Mapping Potential Habitat Restoration Sites to Restore Hydrologic Connectivity

Annual Report

Publication CBBEP – 137
Project Number – 1918
December 2019

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Report by the International Crane Foundation for the Coastal Bend Bays & Estuaries Program
CBBEP No. 1918
12-09-2019

Contents

Introduction

Historic wetland degradation has impacted the health and sustainability of coastal systems worldwide, and is a continuing issue in the Texas Coastal Bend. Restoration, enhancement, and creation initiatives that restore hydrologic connectivity are essential to recover the function and delicate balance within our Gulf Coast Prairies and Marshes Ecoregion.

Early within the Coastal Bend Bays & Estuaries Program, the Habitat & Living Resources Team recognized the benefit of integrating stakeholder input and sound science approaches into site inventory planning, implementation, and monitoring of landscape-scale habitat restoration. Over the past twenty years, the use of a geographic information system (GIS) approach to identify and map areas has increased and provides a user-friendly catalog that also improves spatial analyses and uses multiple criteria layers (Smith and Wood 2003, Davis et al. 2011, 2012; Stanzel et al. 2014). Within each of these reports, sites were identified with associated impacts and restoration options that, when implemented, would recover system function, value, and sustainability.

We are promoting the use of these decision-support tools to identify future projects that would be beneficial to achieve the Habitat Objective of the Coastal Bend Bays Plans (CBBEP 2018) to “preserve, create, and restore coastal habitats”.

Objectives

The objectives of this report are as follows:

- Review pertinent reports that identify hydrologic restoration sites in Coastal Bend Bays & Estuaries Program (CBBEP) area to identify potential project sites and convene stakeholder meetings to compile and integrate potential restoration projects that would restore hydrologic connectivity within estuarine habitats;
- Develop a user-friendly spatial database in GIS;
- Identify types of hydrologic restoration strategies that would be implemented at each site and identify potential partners; and
- Characterize collective benefits of completed projects at site-specific and regional scale.

Methods

Review relevant studies that previously identified hydrologic restoration sites in the CBBEP area (Figure 1) and assess whether the proposed restoration site has occurred or is no longer relevant due to other factors, such as anthropogenic alternations or severe modification from Hurricane Harvey. Studies reviewed include CBBEP reports from 1997 to 2012 (Smith et al. 1997; Smith and Wood 2003; Davis et al. 2011; Davis et al. 2012).

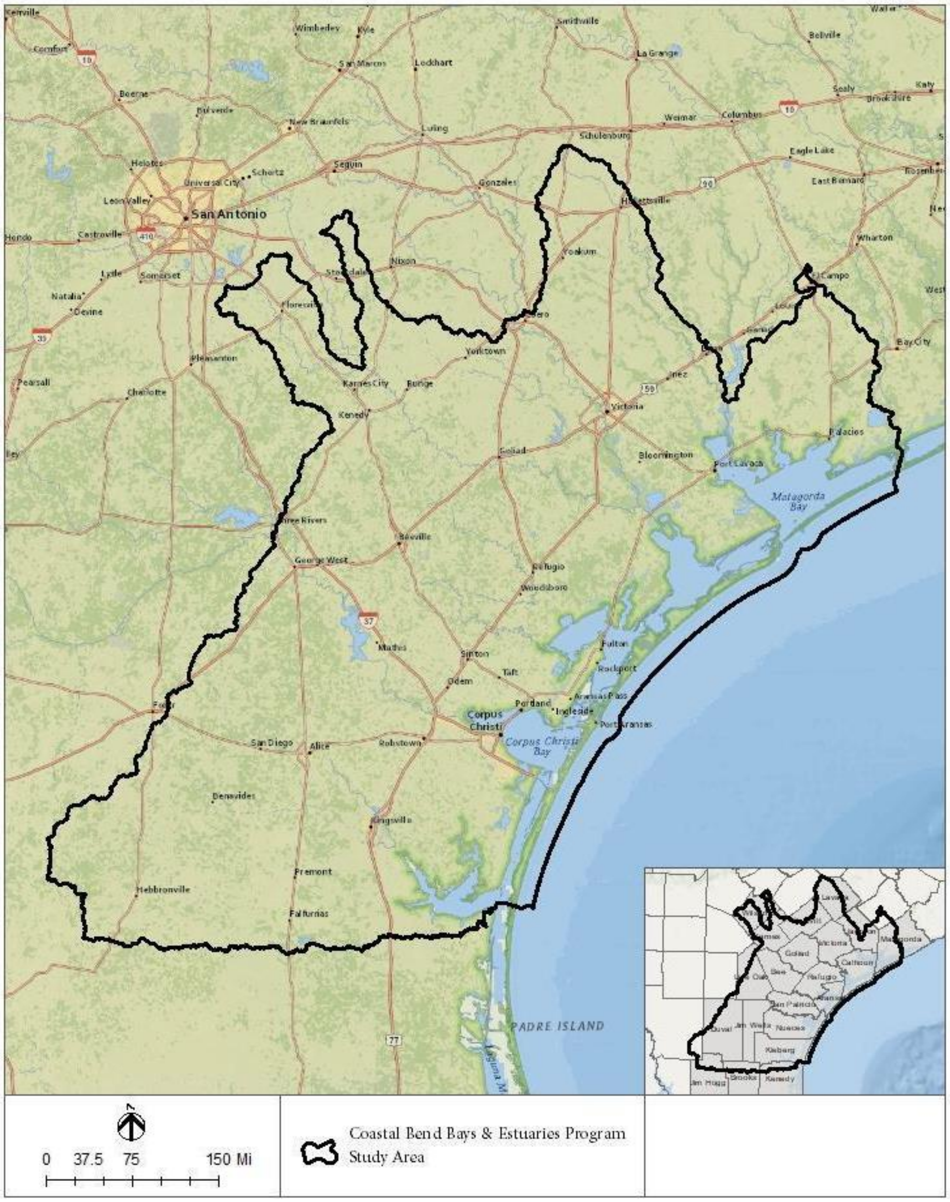

Figure 1. Study Area for identification of restoration sites.

The next step was to develop a spatial database of potential sites and relevant environmental data to assist in identifying and supporting potential restoration sites. U.S. Fish and Wildlife Service's (USFWS's) National Wetland Inventory (NWI) data was downloaded using the USFWS's NWI Wetlands Mapper (USFWS 2019) for each sub-basin within the project area. An 8-digit Hydrologic Unit Code (HUC) classified by the U.S. Geological Survey (USGS) using 1:24,000 scale topographic base maps represents sub-basins (USGS 2018; Figure 2).

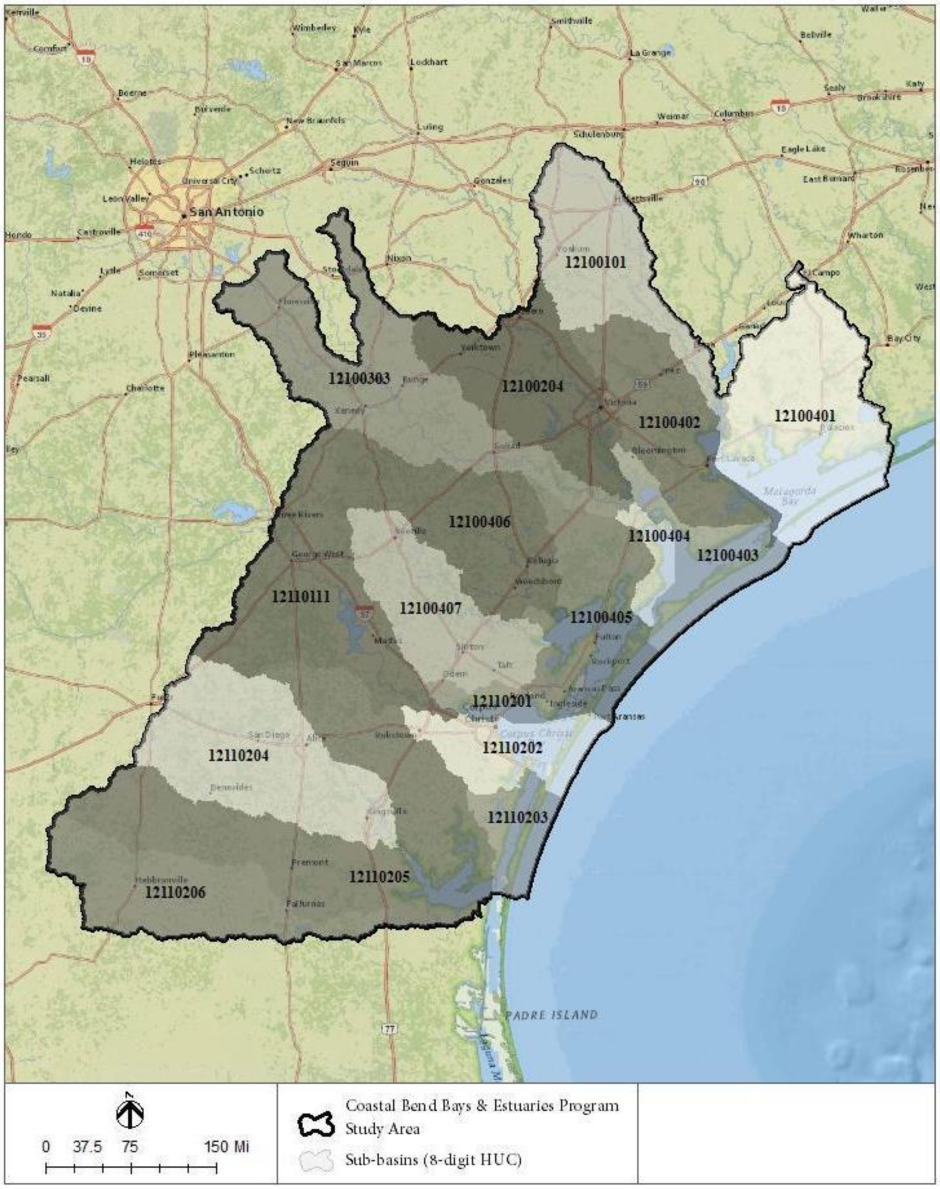

Figure 2. Sub-basins (HUC 8) within the study area.

USGS's National Hydrography Dataset (NHD) was also downloaded and included in the database to identify potential hydrologic restoration sites (USGS 2018). The NHD includes 'NHDLines', which primarily delineates dams, weirs, and gates, non-earthen shores and reefs, and 'NHDFlowLines' that outline more linear features, such as creeks, ditches, and rivers, canals, coastlines, pipelines, and artificial paths (Figure 3).

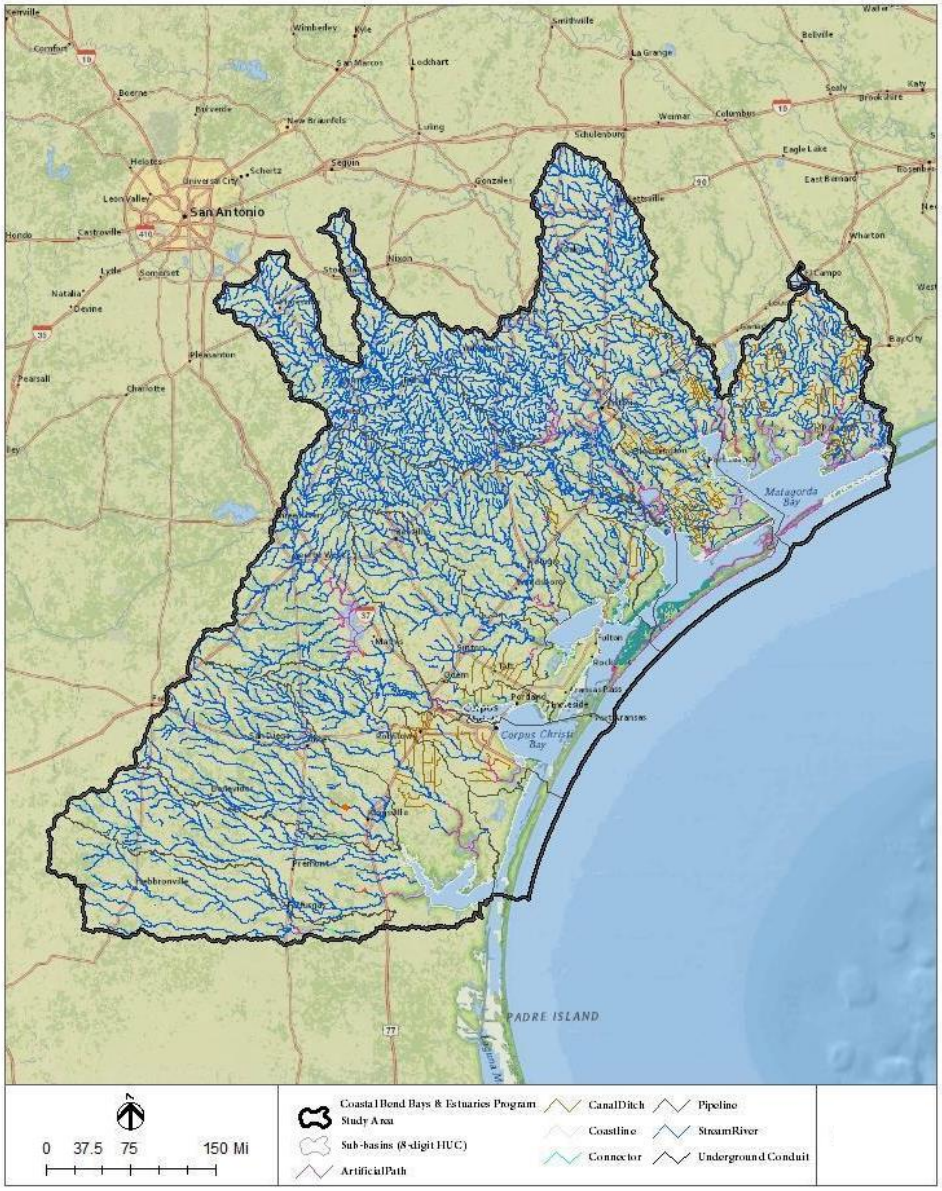

Figure 3. NHD Lines and Flow Lines within the study area.

