embankment Configuration" includes an alternative site lay-out for the construction of an expansion off-channel reservoir north of the existing Harris Reservoir to add 56,760 acre-feet of additional storage capacity to Dow's water supply system (*2016 Region H Regional Water Plan*). This layout, shown in **Figure D-4,** roughly parallels the site's property boundaries and has a slightly larger footprint than the proposed Project. Other project components would be the same as those described for the proposed project.

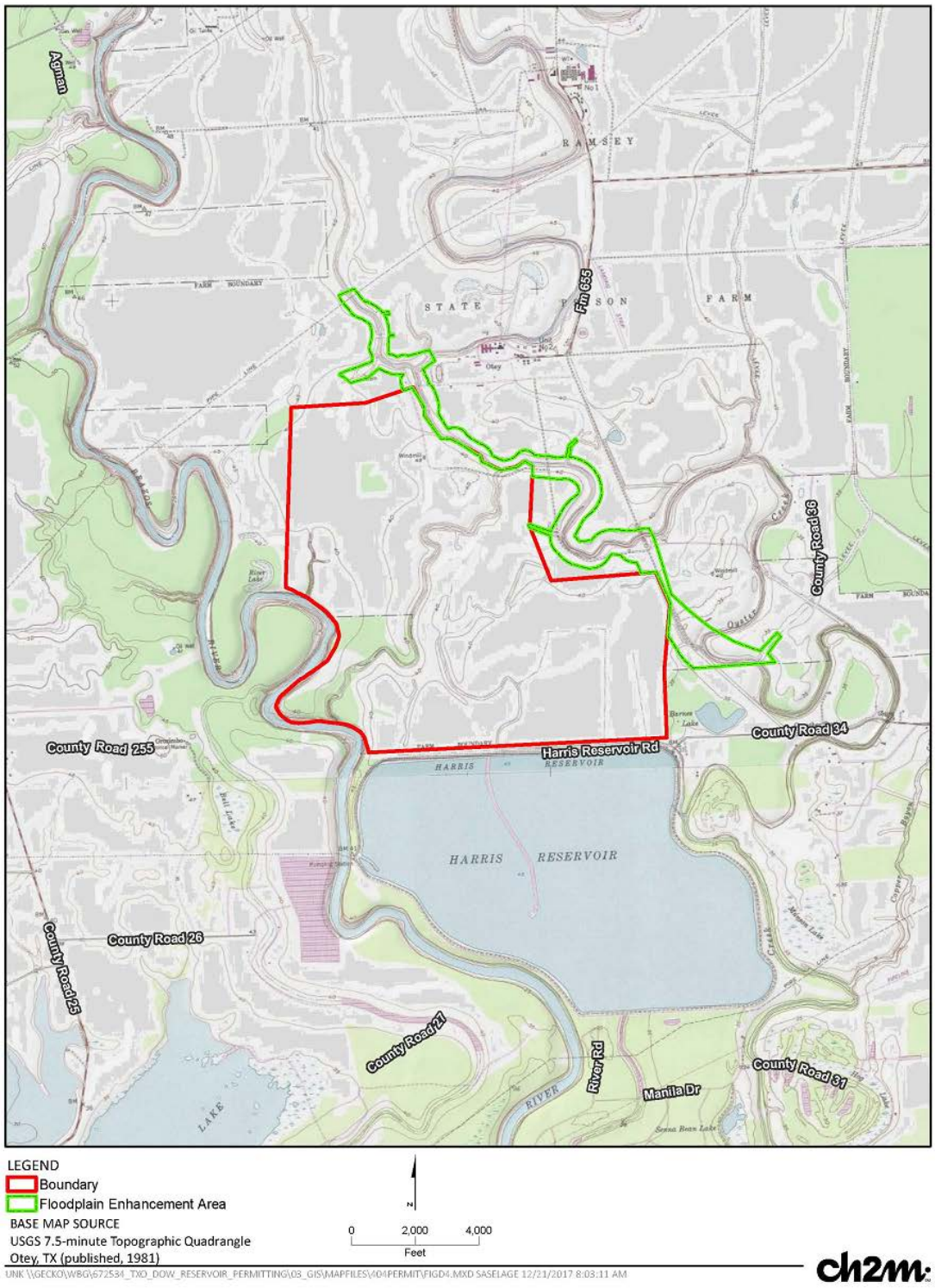


Figure D-4. Harris Expansion Project – Alternative Embankment Configuration
Harris Expansion Project Individual Permit Application

Practicability Factors

Logistical Factors: Because land acquisition and concept-level design have been completed, it is estimated that the project could be operational within five years. Furthermore, Dow currently owns sufficient Brazos River surface water rights authorized for diversion, storage and use for the project. The

outlet works would discharge water directly into Oyster Creek. This alternative received a high rating for the 4 logistical factors.

Technology Factors: The project is capable of delivering water for the Texas Operations at the high rates required and can be constructed while the current storage and conveyance system is in operation. This alternative received a high rating for the 2 technology factors.

Relative Cost Factors: Planning level costs estimates prepared by the Region H Regional Water Planning Group indicate that the annualized capital and operational costs for this alternative would be slightly more than $300/acre-foot/ year and capital costs would be approximately $2,810 per acre-foot (one-time cost not annualized over time). Dow currently owns the 2,200-acre site for the impoundment. This alternative received a high rating for the 3 relative cost factors.

This alternative practicable and would meet the need for the project.

Consequences

Threatened and Endangered Species: Impacts to threatened and endangered species under Alternative 3 would be comparable to the Preferred Alternative.

Water Quality: Impacts to water quality under Alternative 3 would be comparable to the Preferred Alternative.

Wetlands and waters of the U.S.: Surface water quality impacts to the Brazos River and Oyster Creek would be comparable to the preferred alternative. Compared with the preferred alternative, Alternative 3 would result in increased impacts to wetlands and other water of the U.S. do to the inundation of an additional wetlands and streams in the southwest portion of the project.

Aquatic Habitat: Impacts to aquatic habitat under Alternative 3 would be comparable to the Preferred Alternative.

Land Resources: Impacts to land resources under Alternative 3 would be comparable to the Preferred Alternative.

Cultural Resources: The historic sites and artifacts and prehistoric sites described for Alternative 2 (preferred alternative) are present within the project area for Alternative 3. Impacts to cultural resources associated with this project would be higher than those resulting from the proposed project due to the inundation of Historical Site 1. Development of mitigation in consultation with the Texas Historical Commission (THC) may be required.

No impacts to Native American Traditional Cultural Properties would be expected from implementation of the preferred alternative.

Attachment G includes detailed cultural resources reports presenting the results of intensive investigations of the properties.

Impacts to cultural resources under Alternative 3 would be moderate to high.

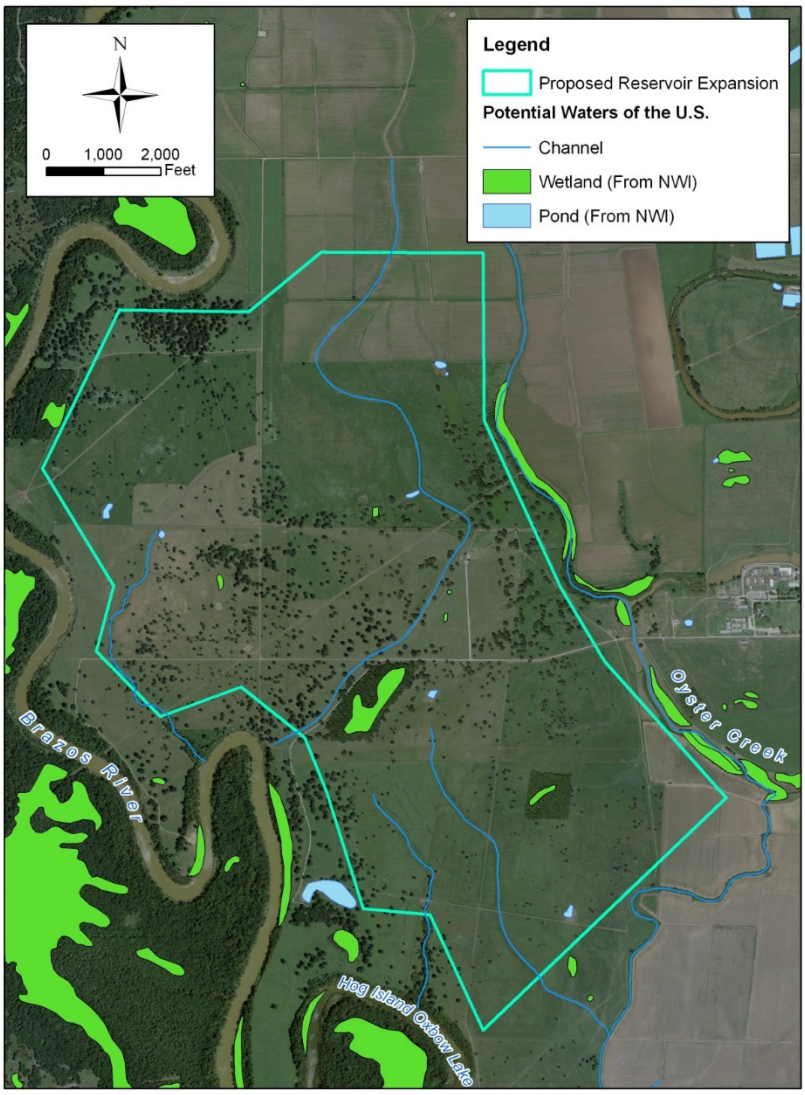
Energy Use/ Green House Gas Contribution: Impacts to energy use/GHG contributions under Alternative 3 would be comparable to the Preferred Alternative.

Environmental impacts to wetlands and water of the U.S. and cultural resources potentially resulting from the Harris Expansion Project – Alternate Configuration alternative are greater than those associated with the Preferred Alternative.

Alternative 4 – Harris Expansion Project – Alternate Location

Description

The "Harris Expansion Project – Alternate Location" alternative includes a site approximately 1.7 miles upstream from the proposed project. This location for the off-channel reservoir would provide approximately the same volume of storage capacity (approximately 45,000 – 50,000 acre-feet). Other project components would be similar to those for the proposed Harris Expansion Project (Alternative 2) and would operate in a similar fashion. **Figure D-5** illustrates the alternative location. The location in this alternative presents a technically feasible location for the off-channel reservoir.



Source: Dow 2015

Figure D-5. Harris Expansion Project – Alternate Location
Harris Expansion Project Individual Permit Application

Practicability Factors

Logistical Factors: Land acquisition and concept-level design have not been initiated for this alternative location. The project could be potentially operational within five years; however, the development schedule is uncertain. This alternate was rated as moderate/ limited for ability to be operational within five years. While the number of affected property owners is low, the current use of the site suggests that one or more sellers would be unwilling to sell the property resulting in a low rating for the land availability factor. The conveyance distance to the existing system operated by Dow for the Texas Operations site and Brazosport Water Authority is greater than for Alternatives 2 and 3. The rating for distance from conveyance factor is moderate/ limited. Dow currently owns sufficient surface water rights authorized for diversion, storage and use for this alternative; it was given a high rating for the water availability factor.

Technology Factors: The project is capable of delivering water for the Texas Operations at the high rates required and can be constructed while the current storage and conveyance system is in operation. This alternative received a high rating for the 2 technology factors.

Relative Cost Factors: Planning level costs estimates prepared by the Region H Regional Water Planning Group developed for the Harris Expansion Project indicate that the annualized capital and operational costs for this alternative would be slightly more than $300/acre-foot/ year and capital costs would be approximately $2,810 per acre-foot (one-time cost not annualized over time). For the purposes of this analysis, capital and operating costs are assumed to be approximately the same as for Alternatives 2 and 3. Dow does not own the site for this alternative location for the impoundment. This alternative received a high rating for the 2 annualized and operating cost factors and a low rating for availability/ cost to acquire land factor.

This alternative is practicable and would meet the need for the project; however, land availability provides constraints to its implementation and may render it infeasible due to logistical factors.

Consequences

Threatened and Endangered Species: The Alternative 4 site is located approximately 1.7 miles upstream from the Preferred Alternative site and habitat is not expected to be substantially different between the sites. Therefore, impacts to threatened and endangered species under Alternative 4 would be comparable to the Preferred Alternative.

Water Quality: Impacts to water quality under Alternative 4 would be comparable to the Preferred Alternative.

Wetlands and waters of the U.S.: Based on National Wetlands Inventory (NWI) and National Hydrography Dataset (NHD), five potential wetlands, six ponds, and three potential streams would be impacted by the impoundment. Five potential wetlands, three ponds, and numerous streams also would be impacted by the Preferred Alternative. Based on NWI and NHD data, impacts to wetlands and waters of the U.S. at Alternative 4 would be comparable to impacts for the Preferred Alternative. The NWI maps for this alternative have not been field verified and are only an interpretation of potential wetlands identified from an aerial photograph. Surface water quality impacts to the Brazos River and Oyster Creek would be comparable to the Preferred Alternative.