Since the NWI and NHD datasets are mapped at a large scale, imperfections occur at the regional level. For example, multiple man-made modifications to the landscape, such as ditches, canals, and earthen dams or levees, located within the CBBEP study area are not identified in the NWI or NHD datasets. A good example is the Guadalupe Blanco River Authority (GBRA) saltwater barrier located in the lower Guadalupe River. This water management feature is not identified as a dam, gate, weir, or other type of hydrologic feature in the NHD datasets (Figure 4).

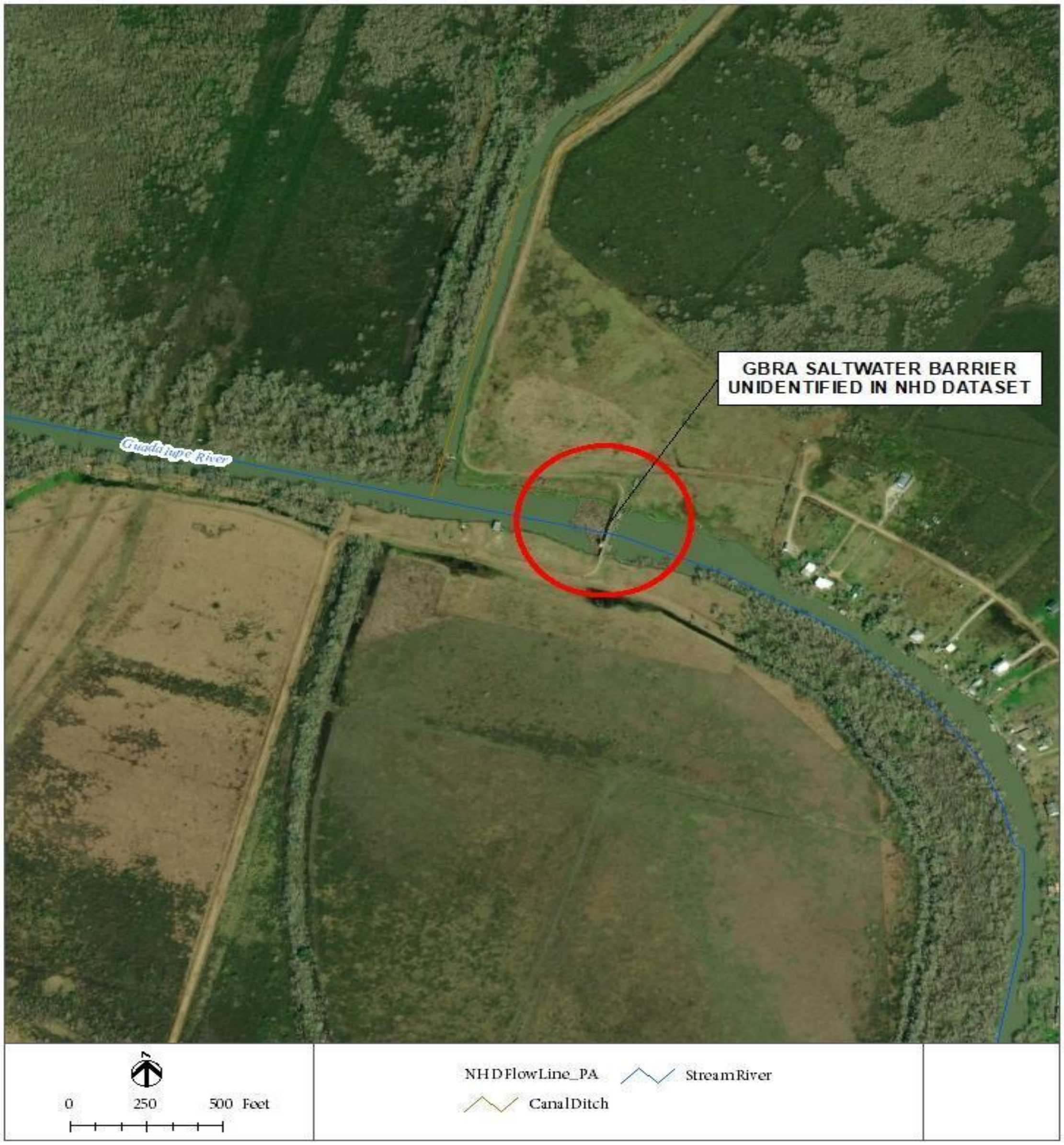

Figure 4. Example of unidentified dam on the lower Guadalupe River.

Hydrologic Restoration Sites

Previously Identified Sites

The CBBEP has funded three projects from 1997-2012 that used a stakeholder approach to identify potential sites within the CBBEP program area for conservation, restoration, enhancement and creation (Smith et al. 1997, Smith and Wood 2003, Davis and Smith 2012). We identified all sites within the reports with the exception of conservation for this project, and created Google Earth kmz files for the 1997 and 2003 sites.

Table 1. List of recommended restoration sites within the CBBEP area from three inventory reports.

Phase	Site #	Site Name
Nueces - Corpus Christi Bay (Smith et al. 1997)		
--	1997-1	Hwy 77 Park
--	1997-2	Hwy 77 and 37 Junction Tertiary Treatment Ponds
--	1997-3	COE Mitigation Site
--	1997-4	Allison Treatment Plant Water Diversion
--	1997-5	Tule Lake
--	1997-6	Nueces Delta Front
--	1997-7	White’s Point

--	1997-8	Nueces Bay North Shoreline
--	1997-9	Corpus Christi Beach Wetland
--	1997-10	Rincon Channel
--	1997-11	Landfill/Oso Creek
--	1997-12	Corpus Christi Botanical Gardens
--	1997-13	Gum Hollow Creek
--	1997-14	Gum Hollow Creek
--	1997-15	Green Lake, Corpus Christi Bay Drainage, and North Shoreline
--	1997-16	Indian Point Western Shoreline
--	1997-17	Sunset Lake
--	1997-18	Indian Point Park
--	1997-19	Hans Suter/Stormwater Drainage
--	1997-20	Mud Bridge

--	1997-21	Graham/Laguna Shores Ponds
--	1997-22	Ramfield Road Wetland
--	1997-23	Caribbean Road Wetland
--	1997-24	McCampbell Slough
--	1997-25	Hwy 35 Wetland
--	1997-26	Pelican Cove Mangroves
--	1997-27	Ingleside Cove Shore
--	1997-28	Pelican Island
--	1997-29	Shamrock Island
--	1997-30	Shamrock Cove
--	1997-31	Wilson's Cut
--	1997-32	Mid-Mustang Island Site
--	1997-33	Fish Pass

--	1997-34	GLO State Tracts 59,60
--	1997-35	Coyote Island
--	1997-36	Gulf Intracoastal Waterway No. Island
--	1997-37	Snoopy's Flats
--	1997-38	City of Port Aransas Intertidal Flat
--	1997-39	Piper Channel
Copano - Aransas Bay System (Smith and Wood 2003)		
--	2003-1	Refugio Kayak Launch
--	2003-2	Invasive Species – Water Lettuce (Fennessey Ranch)
--	2003-3	Black Point – South Bayside
--	2003-4	Egery Island Road Copano Bay
--	2003-5	Memorial Park
--	2003-6	Whitney Lake – Ingleside

--	2003-7	Buccaneer Cove – Aransas Delta
--	2003-8	Aransas Delta Shoreline
--	2003-9	Rincon Bend Aransas River
--	2003-10	Hwy 77 Roadside Park
--	2003-11	Hwy 188/77 Roadside Park
Nueces/Corpus Christi Bay System (Smith and Wood 2003)		
--	2003-12	Indian Point – Nueces Bay
--	2003-13	Charlie's Pasture – Port Aransas
--	2003-14	South of Francine Cohn Preserve – Mustang Island
--	2003-15	Invasive Species – Ward Island
--	2003-16	Botanical Gardens – CC
--	2003-17	May Property – Oso Creek (shoreline)
--	2003-18	May Property – Osos Creek (habitat)

--	2003-19	Redhead Pond – Flour Bluff (hydrologic)
--	2003-20	Redhead Pond – Flour Bluff (invasive species)
Guadalupe-San Antonio River/Delta (Davis and Smith 2012)		
I	2012-1	Sand Pit
I	2012-2	Marthijohnni Swamp
I	2012-3	Linn Lake
I	2012-4	Linn Lake South
I	2012-5	Bald Cypress Swamp
I	2012-6	Rookery off Barge Canal
I	2012-7	Guadalupe Fields
I	2012-8	Green Lake
I	2012-9	Carbide Colony
I	2012-10	March Ranch

I	2012-11	NE Mission Lake
I	2012-12	Guadalupe Delta Swamp Colony
I	2012-13	Traylor's Cut
I	2012-14	Kamey Island Rookeries
I	2012-15	Guadalupe Delta Shoreline
I	2012-16	Swan Point Ranch
I	2012-17	Guadalupe Delta
II	2012-18	San Antonio River Golden Orb Habitat
II	2012-19	River Pasture 2
II	2012-20	River Pasture 1
II	2012-21	McFaddin New Ranch Flat
II	2012-22	McFaddin New Ranch
I	2012-23	Log Jams

Blackjack & Seadrift-Port O'Connor Peninsulas (Davis and Smith 2012)		
I	2012-24	ANWR Shoreline Erosion
I	2012-25	ANWR Mustang Lake Wetlands
I	2012-26	ANWR Sundown Bay Wetlands
I	2012-27	ANWR Dunham Bay Wetlands
I	2012-28	Welder Flats
I	2012-29	Arapaho Holdings
I	2012-30	North Seadrift-Port O'Connor Ridge Shoreline
I	2012-31	Welder Ditch
San Antonio Bay System (Davis and Smith 2012)		
II	2012-32	Boggy Bayou Drainage
I	2012-33	Dunham Island Wetlands
I	2012-34	Grass Island

I	2012-35	ANWR S. Bludworth Island Wetlands
I	2012-36	ANWR N. Bludworth Island Wetlands
I	2012-37	Roddy Island Wetlands
I	2012-38	Rattlesnake Island Wetlands
I	2012-39	Shoalwater Bay Wetlands
I	2012-40	Dewberry Island Wetlands
I	2012-41	Blackberry Island Wetlands
I	2012-42	Bayucos Island Wetlands
I	2012-43	Seadrift Island 609-280C
II	2012-44	Seadrift Island 609-280B and Chain
I	2012-45	Second Chain Islands
I	2012-46	Big Bird Island
I	2012-47	South Pass Islands

II	2012-48	Victoria Barge Canal Island
II	2012-49	Turnstake Island Complex
I	2012-50	Chester Island
I	2012-51	Chicken Foot Oyster Reef
II	2012-52	Upper-San Antonio Bay Oyster Reefs
II	2012-53	Mission Lake-Guadalupe Bay Rangia Clams
II	2012-54	Hynes Bay Tire Removal
Matagorda & San Jose Barrier Islands (Davis and Smith 2012)		
I	2012-55	Cedar Bayou Pass
I	2012-56	St. Joe Marsh/Tidal Flat
I	2012-57	South Matagorda island Tidal Fan Wetlands
I	2012-58	Panther Point Back Barrier Wetlands
I	2012-59	Long Lake Entrance

I	2012-60	S. Pass Lake Entrance
I	2012-61	Vandeveer Island S. Back Barrier Wetlands
I	2012-62	Pringle Lake Entrance
I	2012-63	Back Bay Wetlands
I	2012-64	Sunday Beach
I	2012-65	Army Hole Entrance
II	2012-66	Pelican Island at Pass Cavallo
II	2012-67	Oil Wells Cuts Saluria Bayou

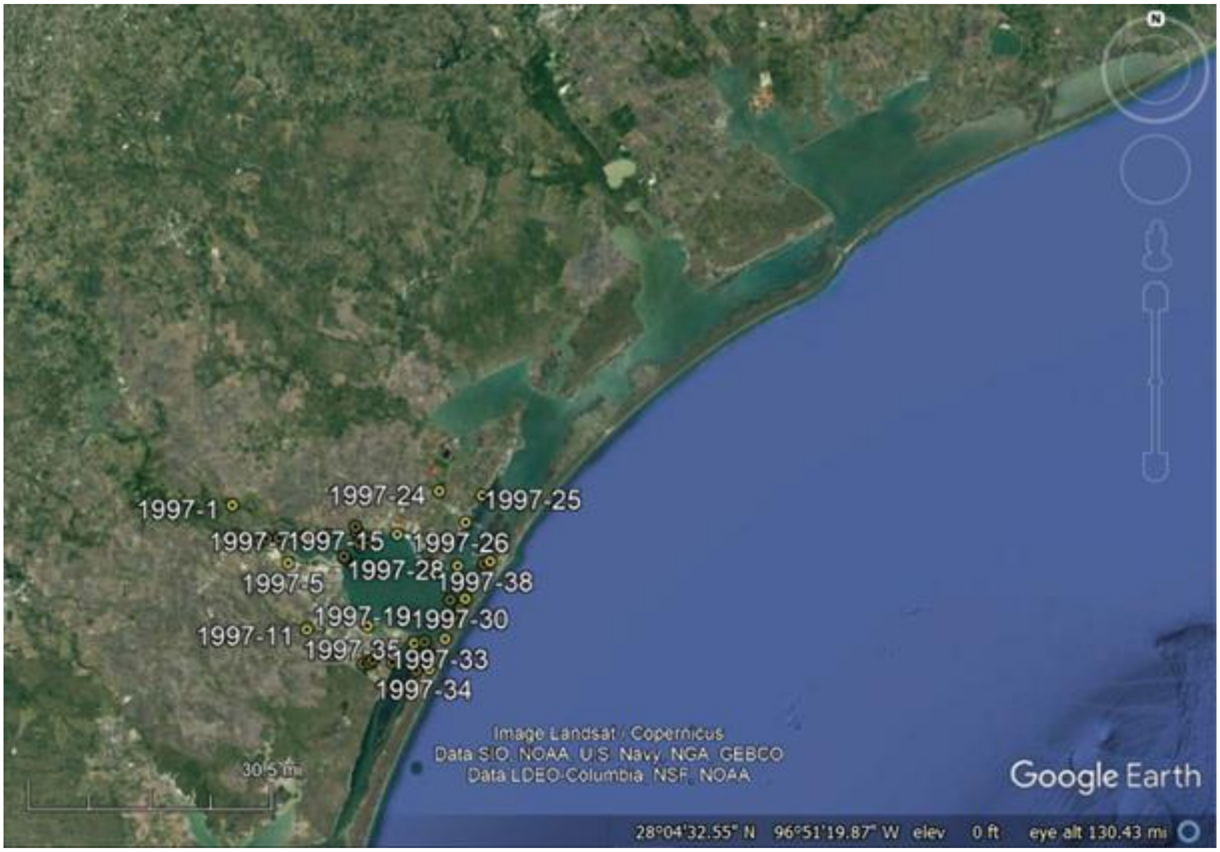

Figure 5. Sites identified for potential restoration, enhancement and creation projects in Nueces/Corpus Christi Bay system (from Smith et al. 1997).

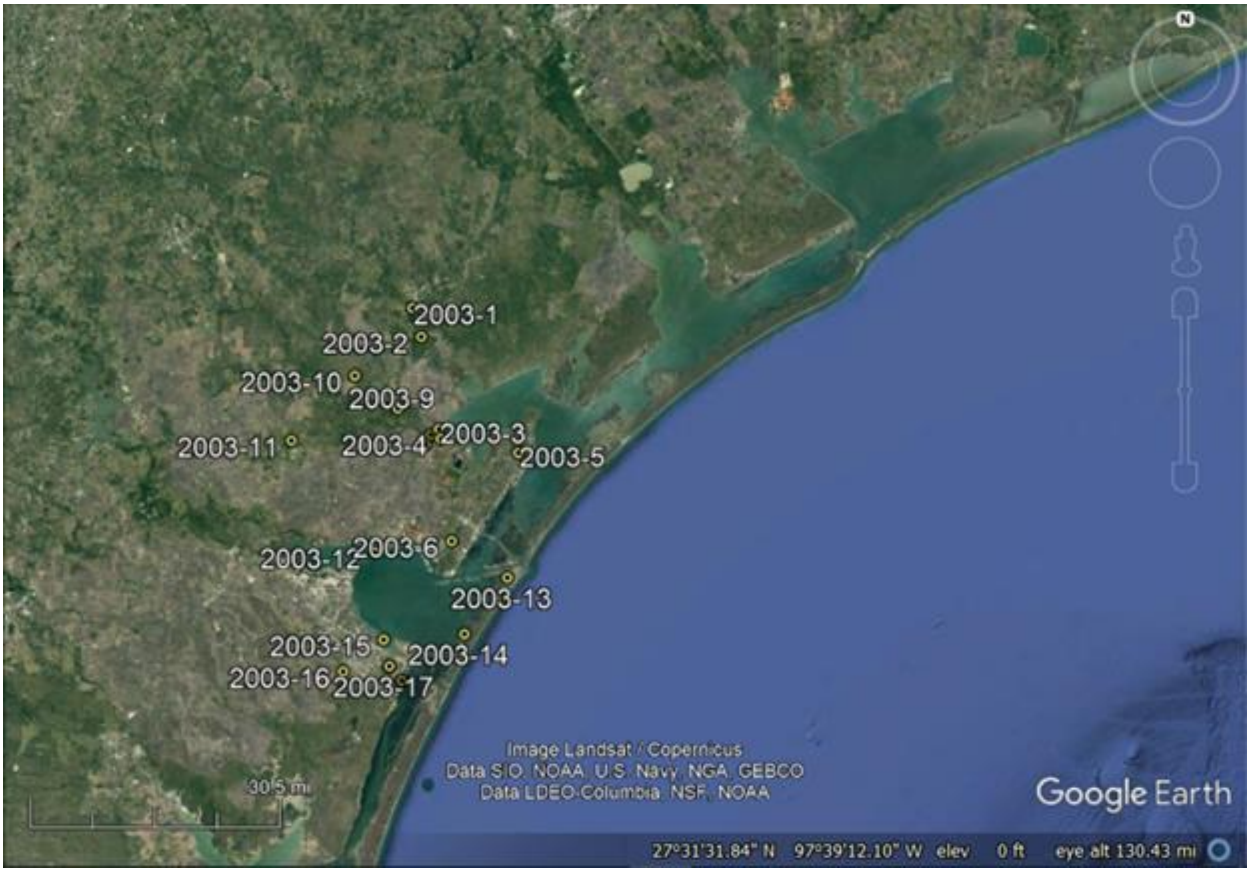

Figure 6. Sites identified for potential restoration projects in Copano/Aransas and Nueces/Corpus Christi Bay systems (from Smith and Wood 2003).

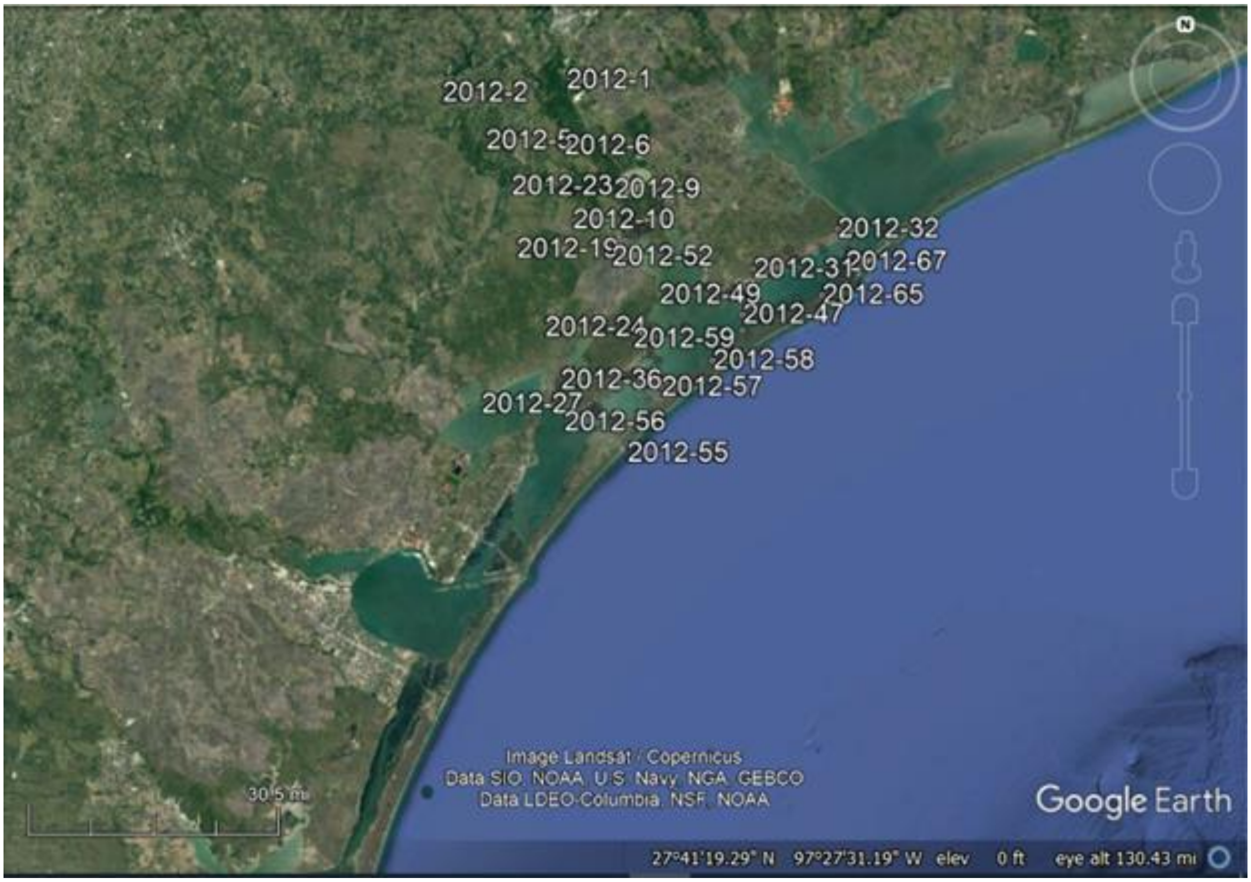

Figure 7. Sites identified in Phase 1 and 2 for potential restoration projects in San Antonio Bay system (from Davis and Smith 2012).

Newly Identified Sites

The International Crane Foundation (ICF) met with multiple stakeholders individually to review and identify areas within the CBBEP area they recommend hydrologic restoration occur to improve ecosystem function. Stakeholder involvement included the San Antonio Bay Partnership, the U.S. Fish and Wildlife Service's (USFWS's) Aransas National Wildlife Refuge (ANWR), USFWS's Gulf Restoration Program, Texas Parks and Wildlife Department and the Coastal Bend Bays & Estuaries Program. Potential restoration activities could include small to large efforts, such as replacing inept culverts under a single road or rerouting drainage ditches across a larger landscape. CBBEP stakeholders for restorative action have recommended ten hydrologic sites located within seven different sub-basins (Figure 8). A summary of the hydrologic sites and relevant characteristics, such as approximate restoration acres, size range, complexity, and number of landowners is included in Table 2.

Figure 8. Newly identified hydrologic restoration sites within the study area.

1. Sea-Dan Ditches and Welder Flats Road

Background Information

Sea-Dan dich 1, 2, and 3, and Welder Flats Road are located within the East San Antonio Bay sub-basin (HUC 12100403) (Figure 9). These sites are located within multiple private properties and conservation easements (Table 2). Based on historical imagery and USGS topographic maps, the Sea-Dan Ditches and similar ditches in the surrounding area were created for agricultural purposes prior to 1952 (Figures 9A and 9B). Similarly, Welder Flats Road appears to have been established prior to 1952 for agriculture and/or oil and gas purposes. The ridge-and-swale topography of Seadrift-Port O'Connor Ridge naturally retains surface water during wet periods. The ditches were excavated through these seasonal wetlands to improve grazing lands. While surface water drained off the uplands to the coastal marshes through these ditches, natural recharge into the upland sandy soils has been compromised.

Restoration Action (per USFWS, SABP, ICF)

1. Restore hydrologic connection to freshwater wetlands adjacent to the ditches using a meandering stream design.
2. Reconnect hydrologic connectivity of the flats, marshes, and seagrass habitat of Welder Flats by constructing water flow structures (i.e., low water crossings, culverts, bridges) along Boat House Road.

Restoration Benefit

1. Surface water removal that still benefits good-quality grazing habitat can be balanced with recharging adjacent wetlands and improve groundwater recharge. Freshwater flows to the downstream areas of coastal marshes and flats will maintain fishery and wildlife productivity in estuarine habitats of Welder Flats and San Antonio Bay.
2. The lower salinity water flowing from the uplands into the northern estuarine habitats will be reconnected through water flow structures along Boat House Road to the southern estuarine habitats and increase fishery and wildlife productivity in Welder Flats and San Antonio Bay.