Aquatic Habitat: The Alternative 4 site is located approximately 1.7 miles upstream from the Preferred Alternative site, but it is unlikely that the substrate composition of the Brazos River would vary significantly from that of 2012 mussel survey site located south of the existing Harris Reservoir. Similar types of aquatic habitat exist on both sites and would be impacted in the same manner. Therefore, impacts to aquatic habitat as a result of Alternative 4 would be comparable to the Preferred Alternative.

Land Resources: The proposed site is not subject to local/regional zoning or land use development regulations, so there would be no impacts related to incompatible zoning. However, approximately

2,000 -2,200 acres of land would be inundated within the embankment on land currently not owned by Dow. Impacts to land resources as a result of Alternative 4 would be comparable to the Preferred Alternative.

Cultural Resources: A cultural resources investigation has not been conducted for the proposed alternative site. Given the proximity to the Preferred Alternative site, it is likely that cultural sites associated with Austin's Colony would be located on the proposed alternative site. Thus, it is anticipated that the project would have similar impacts on cultural resources as the Preferred Alternative.

Energy Use/ Green House Gas Contribution: Impacts to energy use/GHG contributions under Alternative 4 would be comparable to the Preferred Alternative.

Environmental impacts potentially resulting from the Harris Expansion Project – Alternate Location alternative would be expected to be comparable with the Preferred Alternative.

Alternative 5 - Allens Creek Reservoir

Description

The "Allens Creek Reservoir" alternative includes construction of a proposed reservoir with storage capacity of up to 145,533 acre-feet and an approximate annual yield of 99,650 acre-feet proposed in Austin County, Texas. The yield of the reservoir is primarily composed of diversions from the mainstem of the Brazos River which would be pumped via one or two pumps to the impoundment formed by a dam on Allens Creek. The maximum permitted diversion rate is 2,200 cubic feet per second (cfs) or approximately 1,400 MGD (*2016 Region H Regional Water Plan*). The proposed location of the Allens Creek Reservoir is shown in **Figure D-6**.

Surface water diversion and impoundment is authorized by a surface water right held jointly by the City of Houston, the Brazos River Authority and the Texas Water Development Board. Efforts to design and permit the reservoir were initiated by the Brazos River Authority during 2016. Construction is anticipated to be complete in approximately 10 - 15 years (2025 – 2030). Upon completion, water would be sold by the City or the Brazos River Authority to water users throughout the region. This alternative would include buying water from the Brazos River Authority, if available, and releasing it downstream to Dow's diversion structures.

Practicability Factors

The Allens Creek Reservoir alternative would not be able to utilize existing Dow-owned water rights and does not fully meet the project need; however, it was studied in more detail due to its potential to meet the water supply volume required.

Logistical Factors: The Brazos River Authority has initiated steps to develop the Allens Creek Reservoir; however, construction is not expected to begin until 2022 at the earliest. This means that the project will not be operational within five years and the project was given a low rating for that logistical factor. As noted, most of the land has been acquired and the additional property acquisition is anticipated to be completed resulting in a high rating for the affected properties factor. The reservoir is located immediately upstream of the existing Dow intake structure at the existing Harris Reservoir, resulting in a moderate/limited rating for conveyance distance.

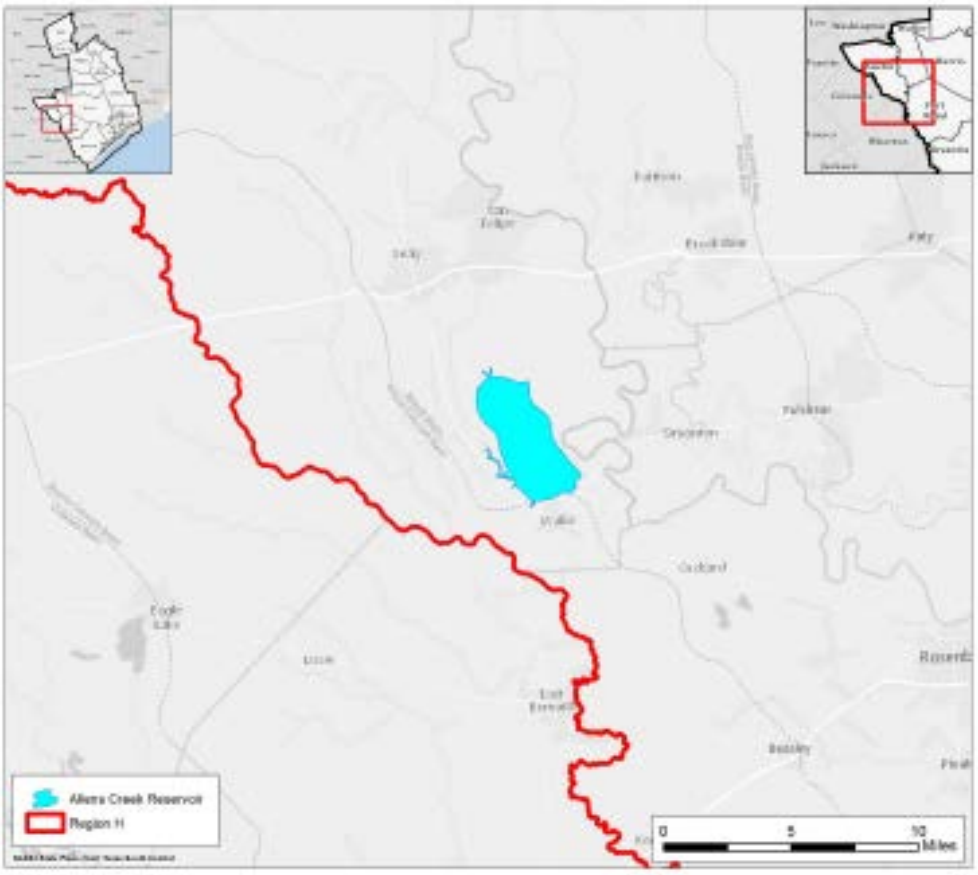
The Brazos River Authority owns 30 percent of the surface water right associated with Allens Creek Reservoir which equates to their allocation being 29,895 acre-feet of firm yield from the project. According to the 2016 Region H Regional Water Plan, however, water supply from the proposed Allens Creek Reservoir has been allocated for projected increases in water demands throughout the region for municipal, agricultural and other manufacturing/industrial sectors. Because the supply is allocated for growth in these sectors, it is not reliably available for Dow's use to reduce the risk of water shortage during drought to meet its current water demands. While it is possible that some portion of the firm

yield from Allens Creek could be available as an interruptible supply from the Brazos River Authority in the near-term, this would result in a variable water supply during drought which could result in operational impacts (e.g., production interruption) to the facilities at Texas Operations. It is unlikely that the majority of the project's calculated yield would be available for Dow's use over the long-term – particularly at the delivery rates needed during drought conditions. Therefore, a low rating was assigned for the water availability to Dow factor.

Technology Factors: The project is capable of delivering water for the Texas Operations, but is unlikely to meet the high delivery rates required during drought in light of demands by other customers. A low rating for the peak-delivery capacity was assigned. The project can be constructed while the current storage and conveyance system is in operation resulting in a high rating.

Relative Cost Factors: Planning level costs estimates prepared by the Region H Regional Water Planning Group developed for the Allens Creek Reservoir indicate that the annualized capital and operational costs for this alternative would be $231/acre-foot/ year and capital costs would be $3,173 per acre-foot (one-time cost not annualized over time). Most of the land needed to construct the Allens Creek Reservoir project has been acquired and the additional land required for the project is expected to be acquired in the near future. This alternative received a high rating for the 3 relative cost factors.

This alternative is practicable and would meet the need for the project; however, the expected development timeframe, allocation of its yield to others in the basin and uncertainty regarding its ability to meet peak delivery requirements during drought create uncertainty as to its ability to meet the project need.



Source: 2016 Region H Water Plan

Figure D-6. Allens Creek Reservoir Location
Harris Expansion Project Individual Permit Application

Consequences

Threatened and Endangered Species: According to the 2016 Region H Water Plan (*2016 Region H Regional Water Plan*, Freese and Nichols (FNI) 2000), 19 species classified as threatened or endangered by the U.S. Fish and Wildlife Service or Texas Parks and Wildlife Department are found in Austin County. None have been observed on the property; therefore, impacts are expected to be minor.

Water Quality: Due to agricultural land uses in the project area, Allens Creek is highly nutrient enriched with low dissolved oxygen concentrations. The proposed reservoir is not expected to increase water concerns in the Brazos River; retention time in the reservoir could provide opportunities for nutrients to be removed (FNI 2000). Therefore, impacts to water quality are expected to be comparable to the Preferred Alternative.

Wetlands and waters of the U.S.: Previous wetland delineations at the project location indicate that approximately 1,428 acres of wetlands would be impacted with the original design. The design was modified to avoid most of the 723-acre Alligator Hole wetland, leaving approximately 700 acres of the original 1,428 delineated acres that would be impacted (FNI 2000). Impacts to wetlands would be major without mitigation as compared with the Preferred Alternative.

Aquatic Habitat: Several fish studies have been conducted for Allens Creek. Allens Creek has a rich diversity of fish species, but not abundant game species. (FNI 2000). Impacts to aquatic habitat would be moderate and greater than those expected with the Preferred Alternative.

Land Resources: The Allens Creek reservoir would inundate approximately 7,003 acres (FNI 2000, *2016 Region H Regional Water Plan*). Impacts to land resources would be greater compared with the Preferred Alternative inundation of approximately 1,900 acres.

Cultural Resources: During the original studies conducted for the reservoir, 33 aboriginal sites three of which indicate human habitation, a burial ground from 650 B.C. to A.D. 950 with 238 burials and a second burial site were identified (FNI 2000). Major impacts to cultural resources would result from Allens Creek and would be substantially greater than those potentially resulting from the Preferred Alternative.

Energy Use/ Green House Gas Contribution:

Impacts to energy use/GHG contributions under Alternative 5 would be comparable to the Preferred Alternative.

Environmental impacts potentially resulting from the Allens Creek Reservoir alternative are greater for both wetlands and other waters of the U.S. and cultural resources than those associated with the Preferred Alternative.

Alternative 6 -Seawater Desalination

Description

Seawater desalination in the Freeport area has been evaluated by various entities over the last fifteen years[4]. Seawater desalination is included in the alternatives analysis due to the continued evaluation of this technology as a method of providing usable water for the facilities at Dow as well as the Freeport area. The capital intensity and high energy cost of desalinating seawater typically make it an alternative of last resort.

[4] The Brazos River Authority conducted a Texas Water Development Board funded feasibility analysis of a desalination project conceptually constructed and operated as a public-private partnership. The 2004 report describes a conceptual project that would be phased in over time. Desalination projects were included in the 2011 Region H Regional Water Plan and the 2016 Region H Regional Water Plan. Yield vary among the projects and information from both the 2011 and 2016 Region H Regional Water Plans was used in this analysis.

The 2016 Region H Regional Water Plan includes an 11,200 acre-feet seawater desalination project to be constructed in the 2040 timeframe. The project would include diversion of seawater using an existing intake facility, a 10 MGD reverse osmosis plant, an existing outfall to discharge brine concentrate into the Gulf of Mexico via the Brazos River and raw water and treated water conveyance facilities.

The 2011 Region H Regional Water Plan included a similar desalination project sized to produce 33,600 acre-feet per year (Region H 2010, TWDB 2016). Information from the initial, larger project as well as the 11,200 acre-foot project studies has been used for this alternatives analysis. Note that to meet the project need, a desalination project would need to be expanded significantly from the representative projects previously studied. Given the limited availability of existing storage to support Dow fresh water rights, a 100+ MGD plant would be needed to meet the approximate 430 acre-foot per day (97,000 gallons per minute) water demands. **Figure D-7** presents the updated location for a potential desalination facility due to the conceptual location of the 10 MGD alternative studied by the Region H Water Planning Group is no longer available. It is assumed for this analysis that the studied plant could be upsized at the proposed location to meet the project need.

Practicability Factors

The seawater desalination alternative would be able to utilize existing Dow-owned seawater rights however, it does not fully meet the project need due to the storage requirements necessary to be prepared for a drought. It was studied in more detail due to its potential to meet the water supply volume required.

Logistical Factors: The plant would need to be sited in proximity to the available seawater with the existing water rights, and the intake design, salty sludge disposal and brine discharges would require authorization by the Texas Commission on Environmental Quality. Hence, it would be more difficult to ensure that a large seawater desalination plant could be operational within five years resulting in a low rating for that factor.