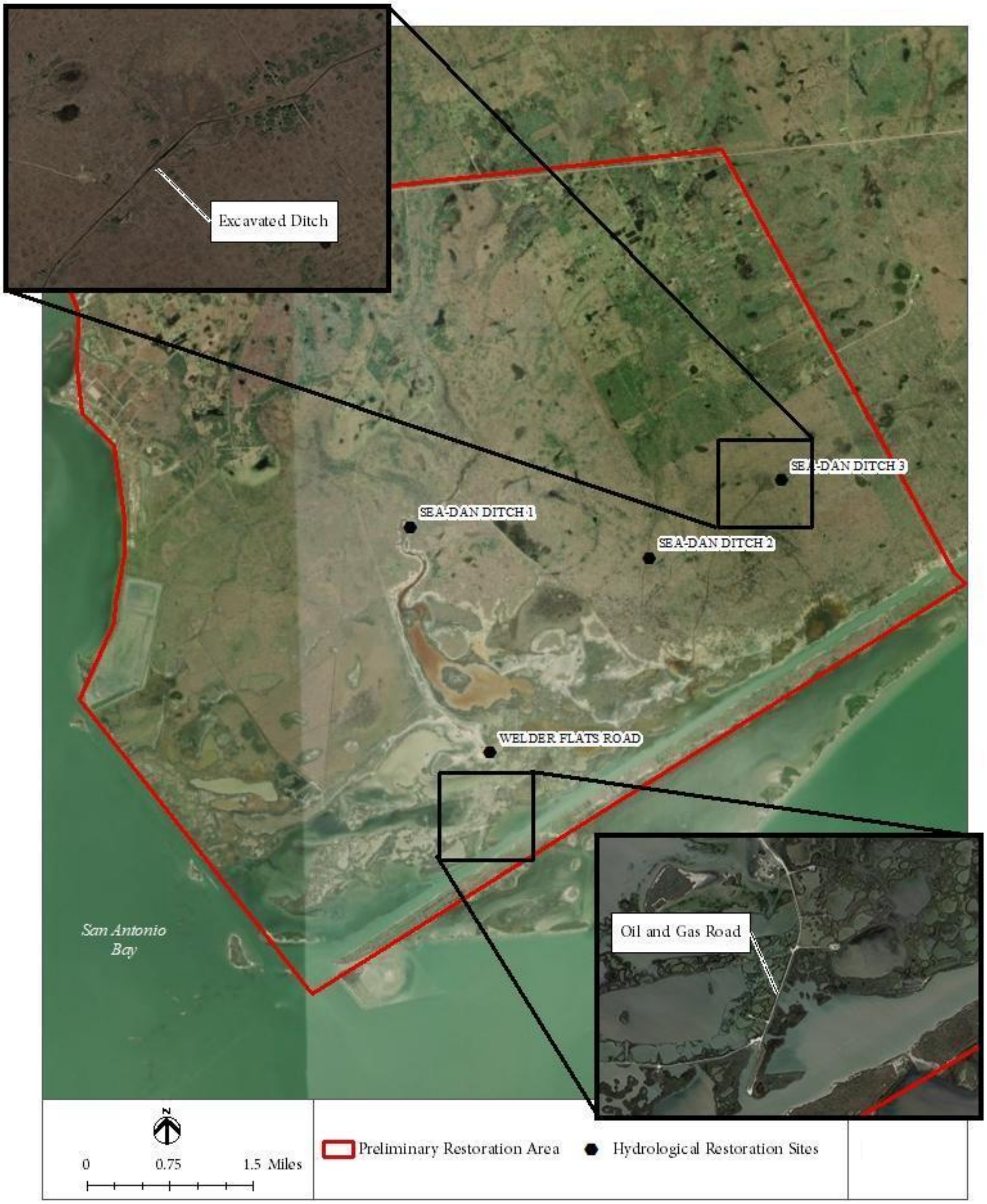

Figure 9. Aerial imagery of Sea-Dan Ditches 1-3 and Welder Flats Road located north of San Antonio Bay.

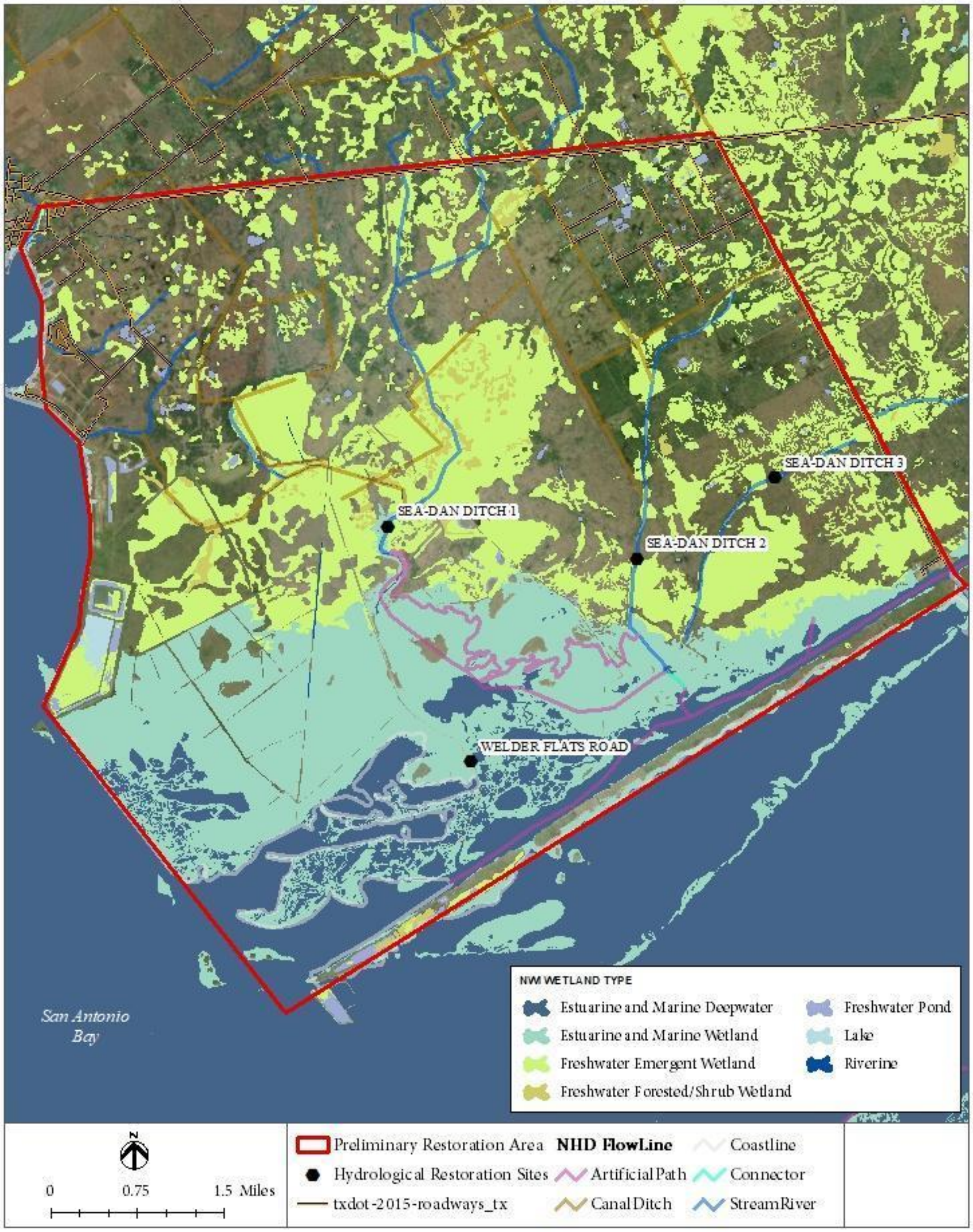

Figure 9A. NHD and NWI data at Sea-Dan Ditches 1-3 and Welder Flats Road.

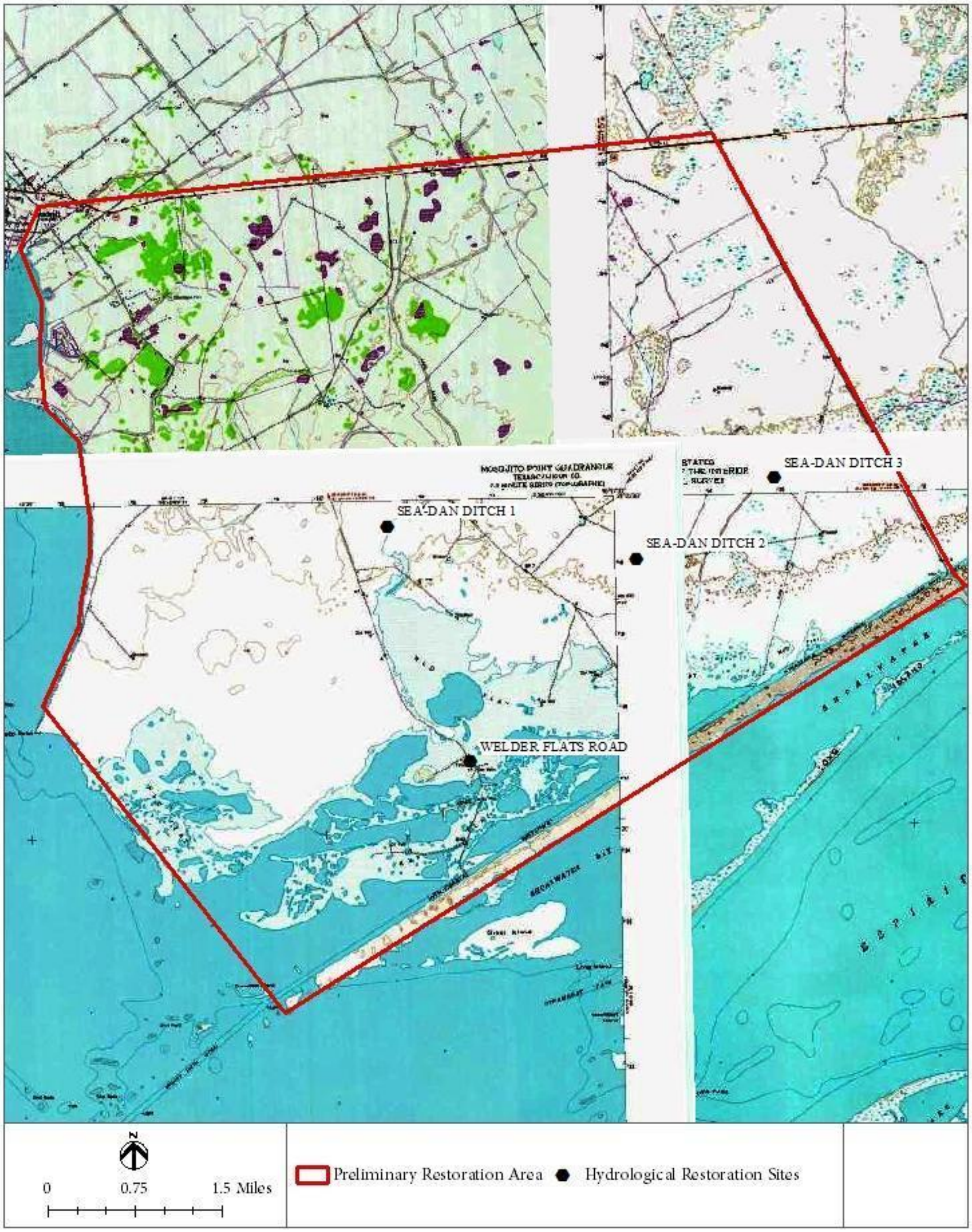

Figure 9B. Historical USGS topographic quadrangles (1:24,000) at Sea-Dan Ditches 1-3 and Welder Flats Road.

2. *Townsend Bayou*

Background Information

A portion of Townsend Bayou is located within the Hynes Bay Unit of the Guadalupe Delta Wildlife Management Area in the West San Antonio Bay sub-basin (HUC 12100404) (Figure 10). Townsend Bayou is mapped as a stream by the NHD Flowline dataset (Figure 10A). The stream flows into Hynes Bay, a secondary bay that is part of the San Antonio Bay estuary system. Townsend Bayou is characterized as having expansive brackish- and saltwater ponds and marshes (Tremblay and Calnan 2011) (Figure 10B).

Various artificial gates, canals, and other restrictions that have been put in place to divert water for municipal, industrial, and agricultural use (Carothers et al. 2015) have significantly altered the natural flow within the entire Guadalupe Delta System. According to the status and trends of wetlands observed with the San Antonio Bay areas (Tremblay and Calnan 2011), fresh marsh within the upper reaches of Townsend Bayou have been replaced by salt marsh by 1979. By 2009, a large portion of Hynes Bay shoreline within Townsend Bayou has converted from salt marsh or open water to irregularly exposed tidal flats.

Restorative Action

1. Remove artificial canals, ditches, and/or levees that have altered hydrologic conditions.
2. Create a freshwater inflow diversion to create a refuge area for San Antonio Bay during periods of drought induced by hypersaline conditions.

Restoration Benefit (per SABP)

1. A diversion project would nourish freshwater and estuarine marshes within Townsend Bayou during drought periods and mitigate salinities in the upper part of Hynes Bay, which will provide greater environmental benefits than the same volume of water continuing past the saltwater barrier.
2. Restore natural range of salinity ranges in Townsend Bayou and increase habitat diversity that will create additional refuge for estuarine species and be more resilient to extended drought conditions.

Figure 10. Aerial imagery at Townsend Bayou located along Hynes Bay in the Guadalupe River Delta area of San Antonio Bay.

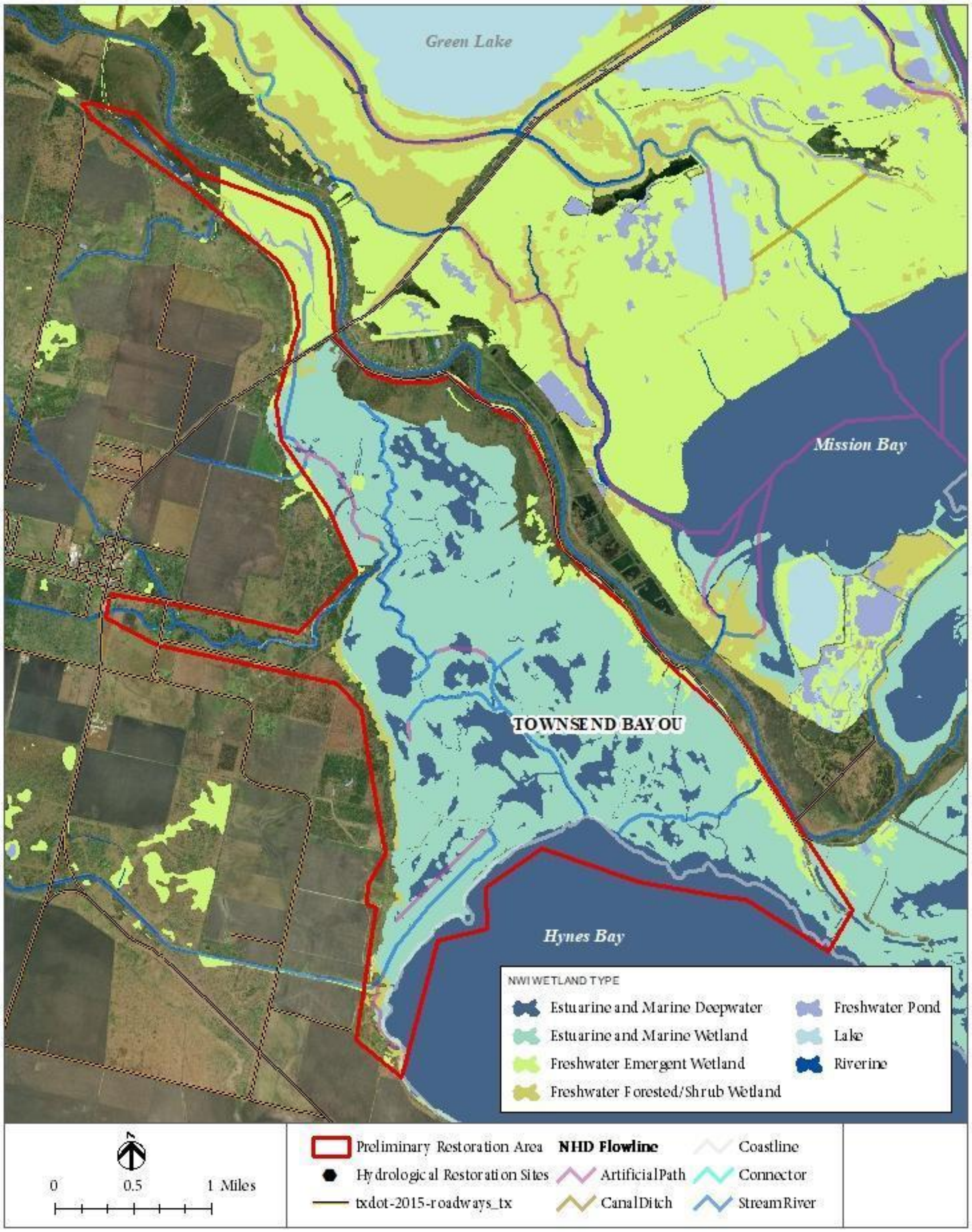

Figure 10A. NHD and NWI data within Townsend Bayou.

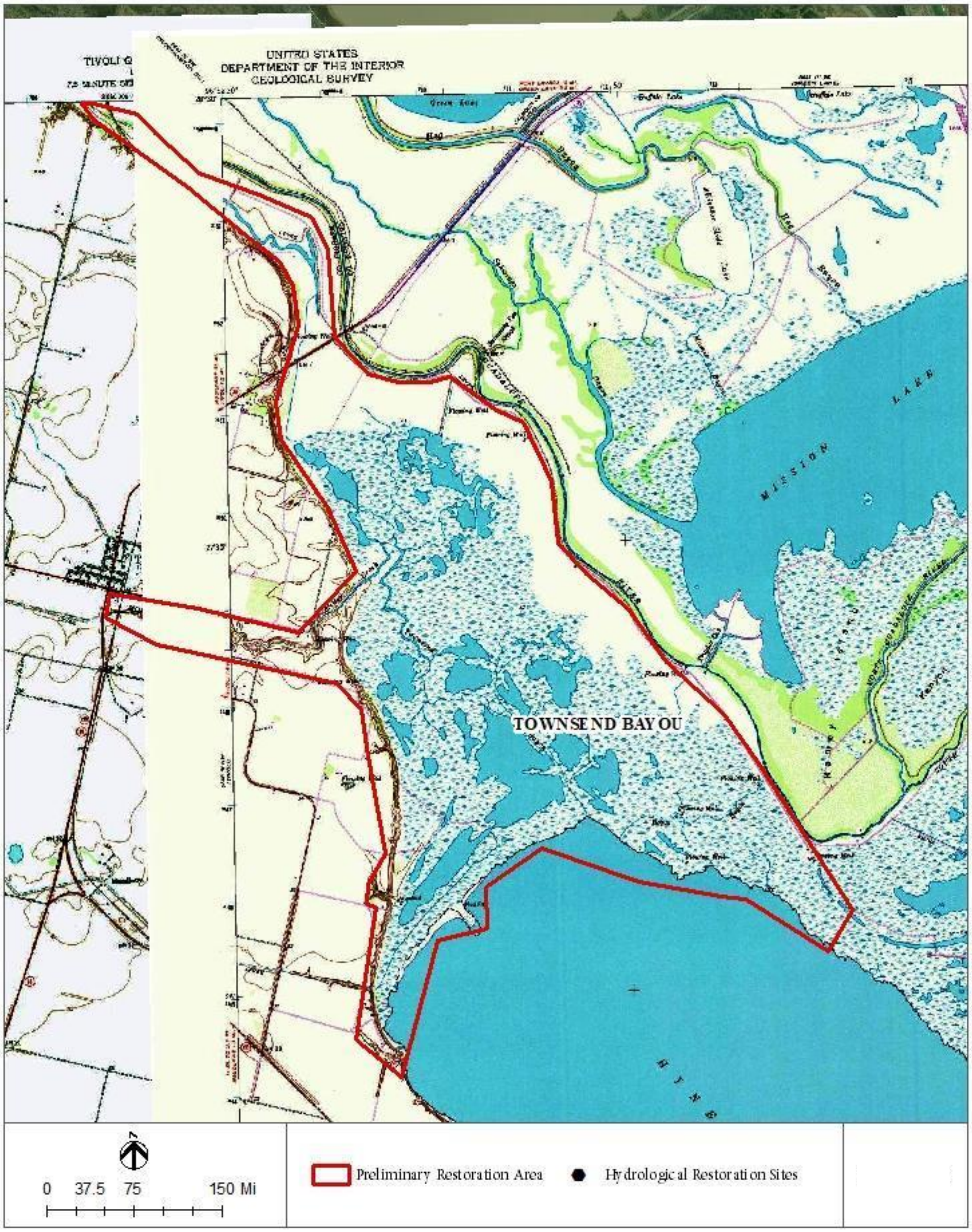

Figure 10B. Historical USGS topographic quadrangles (1:24,000) for Townsend Bayou.

3. *West Marsh*

Background Information

West Marsh is located within the Aransas National Wildlife Refuge on the backside side of Matagorda Island within the East San Antonio Bay sub-basin (HUC 12100403). Matagorda Island is approximately 56,668 acres of gulf beach, dunes, coastal prairie and freshwater marshes, and intertidal estuarine marshes (CBBEP 2017). The island has been protected by the U.S. Fish and Wildlife Service and the Texas Parks and Wildlife Department since 1979. However, artificial levees for cattle production and other man-made modifications have altered the natural hydrology within West Marsh (CBBEP 2017) (Figure 11). Extensive ditching of freshwater marshes along the length of the island have altered natural subsurface freshwater inflows into West Marsh. In addition, sea level rise may have a profound effect on marsh habitats throughout the island (Figures 11A and 11B). Based on a study by Gibeaut and others (2013), the interior ponds on Matagorda Island will increase into low marsh areas in approximately 55 years if the marshes are unable to keep up with sea level rise (0.22 m/0.04 m/yr).

Restoration has been occurring since the late 1970's with the installation of culverts as an attempt to restore natural hydrology within the marsh. Multiple factors including sea level rise, climate change, and degradation of artificial structures (levees and culverts) continue to affect the hydrology and vegetative communities within West Marsh. The CBBEP has been working with the ANWR to identify and prioritize restoration actions. The partial removal of levees and repair of existing culverts were identified as a priority and restoration actions began in 2011. Extensive damage to West Marsh occurred because of Hurricane Harvey in 2017 that will be taken into account in future restoration planning and implementation within the West Marsh site. These actions will increase hydrologic connectivity from Mesquite Bay and reduce hypersaline conditions during summer and extended droughts.

Restorative Action (per USFWS, ICF, CBBEP)

1. Additional culverts and partial levee removal can be designed to restore freshwater flows from shallow ditches in the middle of the island to West Marsh.

Restorative Benefit

1. Restoring freshwater flows from the barrier island interior to West Marsh will increase range of salinity gradients and habitat diversity. Estuarine species, such as blue crab and benthic organisms, will increase in abundance in the coastal ponds and flats. An increase in vegetation coverage may have a positive impact on abating sea-level rise within West Marsh and maintain productive wintering habitats for numerous endangered Whooping Cranes.

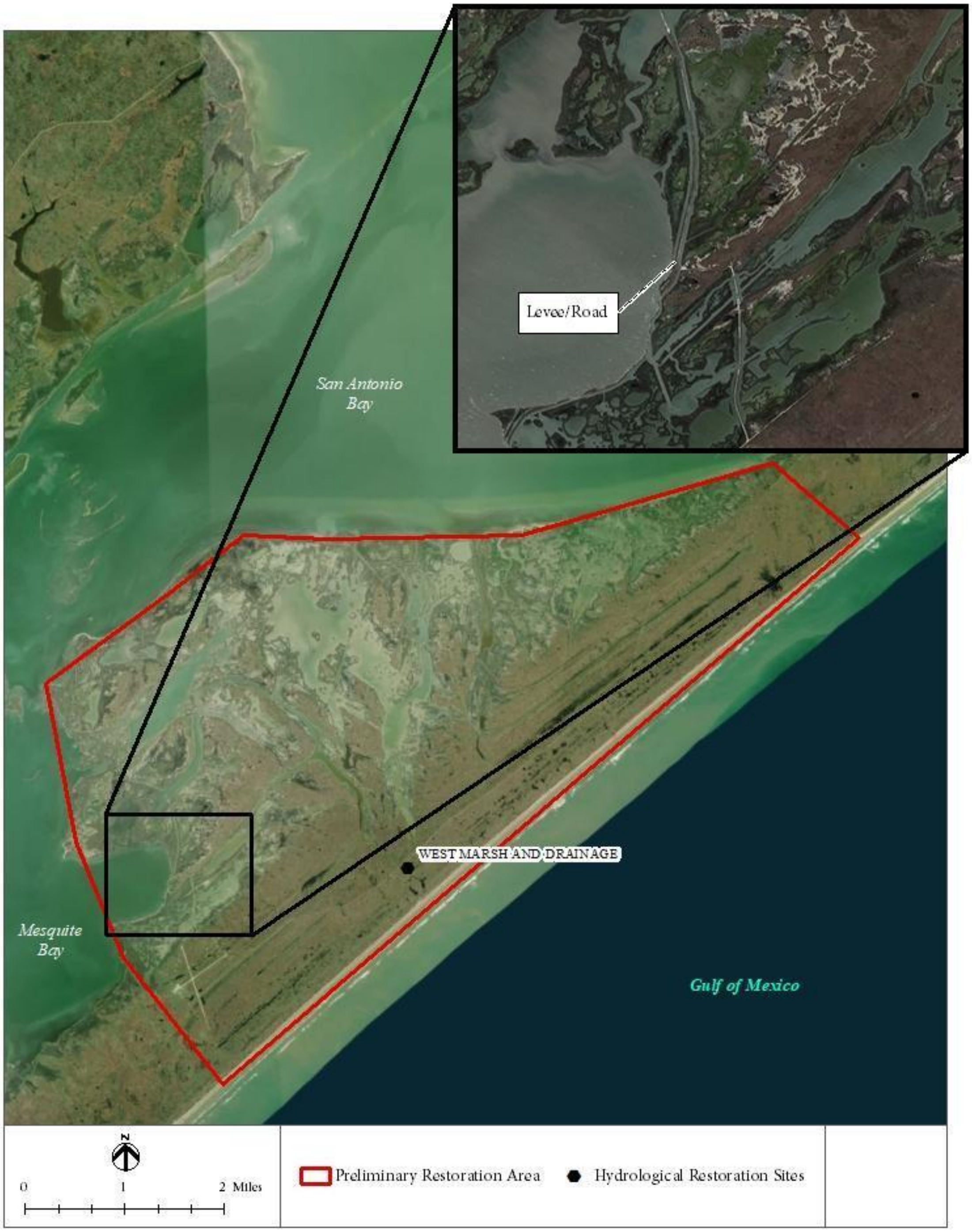

Figure 11. Aerial imagery of West Marsh located on the backside of Matagorda Island.

Figure 11A. NHD and NWI data for West Marsh on the backside of Matagorda Island.

Figure 11B. Historical USGS topographic quadrangles (1:24,000) for West Marsh.