This scenario utilizes an identified Dow-owned property however, the currently identified location for a potential desalination plant would place it in proximity to the seawater intake with existing seawater rights, but would result in greater herbaceous **(**PEM) wetland impacts than the preferred reservoir expansion project. The resulting rating for number of properties needed is high. The distance to the existing treated water conveyance system is estimated at less than 20 miles. For these reasons, the conveyance and available water rights factor were given moderate and high ratings respectively.

Technology Factors: Constructing a seawater desalination facility capable of producing approximately 100-140 MGD during limited drought conditions is feasible, but impractical. The size of the facility to meet the project need about 6 percent of the time when the need will occur based on TCEQ's Water Availability Model is not reasonable. The rating for this factor is low. The project is, however, able to be constructed without disruption to the existing water supply system resulting in a high rating for this factor.

Relative Cost: Planning level costs estimates prepared by the Region H Regional Water Planning Group developed for the 11,200 acre-feet per year project indicate that annualized capital and operating costs are calculated to be $2,454 per acre-foot of delivered water (more than 8 times the calculated cost for the preferred alternative) and capital costs would be $11,869 per acre-foot (one-time cost not annualized over time) which is more than 4 times greater than the preferred alternative.

The presented unit cost estimates would be expected to decrease incrementally as the annual yield of the project increases; however, the cost of desalinated seawater would remain significantly higher than the other options. This alternative was given a low rating for the relative cost factors and relative energy consumption.

Available sites for an expanded desalination facility are limited. The location identified for this analysis (Figure D-7) is an available site within the vicinity of accessible seawater. This location has 50 out of 53 acres of herbaceous (PEM) wetlands which would be impacted by the project. Other locations considered to be able to efficiently access coastal water for a desalination project would have considerable wetlands impacts.

This alternative is not practicable, but could potentially meet the need for the project if upsized; however, the expected development timeframe, extraordinary high costs and capacity required to meet peak delivery requirements during drought conditions which is intermittent and unpredictable would result in uncertainty as to its practicability to meet the project need.

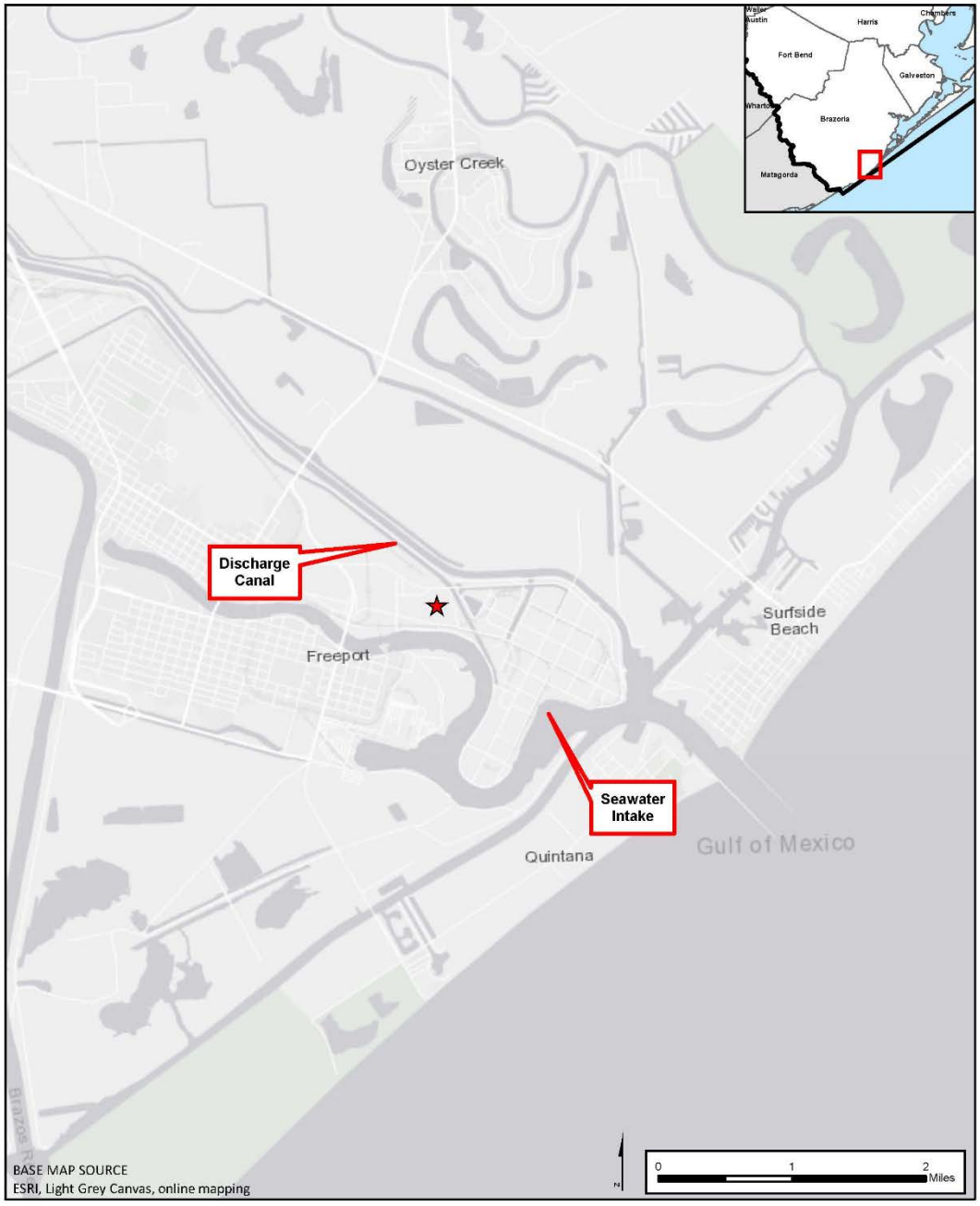


Figure D-7. Seawater Desalination Alternative Location
Harris Expansion Project Individual Permit Application

Consequences

Threatened and Endangered Species: Minor impacts to threatened and endangered species would occur as a result of the proposed alternative. The federally-listed hawksbill sea turtle, leatherback sea turtle, green sea turtle, loggerhead sea turtle, and Kemp's Ridley sea turtle have the potential to occur within the proposed project area for Alternative 6. However, the use of existing intake and outfall structures would reduce impacts to sea turtles that may occur during construction of these structures. The treatment facility would be located near the Texas Operations site and would have negligible impacts to terrestrial threatened and endangered species or their habitats.

No designated critical habitat, as defined by the ESA, is in or near the project area. There would be no impacts to critical habitat.

Water Quality: Discharged concentrate (brine water) may include water with warm temperature containing residues of pre-treatment and cleaning chemicals, their reaction byproducts, and heavy metals. Moderate impacts to water quality would occur as a result of the discharge of brine water resulting from the treatment process (i.e., concentrate) into the existing waste water canal and ultimately into the Brazos River.

Wetlands and waters of the U.S.: The desalination plant would impact approximately 50 acres of potentially jurisdictional wetlands near the Plant A site evaluated. Increasing the footprint of the plant to meet the project need would be expected to increase impacts to wetlands and waters of the U.S. Major impacts to wetlands and waters of the U.S. would occur as a result of the proposed alternative. Additionally, it is likely that the proposed pipeline alignments needed to distribute the treated water throughout the complex and treatment facility would impact wetlands and other waters of the U.S. Therefore, this alternative would have greater impacts than the proposed project.

Aquatic Habitat: Moderate impacts to aquatic habitat would occur as a result of the discharge of the concentrate (brine water). The constant discharge of reject streams with high salinity and temperature levels can be fatal for river and marine life and may cause a permanent change in the species composition and abundance at the discharge site. Mitigation measures such as brine water dilution with seawater or cooling water could be implemented to reduce impacts to aquatic habitat at the discharge site. With appropriate management, impacts to aquatic habitat would be minor to moderate.

Land Resources: The proposed site is located within a heavily industrialized area that is owned and operated by Dow or other industrial facilities. This alternative would have negligible impacts on land resources.

Cultural Resources: The treatment facility is located within a heavily industrialized area and the proposed pipelines would parallel existing alignments whenever possible, reducing the chance of impacting unidentified cultural resource sites. Negligible or minor impacts to cultural resources would occur as a result of the proposed alternative.

Energy Use/ Green House Gas Contribution: Energy requirements for seawater desalination average about 15,000 kWh per million gallons of water produced (Brazos River Authority (BRA) 2004. *The Freeport Seawater Desalination Plant Report*)[5]. Through increased energy use for treatment, desalination can cause an increase in GHG emissions. Alternative 6 would have moderate and long-term impacts on energy use and GHG contributions. The alternatives with next highest energy use (Alternatives 2, 3 and 4) are estimated to use 14 percent of the energy of this alternative. Therefore, energy use and greenhouse gas contributions would be substantially higher than those for the Preferred Alternative as well as the other alternatives identified.

[5] Energy requirements for this alternative were extrapolated from the 2004 report for this alternative and include estimated requirements for treatment only. Pumping required for distribution would be greater.

Comparison of Alternatives Carried Forward

A detailed evaluation of practicability factors is summarized in **Table D-5**. Potential environmental impacts of the alternatives described in this section are summarized in **Table D-6** for the practicable alternatives. The preferred alternative, Harris Expansion Project is the least environmentally damaging practicable alternative based on this analysis.

Table D-5. Evaluation of Alternatives for Practicability
Harris Expansion Project Individual Permit Application

Alternative ○ = Low ◒ = Moderate/ Limited ● = High	**No Action (1)**	**Harris Expansion Project (2)**	**Different Embankment Configuration (3)**	**Different Site Location (4)**	**Allens Creek Reservoir (5)**	**Seawater Desalination (6)**
Overall Project Purpose Factors						
Ability to provide reliable water supply for Texas Operations during extended drought (reliable is defined as: 1) available during a drought, and 2) able to deliver supply at rates equal to water demand to Dow and those they serve on a daily/weekly basis)	○	●	●	●	◒	●
Ability to use existing Dow-owned surface water rights diverted within the authorized diversion segment	○	●	●	●	○	●
Logistical Factors						
Ability to be operational within 5 years	N/A	●	●	◒	○	◒
Property rights / # of property owners affected	N/A	●	●	○	●	●
Conveyance distance to existing conveyance system (greater distances reduce reliability due to main breaks or evaporation)	N/A	●	●	◒	◒	○
Water availability/ water right availability to Dow (either new permits or through agreement/ acquisition)	N/A	●	●	●	○	●
Technology Factors						
Project capable of high peak delivery rates (e.g., 3000 acre-feet per week) with reasonably-sized capital facilities	N/A	●	●	●	○	○
Project capable of being constructed with existing water supply system (Harris and Brazoria reservoirs) remaining in operation	N/A	●	●	●	●	●

Table D-5. Evaluation of Alternatives for Practicability
Harris Expansion Project Individual Permit Application

Alternative ○ = Low ◒ = Moderate/ Limited ● = High	**No Action (1)**	**Harris Expansion Project (2)**	**Different Embankment Configuration (3)**	**Different Site Location (4)**	**Allens Creek Reservoir (5)**	**Seawater Desalination (6)**
Relative Cost Factors						
Annual unit cost per acre-foot per year (annual capital and operations & maintenance)	N/A	●	●	●	●	○
Unit capital cost per acre-foot	N/A	●	●	●	●	○
Availability of suitable land for project at reasonable cost	N/A	●	●	○	●	●

Table D-6. Summary of Potential Environmental Consequences
Harris Expansion Project Individual Permit Application

○ = Low ◒ = Moderate/ Limited ● = High	**Threatened/ Endangered Species**	**Surface Water Quality**	**Wetlands/ Waters of the U.S.**	**Aquatic Ecosystem**	**Land (subsidence/ non-Dow land)**	**Cultural Resources**	**Energy / GHG**
1 - No Action	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2 - Harris Expansion Project (Proposed Project)	○	○	◒	○	○	◒	○
3 - Harris Expansion Project –Alternate Embankment Configuration	○	○	◒	○	○	●	○
4 - Harris Expansion Project – Alternate Location	○	○	◒	○	●	◒●	○
5 - Allens Creek Reservoir	○	○	●	◒	◒	●	○
6 – Seawater Desalination	◒	◒	●	◒	○	○	●

Alternatives Considered but Eliminated from Further Analysis

The first step for this analysis was to screen out those preliminary alternatives found to be not practicable or that would not meet the project's overall purpose or need. For the purpose of this analysis, practicable is defined as alternatives which can be implemented to meet the project purpose and need after costs, existing technology, and/or logistic factors are considered. Additional considerations are whether the alternative includes a special aquatic site as defined by the Clean Water

Act (CWA). The guidelines cover all waters of the U.S. but afford special aquatic sites a higher level of scrutiny and protection. Special aquatic sites include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and stream riffle and pool complexes. From a national perspective, the degradation or destruction of special aquatic sites is considered among the most severe environmental impacts covered by the guidelines. However, due to the water dependent nature of the proposed project, all the structural alternatives involve a special aquatic site. This screening process resulted in the following 9 alternatives being eliminated from further analysis for the reasons identified in this section and summarized in **Table D-1**.