4. *Pump Canal*

Background Information

Pump Canal is located on the Aransas National Wildlife Refuge shoreline at Mesquite Bay and within the West San Antonio Bay sub-basin (HUC8 12100404). Pump Canal is not present on USGS topographic maps (Mesquite Bay, TX) in 1952 and not demarcated by the NHD data (Figure 12). However, the canal appears to have been constructed sometime after 1950s (Allen 1954) and prior to 1990s (Google Earth Imagery, 1995). A levee constructed within the estuarine marsh and parallel to the shoreline effectively limits tidal flows and marsh migration with relative sea-level rise predictions. A refuge maintenance road runs parallel to the peninsula length and bisects natural swales, thus limiting surface freshwater flows to estuarine wetlands. Wetlands within the restoration site boundary include freshwater and estuarine emergent wetlands, and infrequently flooded flats (Figures 12A and 12B). The NHD data shows multiple artificial paths in ponds east and west of Pump Canal that do not appear to follow any natural features, and NHD streams throughout the marsh area appear to represent tidal creeks.

Restorative Action (per FWS, ICF)

1. Restore tidal connectivity of estuarine marshes on either side of Pump Canal by filling in portions of the canal and use borrow materials to increase elevations within the canal and plant estuarine vegetation.
2. Restore connectivity of freshwater and intertidal flats by reducing elevation of the levee areas and restore natural elevation by filling borrow pits with levee materials.
3. Construct additional culverts along East Shore Road that will provide connectivity of freshwater wetlands to estuarine habitats.

Restorative Benefit

1. Reduce fragmentation of the estuarine marsh adjacent to Pump Canal by restoring natural tidal connections and increase vegetated marsh habitat.
2. Restore natural elevation gradients from upland/freshwater habitats to intertidal estuarine habitats and allow natural marsh migration to occur with rising sea-level rise.
3. Restore hydrologic connectivity of freshwater swales to estuarine habitats through road culverts.

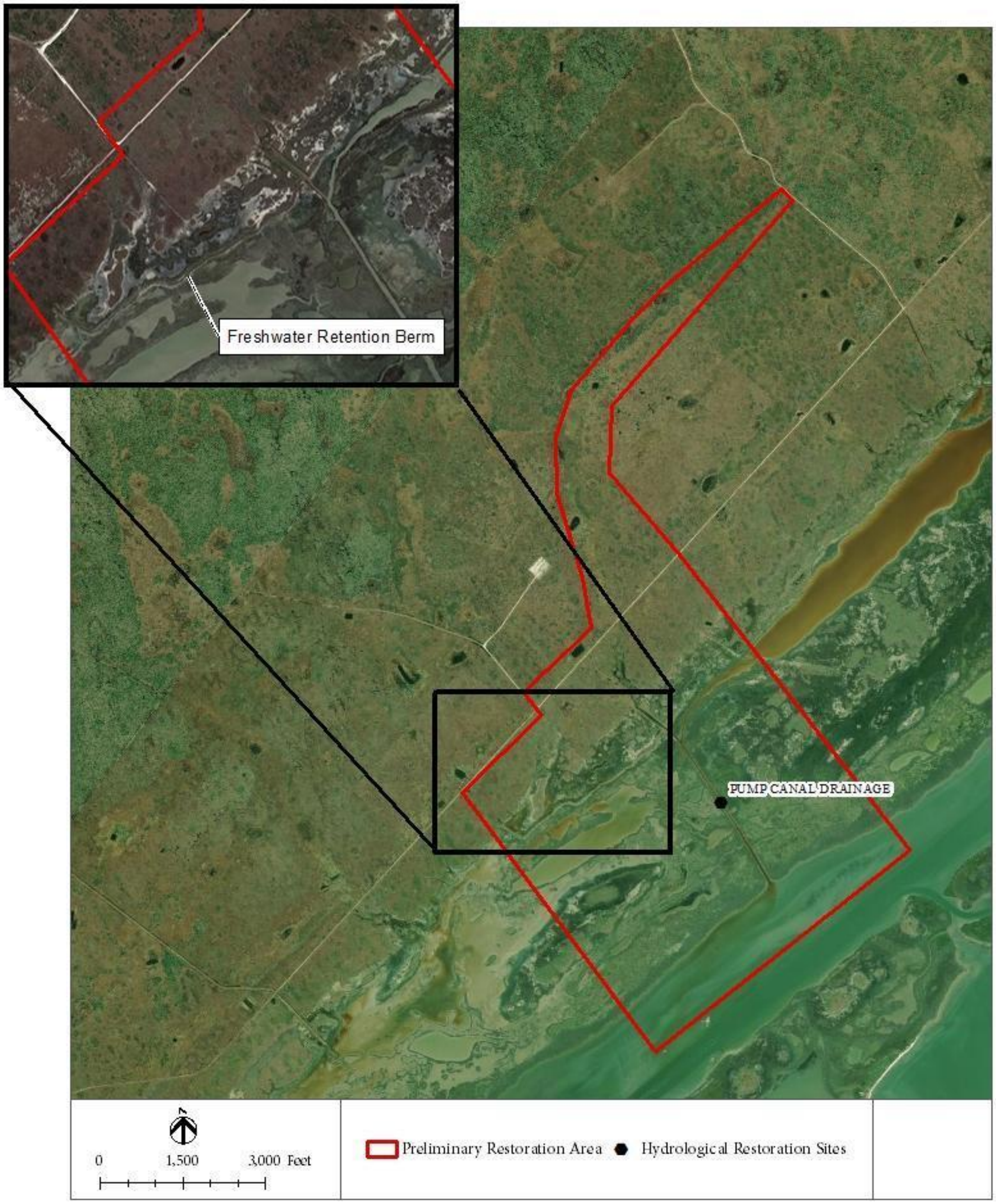

Figure 12. Aerial imagery of Pump Canal Drainage located on Blackjack Peninsula within the Aransas National Wildlife Refuge.

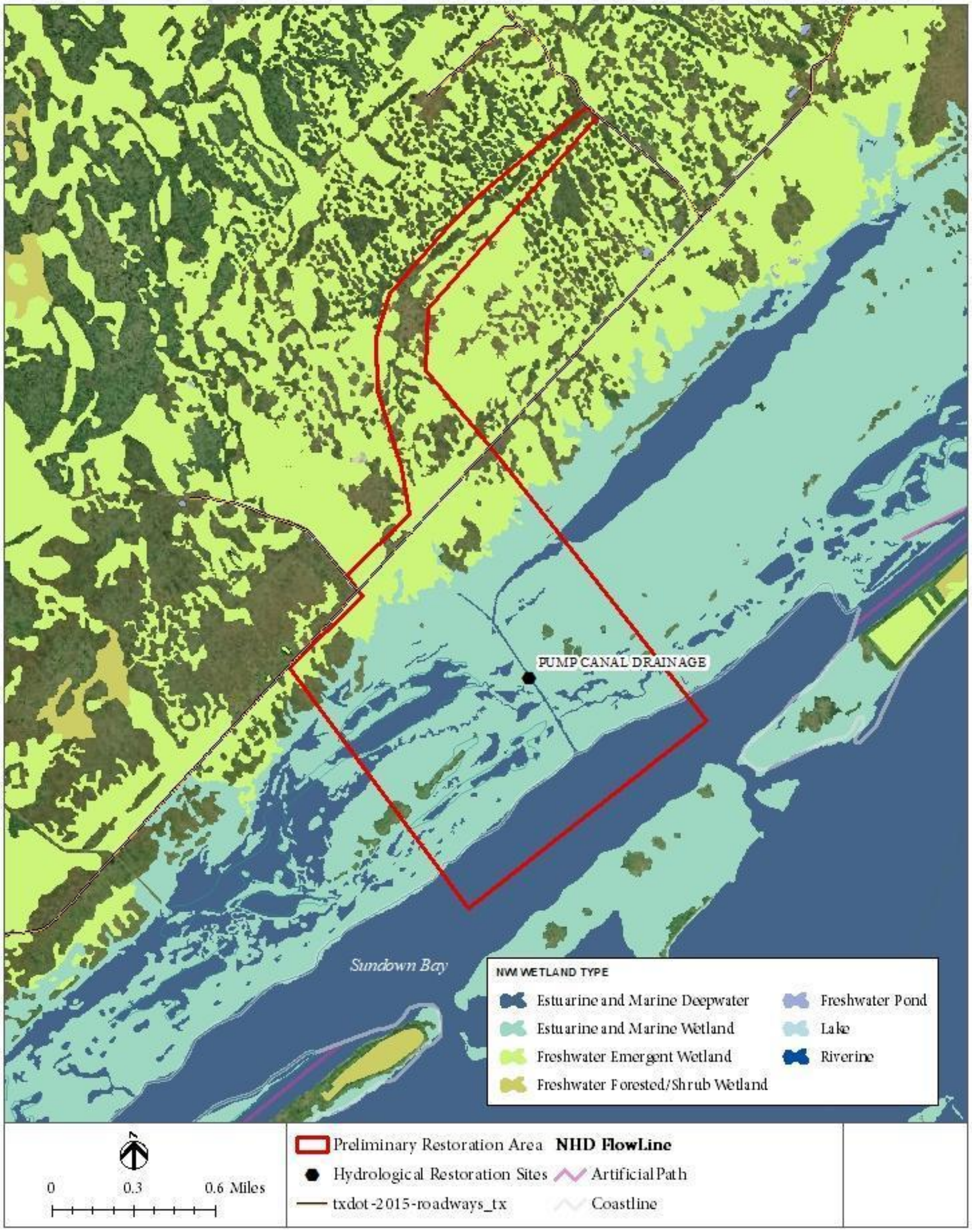

Figure 12A. NHD and NWI data at Pump Canal Drainage located on Blackjack Peninsula within the Aransas National Wildlife Refuge.

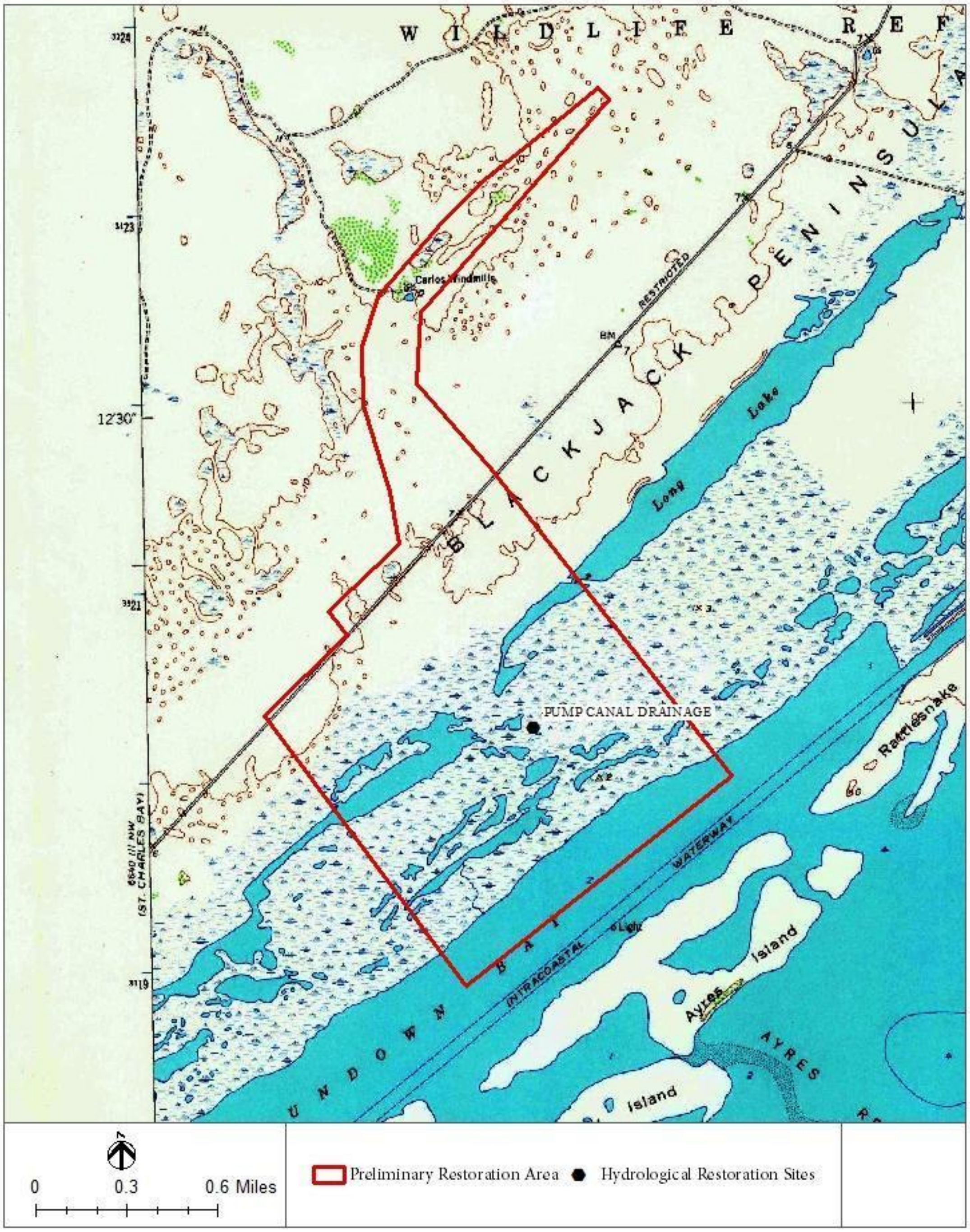

Figure 12B. Historical USGS topographic quadrangle (1:24,000) of Pump Canal Drainage located on Blackjack Peninsula within the Aransas National Wildlife Refuge.