Alternative B - Enhanced Conservation

The Enhanced Conservation alternative includes capital projects and operational changes within the Texas Operations site that would reduce water consumption by an additional 10 percent (approximately 20,000 acre-feet) per year. Water potentially saved from such measures is planned to offset future growth in water supply needs should manufacturing at the Texas Operations site increase in the future.

Dow has implemented water-efficiency measures at their facilities resulting in permanent water savings of approximately 20,286 acre-feet per year - an approximate ten percent reduction of their freshwater demand from the Brazoria and Harris Reservoirs. The Texas Commission of Environmental Quality recognized Dow with an Environmental Excellence Award for the water-savings achievements (TCEQ 2016b). Implemented water conservation measures at Texas Operations include implementing more efficient closed loop cycle cooling. Other conservation projects replaced surface water diversions with recycled process water (soft water). These measures have reduced daily water demands but are not sufficient to provide a reliable water supply during drought.

Therefore, while in the near-term, such measures could reduce daily water demand from Dow's existing water supply and storage system, long-term reductions in daily demand would not be expected as a result of implementing the Enhanced Conservation alternative. Additionally, Dow has estimated that reducing its water demand by 33 percent – if possible – would only extend its existing storage by one month (Dow 2014).

The Enhanced Conservation alternative does not meet the purpose of or need for a reliable water supply for the Texas Operations facilities during extended drought conditions. Therefore, it was not evaluated in detail.

Alternative C - Expanded Reclaimed Water Use

The Expanded Reclaimed Water Use alternative includes use of municipal reclaimed water from the cities of Alvin and Freeport delivered via the bed and banks of Oyster Creek or via pipeline to the Texas Operations distribution system. The projected water demand in 2020 for the cities is 4,644 acre-feet and 1,283 acre-feet, respectively (*2016 Region H Regional Water Plan*). Assuming that 70 percent of water used is treated and discharged and available for reuse, up to approximately 4,150 acre-feet per year (80 acre-feet per week) could be available in an Expanded Reclaimed Water Use alternative. This volume is substantially below Dow's weekly water demand of approximately 3,000 acre-feet per week.

The Expanded Reclaimed Water Use alternative does not create sufficient volume to meet the need for the project. Therefore, it was not evaluated in detail.

Alternative D - Utilize Existing Stored Water or Underutilized Run-of River Rights in Brazos River

The "Utilize Stored Water or Underutilized Run-of-River Rights in the Brazos River" alternative includes executing contract (s) with the Brazos River Authority (BRA) to purchase additional stored water from upstream reservoirs and/or supplementing water supply with water rights acquisition or lease from

other water right holders in the basin. An assessment of the surface water rights available for transfer in the Brazos River concluded that in the Brazos River basin, most of the water use is for industrial or municipal purposes, rather than agriculture. Most municipal and industrial water rights would not be available for acquisition by Dow as the water right holders need to maintain their rights for their own current or future needs. Opportunities to lease agricultural water rights or implement agricultural water conservation measures in exchange for downstream diversion by Dow were considered to provide minimal water supply benefits (Reddy, et al. 2015).

The volume of available water, conveyance losses due to seepage and evaporation and the "junior[6]" status of many of the agricultural rights in the basin result in a project alternative to acquire underutilized surface water rights in the basin not providing a reliable water supply sufficient to meet the purpose of and need for the project. Therefore, it was not evaluated in detail.

Alternative E - Modification of Existing Harris Reservoir

The "Modification of Existing Harris Reservoir" alternative includes activities such as dredging, deepening or raising the embankment of the existing Harris Reservoir to expand the storage capacity.

Expanding the storage capacity of the Harris Reservoir was evaluated at a conceptual level. Technical issues related to dam safety were identified during the analysis. It is unlikely that dredging or deepening the reservoir would provide the needed storage capacity. Therefore, modification of the reservoir to expand the storage capacity would not meet the primary purposes of the project. Additionally, the ability to maintain operations of the reservoir to meet water needs at the Texas Operations site during construction poses challenging constructability issues.

Technical and constructability issues associated with modification of the existing Harris Reservoir render this alternative not practicable. Therefore, it was not evaluated in detail.

Alternative F – Modification of Existing Brazoria Reservoir

The "Modification Existing Brazoria Reservoir" alternative includes activities such as dredging, deepening or raising the embankment of the existing Brazoria Reservoir to expand the storage capacity.

Expanding the Brazoria Reservoir, if feasible, would not provide Dow access to low river flows during drought due to the upstream movement of saline water in the lower Brazos basin during low flow conditions (e.g., the salt water wedge in the lower Brazos River). Historically, Dow has had to cease diversions from the Brazos River intake to the Brazoria Reservoir due to the salt water intrusion.

There are technical difficulties related to dam safety in potentially raising the embankment to expand the storage capacity. It is unlikely that dredging or deepening the reservoir would provide the needed storage capacity. Therefore, modification of the reservoir to expand the storage capacity would not meet the primary purposes of the project.

Salt water intrusion that limits diversions to Brazoria Reservoir during low flow conditions and technical and constructability issues associated with the expansion of the existing Brazoria Reservoir render this alternative not practicable. Therefore, it was not evaluated in detail.

Alternative K – Aquifer Storage and Recovery

The "Aquifer Storage and Recovery (ASR)" alternative includes an ASR well field(s) (either 10 MGD or 14 MGD) in central Brazoria County near Brazosport Water Authority water treatment plant and

[6] In Texas, water rights are authorized under the Prior Appropriations Doctrine which means that water rights have priority, or seniority, based on their appropriation date. That is, during times of water shortage, newer, or junior rights, must forego diversion so that senior waters can be satisfied. This makes junior water rights without storage less reliable than senior water rights. Dow's water rights are among the most senior in the Brazos River basin.

conveyance facilities that could be operated to store treated water during low demand months for retrieval and distribution during summer months. This would provide operational flexibility to maintain storage water in the existing Dow water system reservoirs.

In addition to the well field, the alternative would include conveyance facilities to transport water to Oyster Creek from where it would be diverted and conveyed to the Texas Operations distribution system. Potentially, a new water treatment plant or expanding capacity would be required if the existing Brazosport Water Authority plant provides insufficient treatment capacity to support treatment of water prior to injection into the ASR well field (HDR 2013).

The project would not provide sufficient storage nor ASR well recovery capacity to deliver up to 3,000 acre-feet per week. Expanding the wellfield is not practicable due to land availability constraints near the Brazosport Water Authority facilities. Expansion of the water treatment plant to treat peak flows prior to injection to support a larger project are cost prohibitive.

Additional capital facilities and limited land availability land, and capital and operating cost factors render this alternative not practicable. Therefore, it was not evaluated in detail.

Alternative L - Surface Water from Adjacent Basins

The "Surface Water from Adjacent Basins" alternative includes an interbasin transfer of water from the Colorado River to the west or the Trinity River to the east. In Texas, surface water rights that leave the basin of origin via interbasin transfers lose their seniority and become the most junior right at the time that the interbasin transfer is authorized[7]. An interbasin project would require storage in the basin of origin or near the Texas Operations site to provide a firm yield providing a reliable water supply that could deliver water at needed rates during drought conditions.

Surface water in the Colorado River basin is fully appropriated. Additionally, the Lower Colorado River Authority, the largest water right holder in the basin suspended delivery of interruptible water from its main storage reservoirs north of Austin (lakes Buchannan and Travis) to downstream users for three years during 2012-2014. Therefore, water supply from the Colorado River is not anticipated to be available for Dow's use.

Potentially, surface water from the Trinity River basin could be available for acquisition by Dow for use at the Texas Operations through a water purchase agreement from the Trinity River Authority. Based on recent permitting processes and water supply agreements in Texas, acquisition of the required regulatory authorizations (e.g., surface water permit amendments) would take several years, the water supply agreement would likely include a temporary term (i.e., would not be a permanent water source) and construction of a storage reservoir would be required.

Additional capital facilities, higher energy requirements, limited water availability, water rights constraints, potential impacts to instream flows and freshwater bay and estuary inflows in the basins of origin, costs and regulatory approvals within the timeframe that the project is needed render this alternative not practicable. Therefore, it was not evaluated in detail.

Alternative M - Local Groundwater Supply

The "Local Groundwater Supply" alternative includes construction of a wellfield in Brazoria or Matagorda counties to produce groundwater from the Chicot and Evangeline Aquifers and conveyance facilities to transport water to the Texas Operations distribution system (HDR 2013). Groundwater supply in Brazoria County is primarily from the Chicot aquifer. Water level declined during the 1980s and 1990s; however, water levels recovered and stabilized since regulatory measures were established to

7 There are a few water rights in Texas that include the explicit authorization for interbasin transfer without loss of seniority; however, those are not the standard water right.

reduce groundwater pumping to minimize land subsidence in the region. Similarly, groundwater pumping in Matagorda County is also primarily from the Chicot aquifer. Water levels are somewhat stable with declines projected based on estimated annual average pumping increases in the future.

In both Brazoria and Matagorda counties, annual historical pumping has exceeded the volume of Modeled Available Groundwater, an amount of water established by regional groundwater planning groups within Groundwater Management Area 14 established by the state. While groundwater conservation districts with jurisdiction over groundwater can issue production permits in excess of the Modeled Available Groundwater, they also have the authority to reduce permitted production in excess of the Modeled Available Groundwater volume during the life of the project. Such potential reductions in authorized production make this an unreliable water supply option over time (HDR 2013).

Due to limited volume of permittable groundwater production, uncertainty over future availability of groundwater in Brazoria and Matagorda counties and concerns regarding land subsidence, the Local Groundwater alternative is considered not practicable. Therefore, it was not evaluated in detail.

Alternative N – Remote Groundwater Supply

The "Remote Groundwater Supply" alternative includes construction of a wellfield in southeast Wharton County to produce up to 17,500 acre-feet/year of new water supply from the Chicot and Evangeline aquifers in southeast Wharton County. Conveyance to the Texas Operations distribution system would be accomplished via a 26-mile transmission pipeline to the Brazos River where the water would be conveyed via the bed and banks of the river to Dow's existing diversion facilities from where it would be diverted and conveyed to the Texas Operations distribution system (HDR 2013).

In Wharton County, annual historical pumping has exceeded the volume of Modeled Available Groundwater, an amount of water established by regional groundwater planning groups within Groundwater Management Area 14 established by the state. Assessment of historical pumping, changes in groundwater levels resulting from pumping and regulatory constraints were factors used in developing the project yield. It is unlikely that a wellfield designed to meet the peak capacity needed to meet needs at the Texas Operations site would be permitted. While the Coastal Bend Groundwater Conservation District, the political subdivision with jurisdiction over groundwater production in Wharton County has the authority to issue production permits in excess of the Modeled Available Groundwater volume, it also has the authority to reduce permitted production in excess of the Modeled Available Groundwater volume during the life of the project. Such potential reductions in authorized production make this an unreliable water supply option over time (HDR 2013).

Due to limited volume of permittable groundwater production, uncertainty over future availability of groundwater in Wharton County and the additional land resources needed to develop an approximate 50,000 acre-foot project with the ability to delivery approximately 3,000 acre-feet per week during drought conditions, the Remote Groundwater Supply alternative is deemed to not meet the purpose and need for the project and is considered not practicable. Therefore, it was not evaluated in detail.

Alternative P - Lake Somerville Augmentation

The "Lake Somerville Augmentation" alternative includes construction of a pump station and pipeline to deliver high flows from the Brazos River to increase the firm yield up to an additional 22,800 acre-feet per year in the existing Lake Somerville located in Burleson, Lee and Washington counties (*2016 Region H Regional Water Plan*). The alternative would include buying water released from Lake Somerville from the Brazos River Authority, if available. Stored water releases would be conveyed via the bed and banks of the Brazos River to Dow's existing diversion facilities and delivered to the Texas Operations water distribution system. Because Lake Somerville is owned by the U.S. Army Corps of Engineers (although the water rights are owned by the Brazos River Authority), coordination and permitting would be required to implement this alternative. The project is conceptually identified for implementation

sometime between 2020 and 2030; additional supply may not be available by 2021 to meet the need for the project.

Some estimates indicate that a range of 15 to 30 percent of water released from the central Brazos River basin would be lost to seepage and evaporation, leaving a range of 15,960 – 19,380 acre-feet per year available for diversion for Dow – assuming they had access to all the supply created through this alternative. The Brazos River Authority and the Region H Regional Water Plan project increased water demands in the central basin due to population growth in the area, so it is unlikely that this supply would be available for Dow at the delivery quantities needed to maintain supply at the Texas Operations.