5. *Burgentine Lake*

Background Information

Burgentine Lake is an artificial lake that was formed by the Civilian Conservation Corps in 1939 when they dammed Burgentine Creek (Figure 13). The Aransas National Wildlife Refuge is authorized to maintain the dam and reservoir for water storage and use for recreational purposes. A canal was excavated from the dam area along the western shoreline of St. Charles Bay and fill material was used to construct a maintenance road along the same route. The Refuge has been exploring restoration options that would allow subsurface freshwater to naturally move to the bay shore and reduce salinities in the bay.

Restorative Action (USFWS)

1. Develop connectivity options along the shoreline to allow natural drainage to the shoreline; replant shoreline with estuarine vegetation.

Restorative Benefit

1. The subsurface flow of freshwater into nearshore bay areas would support the establishment of estuarine marshes thus reducing erosion and providing fish and wildlife habitat.

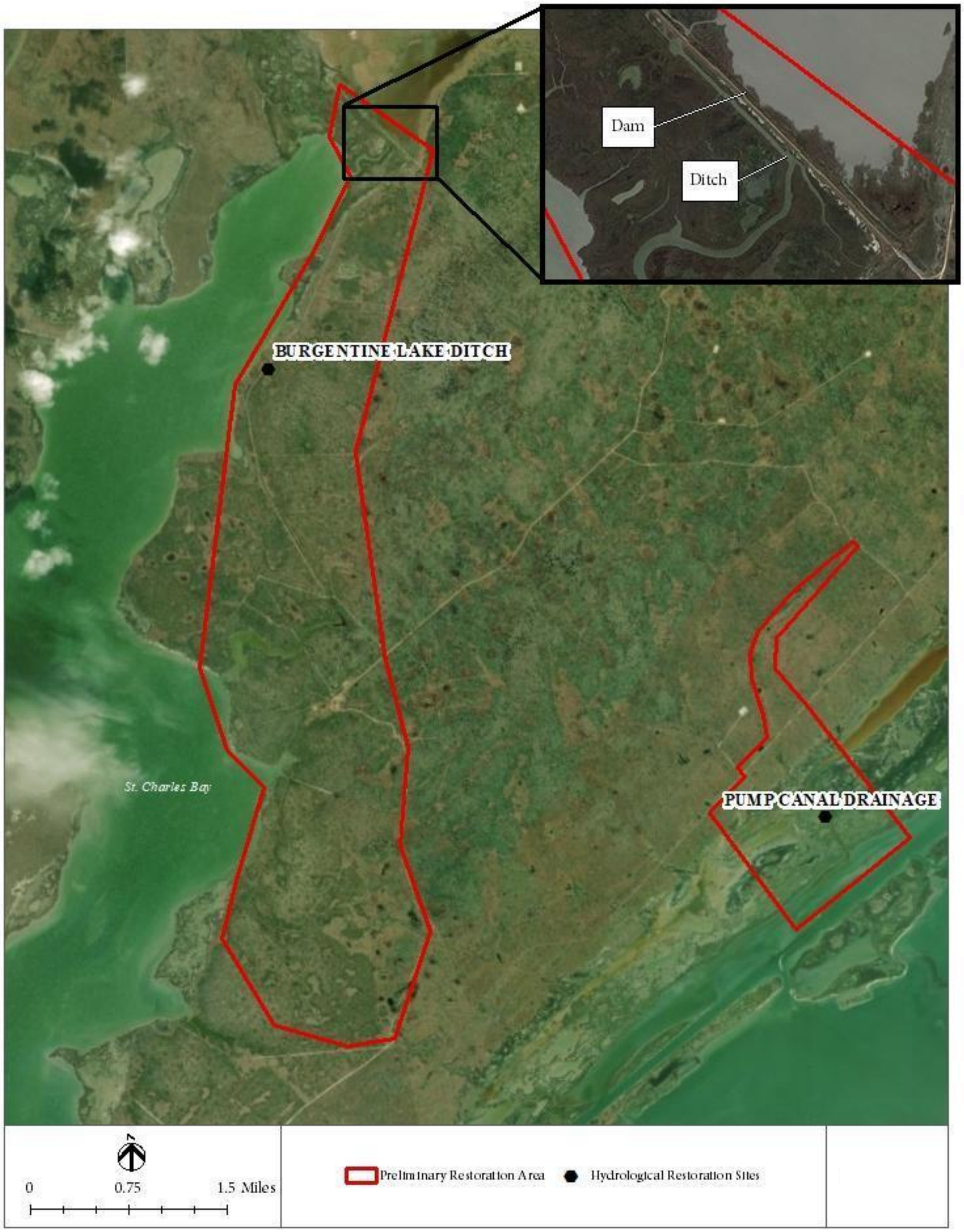

Figure 13. Aerial imagery of Burgentine Lake Ditch located on Blackjack Peninsula within the Aransas National Wildlife Refuge.

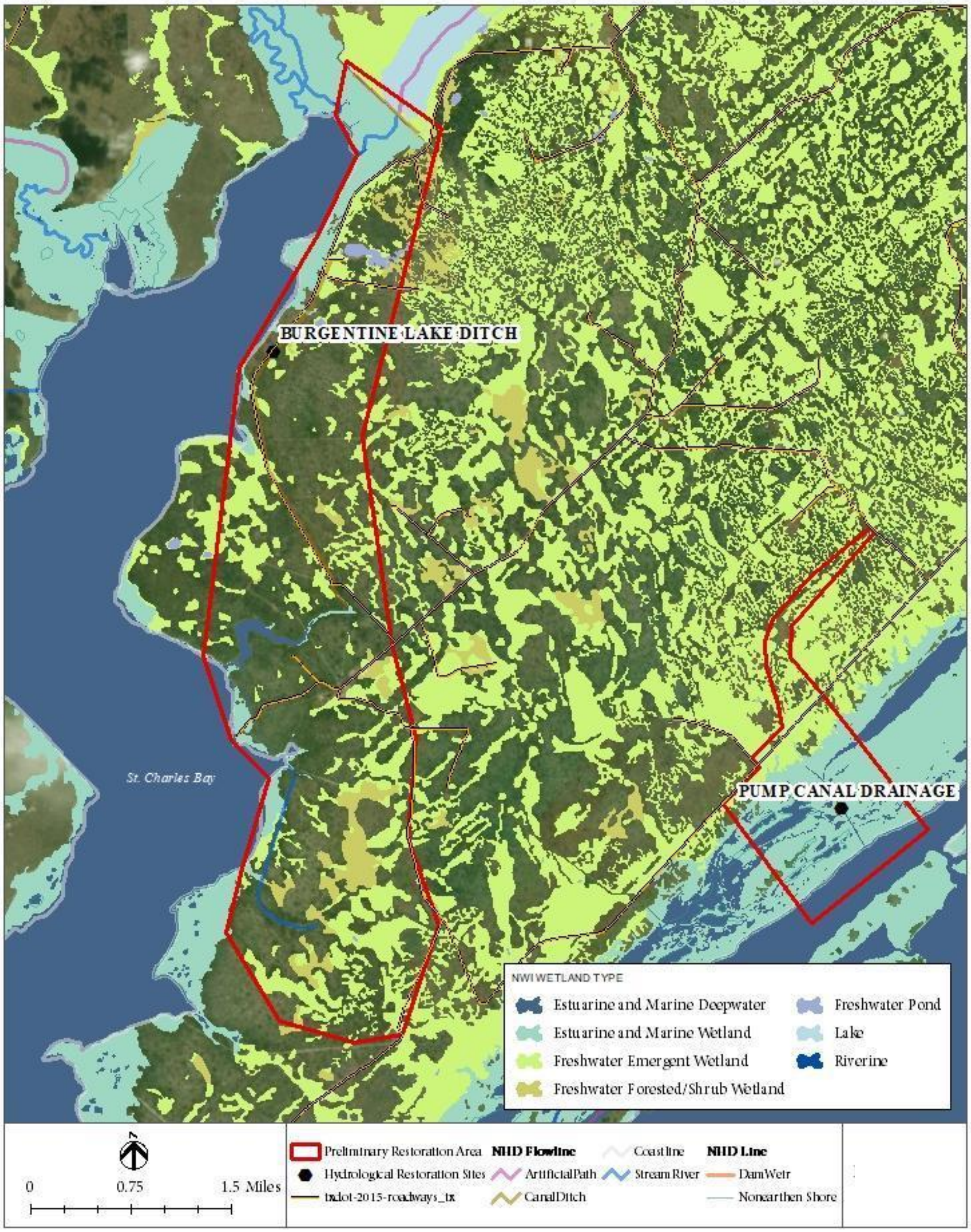

Figure 13A. NHD and NWI data at Burgentine Lake Ditch located on Blackjack Peninsula within the Aransas National Wildlife Refuge.

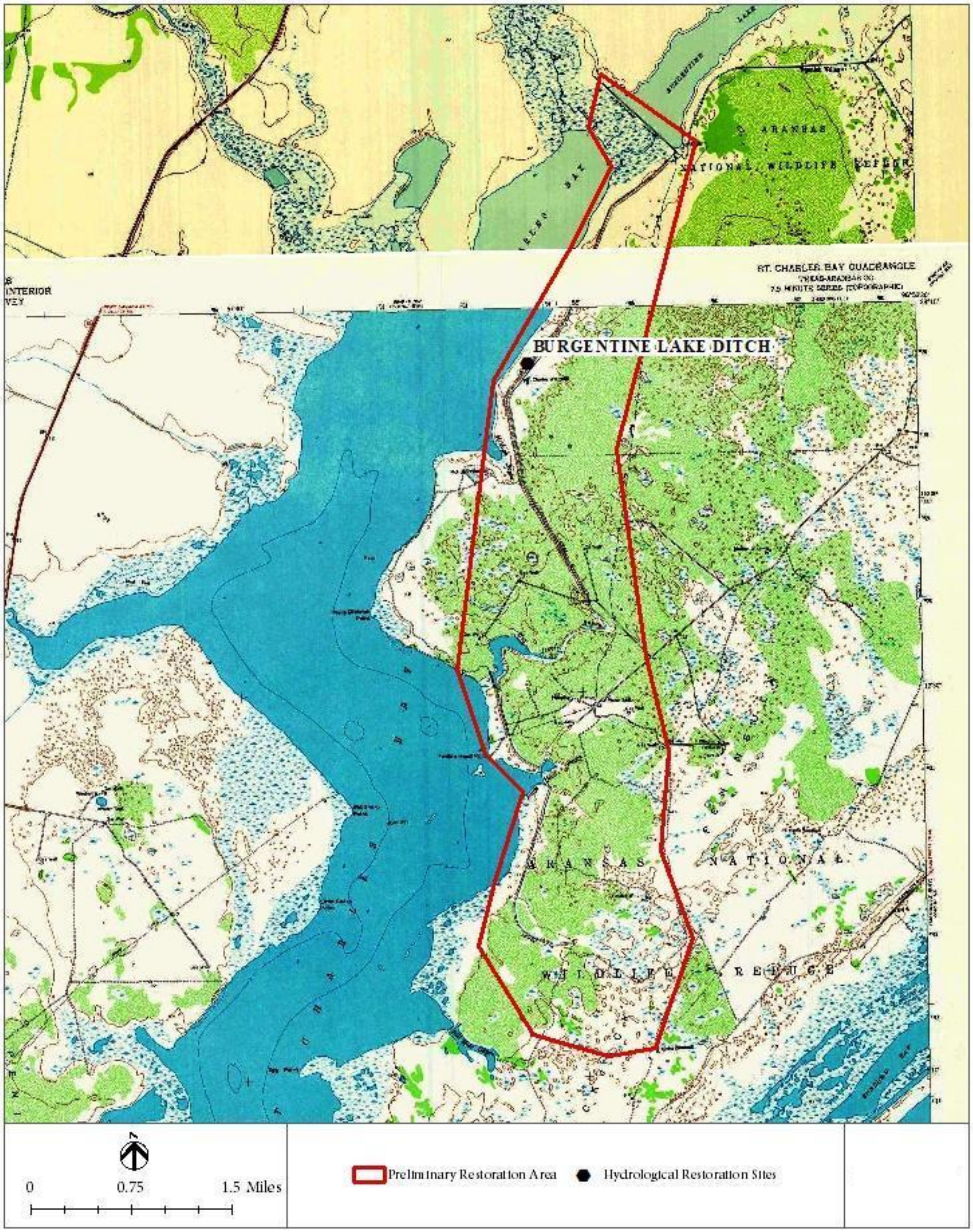

Figure 13B. Historical USGS topographic quadrangles (1:24,000) of Burgentine Lake Ditch located on Blackjack Peninsula within the Aransas National Wildlife Refuge.

6. *Lamar Fresh Marsh*

Background Information

Lamar Fresh Marsh is located on Lamar Peninsula on the western side of SH-35 and north of Seaside Loop and is the largest freshwater marsh on the peninsula (Figure 14). The marsh is mapped by the NWI as a palustrine emergent, persistent, seasonally flooded wetland (PEM1C) (Figure 14A), and has persisted since 1979 based on USGS topographic maps (Lamar, TX) (Figure 14B). Sometime between 2003 and 2008, multiple drainage features appear on the aerial imagery within this area, and one of these features appears to be draining Lamar Fresh Marsh towards the west through a culvert constructed under Hwy 35. A pond was excavated in the uplands to capture water and provide potential waterfowl habitat in 2016.