Due to uncertainty regarding availability of the supply, implementation schedule and the project's inability to meet Dow's water delivery needed, this is not a practicable alternative to meet the purpose of and need for the project. Therefore, it was not evaluated in detail.

Preliminary Public Interest Review Screening

The ultimate decision by the USACE as to whether to issue a permit will be based on an evaluation of the probable impacts of the proposed activity and its intended use on the public interest. The public interest review requires the careful weighing of expected benefits balanced against reasonably foreseeable detriments. Thus, one specific factor (e.g., fish and wildlife values or economics) cannot by itself force a specific decision, but rather the decision represents the net effect of balancing all public interest factors, many of which are frequently in conflict. 33 CFR Part 320, General Regulatory Policies, direct the USACE to consider the following general criteria in the evaluation:

i. The relative extent of the public and private need for the proposed structure or work:

ii. Where there are unresolved conflicts as to resource use, the practicability of using reasonable alternative locations and methods to accomplish the objective of the proposed structure or work; and

iii. The extent and permanence of the beneficial and/or detrimental effects which the proposed structure or work is likely to have on the public and private uses to which the area is suited (33 CFR Part 320.4).

While recognizing that the USACE will further evaluate (and consult with other federal agencies during the permit review process to assess the overall benefits or detriment for some public interest factors, as a committed community partner within the Brazoria County area, Dow prepared a preliminary assessment of the alternative projects' consistency with public interest criteria as part of its evaluation of alternative projects. **Table D-7** provides a preliminary evaluation in which comparisons of public interest benefits versus detriments are framed with "yes" and "no" determinations with "yes" meaning public interest benefits accrued outweigh or are reasonably balanced against foreseeable detriments, and "no" meaning benefits accrued do not outweigh or are not reasonably balanced against foreseeable detriments (USACE 2014). Some factors may not be applicable for some alternatives and are so noted (GPO 2012).

Table D-7. Preliminary Public Interest Review Screening
Harris Expansion Project Individual Permit Application

Public Interest Category	Description	Alternative 1 No Action	Alternative 2 Harris Expansion Project	Alternative 3 Harris Expansion Project – Alternate Embankment Configuration	Alternative 4 Harris Expansion Project – Alternate Location	Alternative 5 Allens Creek Reservoir	Alternative 6 Seawater Desalination
Conservation	Evaluated on benefit or detriment to existing, proposed, or potential future conservation lands.	N/A	Yes	Yes	Yes	Yes	Yes
Economics	Evaluated on the economic benefits important to the local community and whether needed improvements in the local economic base are contributed, affecting such factors as employment, tax revenues, community cohesion, community services, and property values.	No	Yes	Yes	Yes	Yes	Yes
Aesthetics	Evaluated on level of improvement or disturbance to existing visual amenities.	N/A	Yes	Yes	Yes	Yes	Yes
General environmental concerns	Evaluated on the result in beneficial effects or detriments to the quality of the environment.	N/A	Yes	Yes	Yes	Yes	Yes
Wetlands	Wetlands are a productive, valuable public resource which serve significant biological functions, serve as resources for study of aquatic environments and sanctuaries, shield other areas from wave action, erosion, and storm damage, and store storm and flood waters. Wetlands are ground water discharge areas that maintain minimum base flows and are important to aquatic habitat, and serve water purification functions. The alteration or destruction of wetlands can affect natural drainage, sedimentation patterns, salinity distribution, flushing and other environmental characteristics. Evaluated on overall impact on the values and benefits of wetlands listed.	N/A	Yes	Yes	Yes	Yes	Yes
Historic properties	Full evaluation of the general public interest requires that due consideration be given to the effect which the proposed structure or activity may have on values such as those associated with wild and scenic rivers, historic properties and National Landmarks, National Rivers, National Wilderness Areas, National Seashores, National Recreation Areas, National Lakeshores, National Parks, National Monuments, estuarine and marine sanctuaries, archeological resources, including Indian religious or cultural sites, and such other areas as may be established under federal or state law for similar and related purposes.	N/A	Yes	No	Yes	Yes	Yes
Fish and wildlife values	Evaluated on the conservation of wildlife resources by prevention of their direct and indirect loss and damage.	N/A	Yes	Yes	Yes	Yes	Yes
Flood hazards	Evaluated on the avoidance of floodplain development and if there are no practicable alternatives, which avoid floodplain development, whether any significant adverse impact to the floodplain can be effectively mitigated.	N/A	Yes	Yes	Yes	Yes	Yes
Floodplain values	Evaluated on long and short term significant adverse impacts associated with the occupancy and modification of floodplains, as well as the direct and indirect support of floodplain development whenever there is a practicable alternative.	N/A	Yes	Yes	Yes	Yes	Yes
Land use	Evaluated on whether changes to existing zoning or other land use controls are required and whether there is encroachment on adjacent incompatible land uses.	N/A	Yes	Yes	Yes	Yes	Yes
Navigation	Navigable waters of the United States are those waters of the United States that are subject to the ebb and flow of the tide shoreward to the mean high water line and/or those waters that are presently used, or have been used in the past or may be susceptible to use for interstate or foreign commerce. These are waters that are navigable in the traditional sense. Permits are required in these waters pursuant to Section 10 of the Rivers and Harbors Act.	N/A	Yes	Yes	Yes	Yes	Yes
Shore erosion and accretion	Evaluated on potential to widen or narrow of waters of the US and the benefits or detriments to human use and aquatic habitat resulting from these changes.	N/A	Yes	Yes	Yes	Yes	Yes

Table D-7. Preliminary Public Interest Review Screening
Harris Expansion Project Individual Permit Application

Public Interest Category	Description	Alternative 1 No Action	Alternative 2 Harris Expansion Project	Alternative 3 Harris Expansion Project – Alternate Embankment Configuration	Alternative 4 Harris Expansion Project – Alternate Location	Alternative 5 Allens Creek Reservoir	Alternative 6 Seawater Desalination
Recreation	Existing natural resources, such as wild and scenic rivers, can have significant recreational value, which is important to the general public interests, and both potentially negative and positive effects on overall recreational value. The values of recreational benefits are evaluated on overall potential changes to current recreational opportunities.	N/A	N/A	N/A	N/A	N/A	N/A
Water supply and conservation	Water conservation requires the efficient use of water resources in all actions which involve the significant use of water or that significantly affect the availability of water for alternative uses including opportunities to reduce demand and improve efficiency to minimize new supply requirements. Actions affecting water quantities are subject to Congressional policy as stated in section 101(g) of the Clean Water Act which provides that the authority of states to allocate water quantities shall not be superseded, abrogated, or otherwise impaired.	No	Yes	Yes	Yes	Yes	Yes
Water quality	Evaluated for compliance with applicable effluent limitations and water quality standards, during the construction and subsequent operation of the proposed activity. It should be noted, however, that the Clean Water Act assigns responsibility for control of non-point sources of pollution to the states. Certification of compliance with applicable effluent limitations and water quality standards required under provisions of section 401 of the Clean Water Act will be considered conclusive with respect to water quality considerations unless the Regional Administrator, Environmental Protection Agency (EPA), advises of other water quality aspects to be taken into consideration.	N/A	Yes	Yes	Yes	Yes	Yes
Energy needs	Energy conservation and development are major national objectives. Evaluated based on energy requirements, potential for conservation and development with high priority to alternatives involving energy projects.	N/A	Yes	Yes	Yes	Yes	No
Safety	Evaluated on overall risks for human health and/or the creation of unsafe conditions for those with access.	N/A	Yes	Yes	Yes	Yes	Yes
Food and fiber production	Evaluated on the degree of impact on existing and potential food and fiber production properties.	N/A	Yes	Yes	Yes	Yes	Yes
Mineral needs	Evaluated on the benefits or detriment to existing or potential future mineral production.	N/A	N/A	N/A	N/A	N/A	N/A
Considerations of property ownership	Evaluated on whether the property is available and can be used for the project purpose without disproportionately impeding on the rights for private land use, the general right to protect property from erosion, and riparian landowners general right of access to navigable waters of the US.	N/A	Yes	Yes	Yes	Yes	Yes
Needs and welfare of the people	Evaluated on overall benefit or detriment to current and future population of Brazoria County.	No	Yes	Yes	Yes	Yes	Yes

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PLAN

Conceptual Mitigation Plan for the Harris Expansion Project Brazoria County, Texas

Prepared for

The Dow Chemical Company

January 2018

ch2m

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Acronyms and Abbreviations

Cardno	Cardno ENTRIX, Inc. or Cardno
CH2M	CH2M Hill Engineers, Inc.
CFR	Code of Federal Regulations
CWA	Clean Water Act
District	U.S. Army Corps of Engineers Galveston District
Dow	The Dow Chemical Company
iHGM	interim hydrogeomorphic model
OHWM	Ordinary High Water Mark
PEM	palustrine emergent wetlands
PFO	palustrine forested wetlands
PUB	palustrine unconsolidated bottom wetlands
WOUS	waters of the United States
USACE	U.S. Army Corps of Engineers

SECTION 1

Introduction

At the request The Dow Chemical Company (Dow), CH2M HILL Engineers, Inc. (CH2M) prepared this conceptual mitigation plan (the Plan) in accordance with the U.S. Army Corps of Engineers (USACE) Regulatory Program regulations 33 *Code of Federal Regulations* (CFR) 320-331 and 40 CFR 230 for the compensation of unavoidable impacts to Waters of the United States (WOUS) associated with the proposed Harris Expansion Project (Project), in Brazoria County, Texas. This Plan is intended as a supplement to the Clean Water Act (CWA) Section 404/Rivers and Harbors Appropriation Act Section 10 Individual Permit application to be submitted for the project to USACE Galveston District (District).

A preliminary application meeting was held with the U.S. Army Corps of Engineers (USACE) Galveston District (District) on December 11, 2017, to review the proposed project elements and alternatives, as well as the approach for permitting and potential mitigation for impacts to WOUS. Cardno ENTRIX, Inc. (Cardno) biologists conducted two field surveys of the project site from February 28 to March 5, 2012 and April 13 and April 27, 2017. CH2M biologists conducted wetland and stream assessment evaluations of the project site from April 11 to April 14, 2016 and from April 13 to April 27, 2017. The purpose for the project site field surveys was to assess and quantify the ecological functions of the WOUS present at the site to help the project planning and development to identify an alternative site design to avoid and minimize environmental impacts, while still meeting the project's purpose and need. The ecological functions of the resources at potential and final onsite mitigation locations were also assessed so that any loss of ecological functions from the unavoidable impacts from the proposed project could be compensated.

1.1 Mitigation Goals and Objectives

The goal for the development of project-specific mitigation strategies is to fully compensate the unavoidable impacts from the proposed project and to provide an overall improvement to the Oyster Creek watershed near the project. Compensatory mitigation strategies presented in this plan follow 33 *Code of Federal Regulations* (CFR) 320-331 and 40 CFR 230 guidance provided in the District's "Level 1-Stream Condition Assessment for All Ephemeral and Intermittent Streams and for Impacts Less Than 500 Linear Feet to Intermittent Streams with Perennial Pools, Perennial Streams and Wadeable Rivers" (2013), and Guidance Letter 08_03 (2008). USACE guidelines define the strategies as follows:

> ***Restoration*** *– the reestablishment of aquatic resource characteristics and functions at a site where they have ceased to exist or exist in a substantially degraded state.*
>
> ***Enhancement*** *– an activity conducted in existing aquatic resources that increases or improves one or more aquatic functions or characteristics.*
>
> ***Creation*** *– the establishment of an aquatic resource where one did not formerly exist.*
>
> ***Preservation*** *– the conservation or dedication of ecologically important existing aquatic resources in perpetuity through the implementation of appropriate legal and physical mechanisms to prevent its destruction or degradation in the future.*

The development of mitigation strategies includes specific objectives that serve to ensure that there is "no net loss" of ecological functions of aquatic resources. The following are the federal objectives:

- The qualification of ecological functions lost at the project site and gained at the mitigation site(s)
- The replacement of lost functions by identification of potential onsite and in-kind mitigation opportunities prior to seeking offsite and/or out-of-kind opportunities
- The development of mitigation strategies that are easily implementable and sustainable

- The establishment of a monitoring program that includes specific success criteria, ensuring that mitigation strategies are effective
- The establishment of legal instruments to provide permanent protection of mitigation activities

1.2 Project Description

The proposed Project includes expanding water supply storage capacity by adding a new off-channel upland reservoir and associated infrastructure immediately north of the existing Harris Reservoir. The site is located within the reach of the Brazos River from which Dow is authorized to divert its existing surface water right. The Project site is an approximately 2,200-acre tract of land acquired by Dow from the Texas Departmental of Criminal Justice in 2011 and additional acreage along Oyster Creek just north of the proposed Project. The off-channel reservoir would include a 1,929-acre impoundment with nominal storage capacity of about 50,000 acre-feet, an intake and pump station to divert Dow's existing surface water rights from the Brazos River, an outlet to Oyster Creek and an emergency spillway. The Project also includes floodplain enhancements in Oyster Creek and stream restoration (296 acres) and temporary construction staging and laydown areas (78 acres). Figure 1 in Attachment A provides a conceptual layout of the off-channel reservoir site and associated Project components.

SECTION 2

Impact Site

2.1 Site Description

In general, the proposed Project site is located on the Brazos River, between the Brazos River and Oyster Creek, north of The Dow Chemical Company's (Dow) existing Harris Reservoir in Brazoria County in Texas. It is located within the 100-year floodplains of the Brazos River and Oyster Creek, with designated special flood hazard Zones AE and AO on Brazoria County Flood Insurance Rate Map (FIRM) panels 48039C0410H, 48039C0245H, 48039C0240H, and 48039C0405H, dated June 5, 1989. The Project area is drained by a series of man-made ditches that were historically used for agricultural purposes.

Years of agricultural land use throughout the area removed much of the forested habitat and considerably altered the hydrology. The Project site was previously owned by the State of Texas as part of the Ramsey Unit State prison farm; Dow purchased 2,200 acres immediately north of the existing Harris Reservoir specifically for increasing the water supply storage available for the Texas Operations and reducing impacts to private property owners. As such, it has been used for livestock grazing and farming for more than 35 years and land cover on the site is primarily pasture grasses with scattered or clustered trees (HDR 2014). Approximately 60 percent of the Project site is used for agriculture and 40 percent as pasture (Cardno 2014). These prolonged agricultural practices at the site and north along both the Brazos River and Oyster Creek as well as related intensive land use practices, have led to stream bank erosion, destruction of riverine wetlands and riparian areas, increased stormwater runoff, and contributed to high degrees of sediment load in the two watersheds. The current status of water features on the property are degraded and low function.

Within the proposed Project boundary, there are eight man-made agricultural ditches, seven ephemeral streams, four intermittent streams, and three perennial streams, totaling 65,949.7 linear feet of water features (22,785 linear feet of agricultural ditches and 43,164.7 linear feet of streams). The locations of each water body are shown in Figure 2. Also within the proposed Project site, 17 wetland areas occupying 19.57 acres were identified and delineated. Wetland types included palustrine forested wetlands (PFO) totaling 4.14 acres, palustrine emergent wetlands (PEM) totaling 13.51 acres, and palustrine unconsolidated bottom wetlands (PUB) totaling 1.92 acres. The locations of each water body are shown in Figure 2. A summary of wetland and water features identified and mapped within the proposed Project boundary is presented in Table 1-1.

Table 1-1. Total Wetland and Water Features within the Project Boundary
Harris Expansion Project

Feature	Resource Type	Length (ft.)	Acre(s)
PEM#1	PEM	-	6.51
PEM#2	PEM	-	1.85
PEM#3	PEM	-	0.69
PEM#4	PEM	-	0.25
PEM#5	PEM	-	2.89
PFO#1	PFO	-	1.88
PFO#2	PFO	-	1.41
PFO#3	PFO	-	0.86

Table 1-1. Total Wetland and Water Features within the Project Boundary
Harris Expansion Project

Feature	Resource Type	Length (ft.)	Acre(s)
Wetland 1B	PEM	-	1.135
Wetland 2B	PEM	-	0.0003
Wetland 3B	PEM	-	0.036
Wetland 4B	PEM	-	0.059
Wetland 5B	PEM	-	0.04
Wetland 7B	PEM	-	0.046
PUB#1	PUB	-	0.60
PUB#2	PUB	-	0.64
PUB#3	PUB	-	0.68
Ephemeral Drainage #1	ES	6,129.5	-
Ephemeral Drainage #3	ES	2,450.4	-
Ephemeral Drainage #6	ES	135.9	-
Ephemeral Drainage #7	ES	160.0	-
S06	ES	77.0	-
S07	ES	79.0	-
S13	ES	195	-
Ephemeral Drainage Total		**9,226.8**	**-**
S09	IS	123.0	-
S11	IS	442.0	-
S14	IS	124.0	-
Intermittent Stream #1	IS	10,997.9	-
Intermittent Stream		**11,686.9**	**-**
S02	PS	14,773.0	-
S03	PS	3,680.0	-
S08	PS	3,798.0	-
Perennial Stream		**22,251.0**	-
Agricultural Drainage #1	AD	512	-
Agricultural Drainage #2	AD	3,359	-
Agricultural Drainage #3	AD	699	-
Agricultural Drainage #4	AD	3,752	-
Agricultural Drainage #5	AD	6,794	-
Agricultural Drainage #6	AD	824	-

Table 1-1. Total Wetland and Water Features within the Project Boundary
Harris Expansion Project

Feature	Resource Type	Length (ft.)	Acre(s)
Agricultural Drainage #7	AD	4,636	-
Agricultural Drainage #8	AD	2,209	-
Agricultural Drainage		**22,785**	**-**
Total		**65,949.7**	**19.57**

Notes:
[1] Resource Type: PEM = Palustrine Emergent; PFO = Palustrine Forested; ES = Ephemeral Stream; IS = Intermittent Stream; PS = Perennial Stream; AD = Agricultural Ditch

2.2 Impact Areas Descriptions

A request for an approved jurisdictional determination was submitted to the Galveston District on August 27, 2017, and is currently under review by the District. Preliminary jurisdictional boundaries of areas identified as WOUS, along with the unavoidable proposed project impacts are shown in Figure 2.

Impacts to WOUS identified onsite include PEM and PFO wetlands, ephemeral streams, one intermittent stream, and the Brazos River. A summary of potential impacts to WOUS as a result of the proposed Project is presented in Table 2-1. Detailed fill volumes and fill materials are presented in Table 2-2. Photographs taken during field surveys of each of the impact area locations are provided in the 2017 Cardno Wetland Delineation Report and 2017 CH2M Level 1 Stream Assessment and interim hydrogeomorphic model (iHGM) wetland analysis reports.

Impacts to wetlands were tabulated in acres and impacts to streams were tabulated in linear feet.

Table 2-1. Potential WOUS Impacts
Harris Expansion Project

Waterbody ID	Resource Type [1]	Area [2] (acres)	Length [3] (feet)
PEM #1	PEM	6.51	-
PEM #2	PEM	1.85	-
PEM #3	PEM	0.69	-
PEM #4	PEM	0.25	-
PEM #5	PEM	2.89	-
PFO #1	PFO	1.88	-
PFO #2	PFO	1.41	-
PFO #3	PFO	0.86	-
Wetland 1B	PEM	0.00	-
Wetland 7B	PEM	0.00	-
Ephemeral Drainage #1	ES	-	6,129.5
Ephemeral Drainage #3	ES	-	2,450.4
Ephemeral Drainage #6	ES	-	135.9

Table 2-1. Potential WOUS Impacts
Harris Expansion Project

Waterbody ID	Resource Type [1]	Area [2] (acres)	Length [3] (feet)
Intermittent Stream #1	IS	-	10,997.9
S03 (Brazos River)	PS	-	772.6
S06	ES	-	0.0
S07	ES	-	0.0

Notes:
[1] Resource Type: PEM = Palustrine Emergent; PFO = Palustrine Forested; ES = Ephemeral Stream; IS = Intermittent Stream; PS = Perennial Stream
[2] Acreage rounded to the nearest 0.01; measurement is the area of impact
[3] Linear feet measurement rounded to nearest 0.1; measurement is the length of impact

Table 2-2. Type of Fill Material Being Discharged
Harris Expansion Project

	Type and Amount of Fill (yd^3)				
Location	**Sand**	**Soil**	**Riprap**	**Other**	**Total**
PEM#5		35,800			35,800
Ephemeral Drainage #3		7,100			7,100
Intermittent Stream #1		80,600			80,600
S03 (Brazos River)		7,745		330	8,075
Project Total	**0**	**98,945**	**0**	**330**	**99,275**

2.2.1 Wetlands

A total of 16.34 acres of potential jurisdictional wetlands (12.19 acres of PEM wetlands and 4.15 acres of PFO wetlands) would be permanently impacted by the proposed project. These wetlands are described in the 2012 Cardno Wetland Delineation Report and evaluated in the 2017 CH2M iHGM Report.

2.2.2 Intermittent Streams

A total of 10,997.9 linear feet of intermittent stream would be permanently impacted by the proposed project. The stream is described in the 2012 Cardno Wetland Delineation Report and 2017 CH2M Level 1 Stream Assessment Report.

2.2.3 Ephemeral Streams

A total of 8,715.8 linear feet of ephemeral streams would be permanently impacted by the proposed project. These streams are described in the 2012 and 2017 Cardno Wetland Delineation Reports and 2017 CH2M Level 1 Stream Assessment Report.

2.2.4 Brazos River

The proposed project would permanently impact a total of 772.6 linear feet of the Brazos River. The river is described in the 2017 Cardno Wetland Delineation Report and 2017 CH2M Level 1 Stream Assessment Report.

2.3 Ecological Functions and Values Lost

2.3.1 Wetlands

The District's standard operating procedure for assessing ecological value lost for PEM wetlands is to follow the iHGM protocol. An iHGM analysis was completed for each palustrine emergent (PEM) and palustrine forested (PFO) wetland within the 2,200-acre survey area, considering current conditions and expected conditions following reservoir construction. The analysis yielded the existing physical, biological, and chemical Functional Capacity Index (FCI) of each wetland. Calculated using the impacted acreage presented in Table 2-1 and the FCI for each wetland, the number of Functional Capacity Units (FCUs) for each wetland within the Project that would need to be replaced by mitigation are presented in Table 2-3.

Table 2-3. Functional Assessment Results for Wetland Features on the New Harris Reservoir Site
HarrisExpansion Project

Feature	Potential Function Capacity Impacts (Physical)	Potential Function Capacity Impacts (Biological)	Potential Function Capacity Impacts (Chemical)
PEM #1	0.337	3.037	-1.627
PEM #2	0.096	0.865	-0.463
PEM #3	0.036	0.321	-0.172
PEM #4	0.001	0.033	-0.037
PEM #5	0.150	1.351	-0.724
PEM Total	**0.620**	**5.607**	**-3.023**
PFO #1	0.879	1.258	0.438
PFO #2	0.513	0.871	0.080
PFO #3	0.129	0.595	-0.066
PFO Total	**1.521**	**2.724**	**0.452**
Total	**2.141**	**8.331**	**-2.571**

2.3.2 Other WOUS

Per the District's standard operating procedure, loss of stream function was analyzed using the "Level 1- Stream Condition Assessment for All Ephemeral and Intermittent Streams and for Impacts Less Than 500 Linear Feet to Intermittent Streams with Perennial Pools, Perennial Streams and Wadeable Rivers" (USACE 2013). Stream Assessment forms documenting current conditions (actual) were compared to post-construction Theoretical Stream Assessment forms (theoretical) for each transect for the entire 2,200-acre survey area. The change in the Reach Conditional Index (dRCI) between the actual and theoretical stream assessments, the linear feet of stream within the 2,200-acre survey area, and an impact factor for the type and magnitude of impact were utilized to calculate the compensation requirement or number of stream credits needed for impacts to each stream. Level 1- Stream Condition Data Forms are included in Appendix B

and Table 2-4 summarizes the results of the Level 1 Stream Assessment and estimated compensation requirements for each stream.

Table 2-4. Estimated Compensation Requirements (Credits) for Stream and Drainage Features within the 2,200-Acre Harris Reservoir Site Based on Level 1 Stream Assessment
Harris Expansion Project

Feature	Reach Conditional Index (RCI)	Change in Reach Conditional Index (dRCI)	Impact Factor	Linear Feet of Impact	Compensation Requirement (Stream Credits)
Ephemeral Drainage #1	2.64	1.44	1	6,129.5	8,826.5
Ephemeral Drainage #3	3.05	1.70	1	2,450.4	4,165.7
Ephemeral Drainage #6	2.94	1.94	1	135.9	263.6
Ephemeral Drainage Total					**13,255.8**
Intermittent Stream #1	2.94	1.94	1	10,997.9	21,335.9
Intermittent Stream Total					**21,335.9**
Total					**34,591.7**

Ecological functions and values of the existing ephemeral streams are poor. The channels are primarily narrow and shallow and exhibit a discontinuous Ordinary High Water Mark (OHWM). The riparian corridors are dominated by grazed pastureland or cropland and aquatic life use is poor. Benefits to local watershed water quality are also limited due to the low density of vegetation to uptake nutrients and filter particulates along with the lack of upland and wetland soils to aide in nutrient cycling and metals uptake.

The intermittent stream provides poor to moderate ecological functional values to the immediate project area and to habitats downstream. The reduced ecological function stems primarily from the intermittent stream's hydrology, including the varying frequency of inundation from Oyster Creek and the Brazos River. While some aquatic organisms were observed during field surveys, the available habitat for species that would be expected to occur was poor. The ecological functions that the intermittent stream impact area provides the following:

- Limited in-stream habitats for aquatic fauna
- Nutrient sources to the Brazos River from the surrounding watershed
- Foraging areas for wading birds and terrestrial species

SECTION 3

Mitigation Strategy

Mitigation strategies to compensate for the unavoidable impacts to WOUS from the proposed Harris Expansion Project were developed through onsite field surveys and a detailed design analysis. The implementation of mitigation strategies is designed to address the federal objective of "no net loss" of ecological functions of aquatic resources. During the site selection process, several options for providing compensatory mitigation for the unavoidable impacts proposed by the Project were considered. The 2008 Final Compensatory Mitigation Rule states that mitigation options should be considered based on the following hierarchy:

- Purchasing credits from an operational mitigation bank
- Purchasing credits from an approved in-lieu fee program
- Permittee-responsible mitigation under a watershed approach
- Permittee-responsible mitigation through on-site, in-kind mitigation
- Permittee-responsible mitigation through off-site and/or out-of-kind mitigation

The Project site is located within the primary and secondary service areas of multiple mitigation banks; therefore, this option was selected for mitigation of loss of wetlands on the Project site. The Project site is outside of the primary and secondary service areas for any mitigation banks or in-lieu fee programs that offer stream credits; therefore, permittee-responsible mitigation through on-site, in-kind mitigation was selected for stream mitigation. These strategies provide the most direct compensation to lost ecological functions at the Project site and are consistent with USACE guidance.

Mitigation of lost ecological wetland function through mitigation banking is described in Section 3.1. Stream mitigation projects are described in Section 3.2. cross-sections for each of the onsite locations are presented in Appendix A. The sheets include a plan view with aerial mitigation extent and a typical cross section. Photographs taken during field surveys of each of the impact area locations are provided in the 2012 and 2017 Cardno Wetland Delineation Reports and the 2017 CH2M Level 1 Stream Assessment and iHGM Wetland Analysis Reports.

3.1 Proposed Wetland Mitigation

The proposed project is within the primary service area of several approved wetland mitigation banks. The proposed mitigation for unavoidable loss of wetlands is to purchase credits from approved mitigation banks.

3.2 Proposed Onsite Mitigation

Onsite locations were evaluated to assess the potential to meet the Project's compensatory mitigation goals for impacts to linear water features (Figure 2). Priority was given to onsite mitigation that would provide the most direct compensation (location and in-kind) for project impacts.

The goals of the mitigation strategies proposed to be implemented onsite include re-establishment, restoration, and enhancement of the ecological functions of the aquatic resources at the project site so that the resources will increase their values within the surrounding watershed and the Oyster Creek corridor. The mitigation strategies will accomplish the following:

- Rehabilitate or enhance ecological functions of a stable bank and riparian buffers to improve and support in-stream functions.

- Re-establish streams within the Oyster Creek floodplain to provide an increase in aquatic resource area.
- Create sustainable mitigation designs.

3.2.1 Oyster Creek-Project 1

Project 1 begins in northern reaches of Oyster Creek and rehabilitates and enhances 3,621 linear feet of Oyster Creek. The segment of Oyster Creek within Project 1 currently has a mature riparian buffer out to 100 feet and has instream structure in the form of vegetation and root wads. Project 1 activities will include 2,356 feet of bankfull benching, 3,621 feet of buffer preservation of the existing 100-foot buffer, and buffer re-establishment out to 200 feet (Figures 3 and 4).

3.2.2 Oyster Creek-Project 2

Project 2 begins immediately south of Project 1 and rehabilitates and enhances 12,868 linear feet of Oyster Creek. The segment of Oyster Creek within Project 2 currently has a mature riparian buffer out to 100 feet within the northern portion of the project and is heavily impacted by farming activities in the southern portion with a much narrower riparian buffer. Project 2 activities will include 7,768 feet of bankfull benching, 12,868 feet of buffer preservation of the existing 100-foot buffer, and 12, 868 feet of buffer re-establishment out to 200 feet where possible (Figures 5 and 6).

3.2.3 Oyster Creek-Project 3

Project 3 will be located on the southeast boundary of the Harris Expansion Project embankment. Project 3 will reestablish an ephemeral drainage within the Oyster Creek floodplain through construction of 5,522 feet of channel. The project will also reestablish 5,522 feet of buffer out to 200 feet and preserve 5,522 feet of buffer. Hydrology of the channel will be influenced by the flow of Oyster Creek (Figures 7 and 8).

3.3 Native Vegetation Plantings

Native vegetation plantings will occur within the onsite restoration, enhancement and reestablishment Projects 1-3 described in Section 3.2.

Following the selective removal of invasive species and slope stabilization, re-establishment of the riparian buffers will occur through plantings of desirable native plant species. Tree and shrub species will include species native to the local forested riparian habitat, along with less-common species, to increase the overall species diversity of the riparian buffer and to provide increased benefits to wildlife species. Native species plantings will include various size classes planted at densities appropriate for developing stable vegetation stratum, reducing erosion, and improving overall habitat. The range of size classes of planted trees will produce an uneven aged forest canopy when mature. These planted communities should reach maturity within 15 to 30 years. After the 5-year monitoring period, the planted native trees and shrubs communities will be self-sustaining and self-organizing.

The proposed plant species for afforestation have a wetland indicator status of facultative (“FAC”), facultative wetland (“FACW”), or obligate (“OBL”) per the Regional Wetland Plant List for the Atlantic and Gulf Coastal Plain (“AGCP”) Region. Species selected either occur in or have a native range encompassing Brazoria County or adjacent counties. The planting effort will integrate fast-growing soft mast species with slower-growing hard mast species to allow for greater vertical structural diversity, which is a necessary habitat for forest breeding birds. The exact species and quantities for planting will be determined by the availability of the species from commercial nurseries providing seedling. Seedling planting density will be at a rate of at least 538 stems per acre, utilizing 9’x9’ spacing. Seedlings will be planted utilizing raised beds to encourage survival. Single stem planting of PFO species will occur the first planting season (December through February) following site preparation. Selected species will be site-appropriate for habitat design, soil-moisture regime, and species richness that are commercially available. The planted species will include

some or all of the following trees and shrubs: pecan (*Carya illinoinensis*), water oak (*Quercus nigra*), laurel oak (*Quercus laurifolia*), willow oak (*Quercus phellos*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and cedar elm (*Ulmus crassifolia*). Grasses and forbs establishment will take place through the broadcast of a riparian seed mix dominated by species such as: switchgrass (*Panicum virgatum*), busy bluestem (*Andropogon glomeratus*), and Florida paspalum (*Paspalum floridanum*). The riparian seed mix will also include other various grasses, legumes, mints, and rushes to a lesser degree. The species will become established quickly stabilizing bank soils.

Planting to replace dead native vegetation will be a component of the monitoring plan established to support the success of mitigation (See Section 5). The monitoring plan will specify the success criteria for plantings.

3.4 Invasive and Nuisance Species

Invasive plant species such as Chinese tallow (*Triadica sebifera*) and Johnson grass (*Sorghum halepense*) readily occur throughout the onsite and offsite mitigation areas particularly in disturbed areas and throughout the riparian corridor. Invasive plant species will be selectively removed and controlled using chemical methods. Herbicides will be selected based on the type of application procedure and will be in accordance with federal regulations. The invasive plant removal and follow-up herbicide applications will be conducted by experienced contracted personnel. The monitoring plan will specify the success criteria for invasive species and their removal.

For herbicide treatment, the contractor shall abide by the following protocol:

1. The application of herbicide shall be pursuant to the regulations maintained by the Texas Department of Agriculture.
2. Herbicide shall be applied under the direction of a State licensed herbicide applicator.
3. The contractor shall be responsible for acquiring a spray permit through the Texas Department of Agriculture.
4. All herbicides are to be used in accordance with label requirements and/or special use labels. The contractor will be solely responsible for any penalty, fine, or damages resulting from misuse of herbicides. Should damages occur as a result of herbicide misuse, the contractor will replant at their own expense.
5. The contractor shall apply herbicides in a manner to minimize damage to non-target species.
6. The contractor shall be responsible for all herbicide application and handling with “Hold Harmless” protection for the owner.
7. All herbicides shall have a marking dye to show where treatments have taken place.
8. Report and clean-up all spills in accordance with local, county, state, and Federal requirements. All incidences regarding spills of herbicides and/or gasoline shall be immediately reported to TCEQ.
9. Daily log reports shall be kept by the contractor during active treatment periods.
10. No soil herbicides, such as Spike or Velpar, will be utilized.
11. No fuel or herbicide storage shall be allowed onsite.
12. The contractor shall police staging sites and maintain those sites free of trash.

3.5 Ecological Functions and Values Gained

The restoration of forested riparian habitats along the Oyster Creek will provide increases in function and value to wildlife habitats onsite. Preservation of these areas will maintain existing wildlife habitats keeping

them from being lost from future conversions to development or agricultural land uses. Rehabilitation and enhancement of the forested riparian habitats and the re-establishment of degraded stream reach will provide wildlife corridors, nesting, and foraging opportunities along the Creek for such species as white-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), fox squirrel (*Sciurus niger*), gray squirrel (*Sciurus carolinensis*), wood duck (*Aix sponsa*), bald eagle (which are known to occur within the vicinity of the Project), pileated woodpecker (*Dryocopus pileatus*), belted kingfisher (*Ceryle alcyon*), herons and egrets, barred owl (*Strix varia*), and red-shouldered hawk. The planting of oak species will increase the available mast for deer, squirrels, mice, and voles. The smaller mammals will then, in turn, provide food sources for larger predators such as bobcats, foxes and coyotes.

Forested riparian buffers also promote stable banks and improved water quality. They reduce the velocity of stormwater runoff, allowing sediments to settle that would otherwise enter the surface water system. Canopy trees provide shading and temperature moderation for the adjacent waterway. Large woody debris provides energy dissipation and surface areas for sediment accumulation which can help to stabilize eroding banks. Riparian buffers facilitate recharge and nutrient uptake by vegetation, and increase flood storage capacity.

The stabilization of stream banks and restoration of associated riparian buffers along stream channels will prevent smothering of in-stream habitat substrates from bank erosion. Preserved and restored riparian habitats will provide nesting, foraging, and refuge for wildlife species and connections to adjacent habitats. The habitats for aquatic organisms provided by the preserved and re-established stream channels are limited by the altered hydrologic patterns, but scattered temporary pools may provide breeding areas for aquatic macroinvertebrates and insects. Amphibians such as the northern spring peeper (*Pseudacris crucifer*), American toad (*Bufo americanus*), bullfrog (*Rana catesbeiana*), northern cricket frog, southern leopard frog (*Rana sphenocephala*), and green frog (*Rana clamitans melanota*) may use these areas for breeding and nursery habitat. Intermittent streams are important foraging areas for waterfowl as well as wading birds such as great blue herons (*Ardea herodias*). Mammals expected to use the preserved stream channels include beaver, muskrat, and raccoon.

SECTION 4

Compensatory Mitigation Evaluation

Table 4-1 summarizes the stream credit requirements for impacts to jurisdictional streams within the project site and the stream credits created from Projects 1-4.

Table 4-1. Summary of Stream Credits Required and Proposed Mitigation Credits
Harris Expansion Project

Feature	Compensation Requirements (Estimated Stream Credits Needed)	Estimated Stream Credits Generated
Ephemeral Drainage #1	8,826.5	-
Ephemeral Drainage #3	4,165.7	-
Ephemeral Drainage #6	263.6	-
Intermittent Stream #1	21,335.9	-
Total Mitigation Credits Required	34,591.7	-
Project 1	-	4,411
Project 2	-	21,279
Project 3	-	19,603
Total Mitigation Credits Proposed	-	45,293

SECTION 5

Monitoring Plan

Section 5 addresses proposal monitoring parameters, success criteria and performance standards, techniques, frequency and duration, maintenance and corrective actions, and reporting. The monitoring plan is designed to measure and document the progress, successes, and failures (if any) of the main strategies of the proposed compensatory mitigation plan (previously described). The key mitigation components include riparian buffer restoration, bank stabilization, re-establishment, and preservation of riparian buffer habitats.

5.1 Monitoring Parameters

Ecological and physical parameters to be monitored are site-specific based on the mitigation objectives for each location. A description of each mitigation area and its monitoring parameters is presented in Table 5-1. Specific success criteria and performance standards used to evaluate these parameters are listed in Table 5-2.

Table 5-1. Monitoring Parameters
Harris Expansion Project

	Monitoring Parameters [a]	Success Criterion No. [b]
Projects 1,2	Streambank and streambed improvements along Oyster Creek	
	Bankfull benching	1, 7
Projects 1,2	Preservation of a 100-foot wide forested riparian buffer along Oyster Creek	
	Planting native vegetation in several areas (as applicable to the specific area being restored)	2 or 3, 4, 7
Project 3	Heavy buffer planting from 0-200’	2 or 3, 4, 7
Projects 1,2	Heavy buffer planting 100-200’	
	Intermittent plantings along the shoreline for shading of the River to improve fish habitat	2 or 3, 4, 7
Project 2	Biological rehabilitation	
	Streambank plantings	2 or 3, 4, 7
	Placement of large woody debris (dead trees) submerged within the main stem of the River and embedded along the bank	5, 6, 7
Project 3	Re-establishment of ephemeral channels	
	Channel construction	1, 7

[a] Engineered slopes typically consist of riprap cobble with live willow stakes and rolled coirs with plantings amongst.

[b] Refer to Table 5-2 for correlation by number with each success criterion.

5.2 Success Criteria and Performance Standards

All mitigation areas will be monitored for site-specific parameters during each monitoring event (conducted at a minimum two times each year with subsequent site visits occurring on an annual basis. Applicable success criteria and performance standards will vary between mitigation sites, depending on the restoration or enhancement goal at each site. Some sites will be evaluated against more than one criterion. A photographic log documenting existing conditions and progress made will be maintained and submitted with the annual report to the District. Table 5-2 summarizes success criteria and performance standards.

Table 5-2. Success Criteria and Performance Standards
Harris Expansion Project

Success Criterion No.	Success Criteria and Performance Standards
Streambed and Streambank Improvements/Channel Re-establishment	
1	Bank stabilization areas will score within the risk categories of "very low" or "low" according to the Bank Erosion Hazard Index (BEHI) metric.
Vegetation	
2	Survival of planted woody species. In open areas (for example, agricultural fields) and/or newly graded areas where no tree canopy currently exists, 80 percent (430 stems per acre) survival rate of tree and shrub plantings after 2 years and 75 percent (404 stems per acre) after 5 years per planting zone
3	Survival of planted woody species. In areas where a tree canopy currently exists, 75 percent (404 stems per acre) survival rate of tree and shrub plantings after 5 years per planting zone.
4	Undesirable vegetation less than 5 absolute percent cover of invasive, noxious, or competing vegetation, in particular Johnson grass, in planted areas.
Biological Rehabilitation	
5	Not more than 20 percent loss of established, submerged, or embedded tree trunk fish habitat structures.
6	Edge of abutting or adjacent riverine habitat partially shaded by planted woody vegetation by monitoring year 3 in each mitigation area planted with woody species (yes or no).
Long-Term Legal Protection	
7	Signed and notarized conservation easement and/or deed restriction placed on mitigation area that protects the mitigation goals and objectives in perpetuity.

5.3 Monitoring Techniques

All vegetation data collection and site assessments will be conducted by experienced biologists, using a sampling protocol similar to that recommended for the Comprehensive Method in the 1987 USACE *Wetland Delineation Manual* or other established forestry techniques.

5.3.1 Data Collection

Vegetation monitoring plots (measuring, at a minimum, 50-foot by 100-foot, where possible) will be established in one or more locations within each planted area. Some planted areas will have more than one monitoring plot, set up in representative locations, so as to sample at least 25 percent of the area planted. Monitoring plots will be situated to span all planting zones (Zones 1 – 4) in bank stabilization areas. Plot locations will remain fixed from one monitoring event to the next; and plot corners will be marked in the field by aboveground polyvinyl chloride (PVC) pipe and flagging.

Data collection in each vegetation monitoring plot will include measurements of trees, saplings/shrubs, woody vines, and herbaceous plant species, as appropriate for each mitigation area. Data recorded by species will include measurements such as height class, diameter-at-breast height, basal area, and frequency of occurrence, and number of stems. Data recorded will include also a list of plants that have colonized the mitigation area, an estimated percent cover of desirable native species and that of invasive exotic species. Additionally, general observations, wildlife use, and photographs of the area will be recorded.

From these data, the survival rate per species, density, relative percent cover, and general health of the mitigation areas can be assessed. Percent survivability for each monitoring event will be calculated as:

$$\% \text{ Survivability} = \frac{\text{Existing \# of plantings of Species A in Zone X}}{\text{Original \# of plantings of Species A in Zone X}}$$

The number of remaining viable shrubs, saplings, and trees will be tallied against the total number originally planted and any subsequent replantings. The total recorded will be extrapolated to determine the overall survival rate for the area per planting zone. Canopy percent cover per plot will be estimated and used for annual assessment of health and growth comparisons.

Bank stabilization areas will be evaluated using the BEHI scoring metric (Rosgen, 2001) for estimates of overall bank stability. The BEHI provides a method of assessing stream bank condition about the potential for erosion. The metric assigns risk categories based on a numeric scoring system. The entire length of each bank stabilization area will be assessed in 100-foot increments. The monitored increments will be marked in the field by aboveground PVC pipe and flagging.

5.3.2 General Observation

During each monitoring visit, the biologist will record a general description of the mitigation areas, which will include any wildlife observations and assessment of the vegetation health and growth. Evidence of water flow through the hydrologic connections will be noted and photographed. Observation and photographic evidence of bank stability includes the stability of the submerged or embedded tree trunks in the fish habitat enhancement area, and the percentage of shading provided by planted woody species adjacent to Oyster Creek and stream channels.

Additionally, assessment and photographic documentation of potential problem situations will be made during each monitoring visit. These potential problems might include bank erosion; presence of invasive exotic, noxious vegetation; or significant die-off of planted material.

5.3.3 Photograph Stations

Photographic monitoring will be conducted at each visit to provide a qualitative estimate of changes in dominant vegetation over time. Photographs will be taken from the same location and in the same direction at each visit. Each photograph station, set up during the first monitoring visit, will be marked in the field by above ground PVC pipe and flagging; and its location will be recorded using a handheld GPS unit. A minimum of three photograph stations will be established in each of the planted mitigation areas.

5.4 Monitoring Frequency and Duration

Monitoring events are normally required (by the District) to be conducted a minimum of two times the first year with subsequent site visits occurring on an annual basis. They will be conducted once in spring, summer, and fall, unless directed otherwise in the permit conditions written by the District.

A baseline monitoring event will be performed within each of the mitigation areas following the monitoring frequency and duration described previously, immediately after the mitigation construction period (plantings, banks stabilization). The data collected from the baseline monitoring event will serve as the basis of comparison for future monitoring events and for the calculation of success criteria. During this event, the permanent monitoring plots will be established. This event will also serve to confirm the “as-built” condition of the mitigation areas. Any deficiencies, such as dead or dying plants or bank erosion/failure, noted during the baseline event will be immediately corrected. Any corrections such as replantings or regrading will be considered part of the baseline event and those areas re-evaluated to update the baseline “as-built” conditions.

It is anticipated that the typical 5-year duration of mitigation monitoring will be needed to assess if the woody-species planted areas are trending toward a mature forested riverine buffer.

5.5 Maintenance and Corrective Actions

If any problems are identified during the subsequent monitoring inspections, solution and remediation will occur as soon as practicable. Corrective actions that may be needed could include repair and stabilization of failed slopes, replanting of dead or dying trees or shrubs, herbivory deterrence and control of invasive exotic, noxious or competing vegetation (primarily Johnson grass), which threatens survival of the desired native species.

If any areas require treatment for control of invasive exotic and noxious vegetation, a subsequent site visit would be made as soon as possible to conduct physical removal and/or habitat-appropriate-herbicide spraying of the problem vegetation. Herbicide application treatments will be performed by a licensed professional contractor certified to safely handle and apply herbicides.

If the success criterion for planted species provided in Table 5-2 are not achieved, the applicant will replant to 50 stems per acre over the success criterion to allow for additional mortality with the potential to still meet the final success criteria. If needed, the applicant will replant and continue to monitor the planted enhancement and restoration areas until the permit conditions are met, as determined by the District.

Cumulative rainfall and temperature recorded at the nearest local National Oceanic and Atmospheric Administration station might be obtained from the National Weather Service Office to use in understanding unexpected growth of the planted materials, which would be documented in the monitoring report. In those circumstances where the mitigation sites are not meeting the expected milestones for success, adaptive management will be utilized to take action to adjust to these circumstances to ensure a successful mitigation.

All corrective actions taken at a mitigation site will be described in the annual report to validate the successful completion of the corrective actions.

5.6 Annual Report

Results from each monitoring site inspection will be summarized in a report to be submitted annually to the District, or on another reporting schedule as directed in the permit conditions. All monitoring reports submitted will include the following:

1. Project name and permit number
2. Site aerial showing project location, sampling plots, and photographic station locations
3. Permittee's name, address, and phone number
4. Report preparer's name, address, and phone number
5. Purpose and goals for mitigation site
6. Brief summary of mitigation strategy/actions
7. Date mitigation action commenced
8. Dates of site inspections
9. Dates of any maintenance activities
10. Summary of observations and measurements
11. Assessment of success toward the performance standards or success criteria

12. Observed problems (slope failure, erosion, stressed or dead trees or shrubs, vandalism, invasive plants, storm damage, etc.)
13. Implemented or recommended solutions to correct problems or deficiencies
14. Photos from each of the site inspections by photographic station, location, and date

SECTION 6

Mitigation Work Plan

The schedule for beginning mitigation activities will be coordinated with the initiation of the project construction to minimize the time between project impacts. A detailed mitigation work schedule will be provided in this section as the applicant progresses through the mitigation design process.

SECTION 7

Site Protection

7.1 Legal Protection

The mitigation sites will be protected by being placed into a conservation easement in perpetuity that will be held by a third party land trust. The mitigation sites will be placed into a conservation easement within 180 days of permit issuance. The applicant will establish a non-wasting fund that will provide the sponsor with the resources necessary to monitor and enforce the site protection in perpetuity. Management and stewardship by the sponsor will prohibit all development and other activities except those outlined in this mitigation plan.

7.2 Physical Protection

The Project site and the existing Harris Reservoir located south of the Project site is owned by Dow and is not accessible to the general public. The property to the north of the Project site is owned by the Texas Department of Criminal Justice Department of Corrections Ramsey Unit which also has restricted access. The western boundary of the Project site is bordered by the Brazos River. The applicant will install a fence around the perimeter of the restoration areas to protect the areas from cattle grazing impacts.

SECTION 8

Mitigation Costs

As the applicant progresses through the mitigation design process, the estimated costs including raw materials, earthwork, labor, monitoring, maintenance, reporting, and profit margins, as well as a contingency factor associated with the proposed mitigation strategies will be presented in this section. The estimates for all mitigation activities will be based on 2018 dollars and are subject to change based on the availability of materials and any subsequent changes to the mitigation plan itself. The cost estimate is provided as information only regarding the financial magnitude of the mitigation activities described in this plan and is not intended for any other purposes. The actual implementation costs may vary. Dow's ability to assure the financial responsibility of these mitigation costs is described in Section 10.

SECTION 9

Adaptive Management Plan

Dow is solely responsible for the implementation of the mitigation Plan and the activities it describes, including monitoring, maintenance, and cost. Any remedial measures that may be needed if performance standards defined by the monitoring plan are not met in a timely manner as a result of damages sustained from the herbicide application will be the responsibility of the herbicide contractor. The performance standards will regularly be measured as described in the monitoring plan and mitigation work plan to track deviations from the mitigation goals. The active monitoring will allow for any remedial actions such as replanting or reconstruction to be implemented quickly. The financial assurances provided by the Dow, described in Section 10 meets USACE requirements and provides requisite assurances that any remedial actions needed will be available.

Potential challenges that exist for the proposed mitigation actions include extreme flood events that could impact rehabilitation and re-establishment activities. The design of the mitigation actions will accommodate for infrequent flood events and extreme events outside of design parameters would be unexpected. Regional drought conditions could affect native vegetation plantings, particularly before plants become well established. Watering of plants may be needed and will be determined by Dow or designated contractor if drought conditions persist. As previously discussed, if herbivory of plantings becomes an issue, then plants may be protected with tubes at the discretion of Dow or designated contractor.

If performance standards are not being met after the application of remedial actions, Dow may incorporate additional mitigation strategies, activities, or locations. The additional mitigation may occur onsite or on other lands controlled by Dow or offsite at others location. USACE would be notified and a separate mitigation plan for the additional activities would be developed. The additional activities proposed would supplement for the loss of ecological functions and values from project impacts as described in this mitigation plan. The supplemental mitigation would be submitted to USACE for approval prior to implementation.

SECTION 10

Financial Assurances

Short-term financial assurances in the form of a bond, letter of credit, escrow account, or casualty insurance policy, will be put in place after the permit is issued and within 60-days of the USACE approving financial assurance mechanism language. This financial vehicle will cover costs associated with construction, monitoring, and maintenance during the monitoring period for the restoration site. Financial assurance amounts may be phased down once construction is completed and success is documented. The amount of financial assurances required is under development.

SECTION 11

References

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