Restorative Action (per TPWD, ICF)

1. Construct a water control structure east of Hwy 35 culvert that can be manipulated to manage water levels in the marsh.
2. Restore the west pond to previous wetland swale levels using excavated material adjacent to the pond; replant with native vegetation.

Restorative Benefit

1. Restore freshwater habitat diversity for waterfowl, wading birds, and aquatic invertebrates and provide wildlife viewing opportunities.
2. Restore hydrologic connectivity among freshwater wetlands on the uplands on the western area.

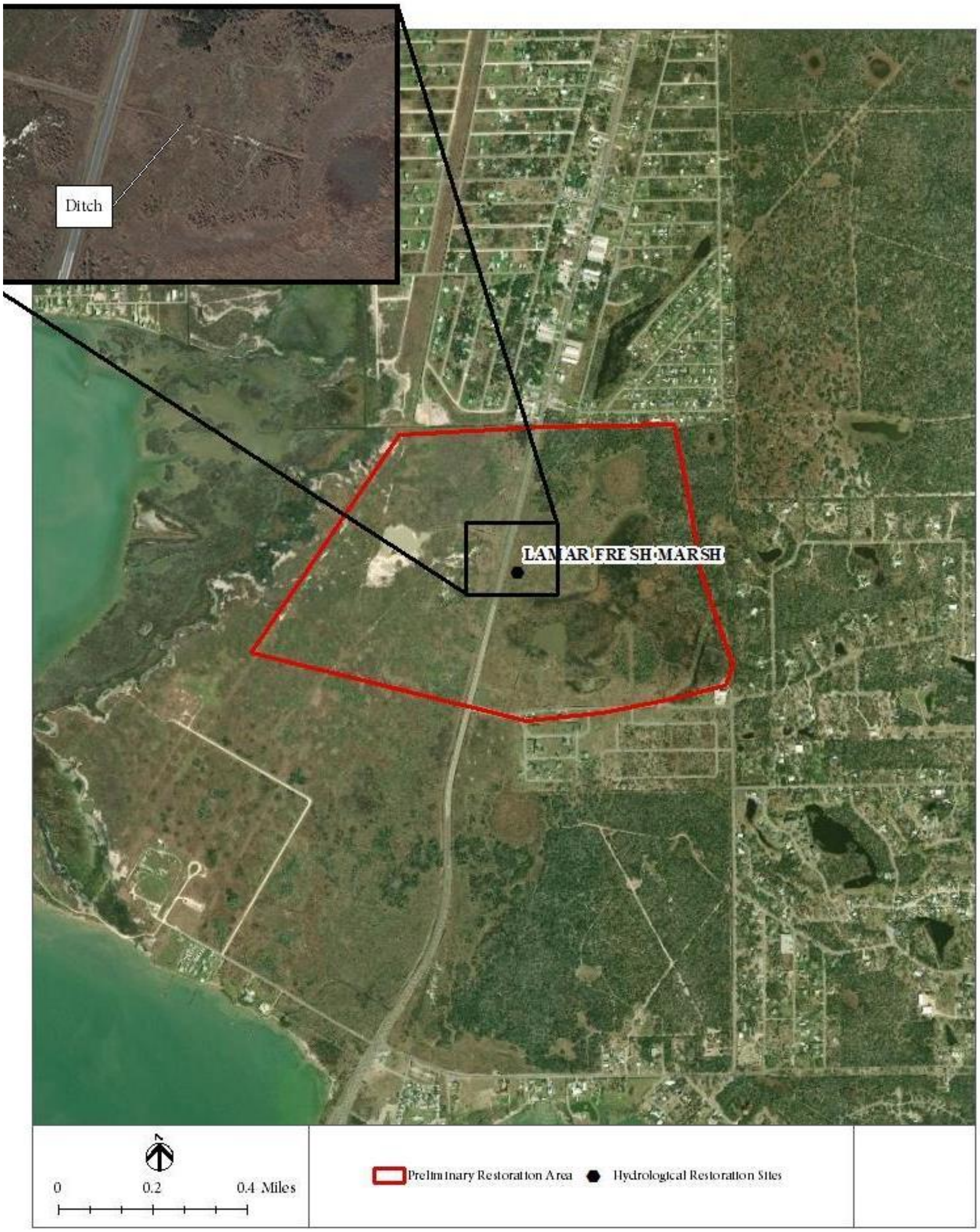

Figure 14. Aerial imagery of Lamar Fresh Marsh located on Lamar Peninsula north of Copano Bay.

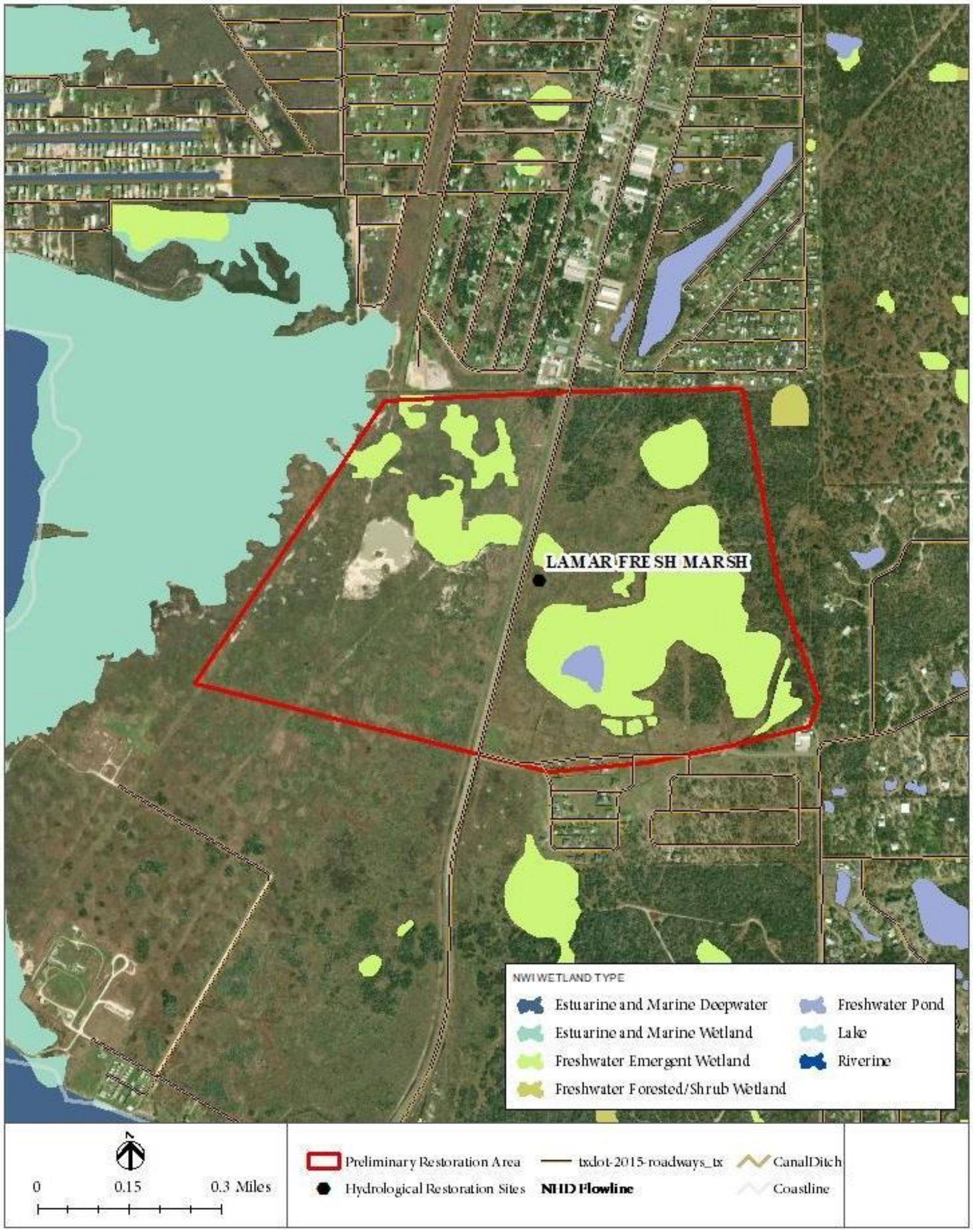

Figure 14A. NHD and NWI data at Lamar Fresh Marsh on Lamar Peninsula north of Copano Bay.

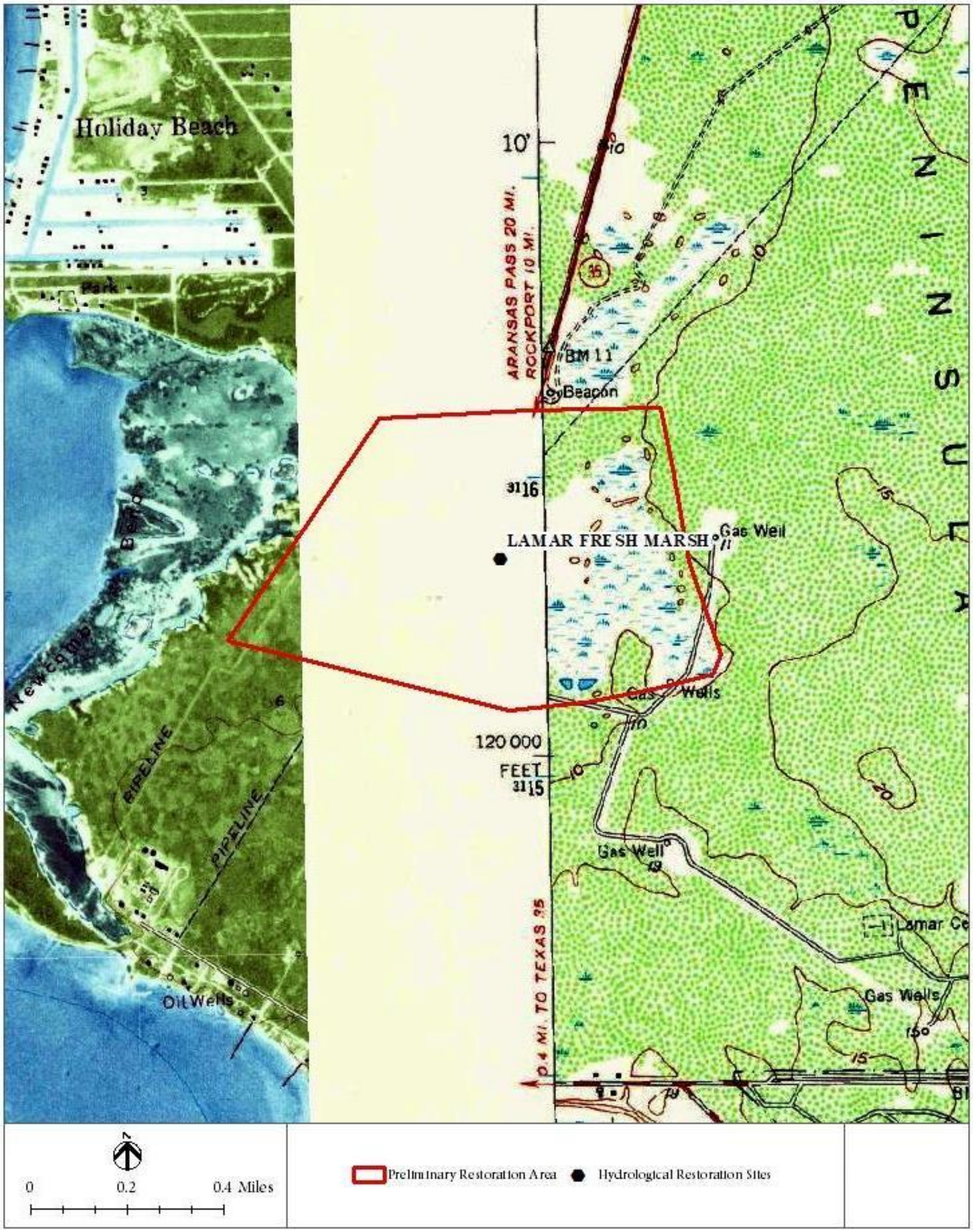

Figure 14B. Historical USGS topographic quadrangle (1:24,000) at Lamar Fresh Marsh on Lamar Peninsula north of Copano Bay.

7. *Copano Creek*

<u>Background Information</u>
Copano Creek is located primarily within Aransas Bay watershed (HUC8 12100405) and is one of the larger creek basins flowing into Copano Bay near Turtle Pens that bisects the mainland from Lamar Peninsula.. The Copano Creek basin includes Alameda Creek and other un-named tributaries to Copano Creek (Figure 15). The creek provides drainage from areas west of Hwy 77 which are comprised of an extensive network of freshwater wetlands and prairies. Several hydrologic alterations have been implemented to drain grazing land and provide extensive habitat for waterfowl and wildlife.

Upon review of aerial imagery in Google Earth, low water crossings and other types of land disturbance activities have impacted the creek on the eastern portion and downstream areas of Copano Creek. For example, a dam or water impediment near the Tom Connor oil field appears to separate standing water within the creek from narrower and drier creek bed. This can be seen by viewing changes in habitat mapping by the NHD and NWI datasets, for example a change from riverine wetland type to palustrine forested wetland. Best management practices have been variously used to impound creek water, reduce bank erosion and traverse the creek bed.

<u>Restorative Action (SABP, ICF, FWS)</u>
1. The hydrologic restoration along Copano Creek can be planned, designed and implemented in discrete phases while working with cooperative landowners. An evaluation of existing structures should be employed to understand the historic and current reasons for each alteration prior to developing the plan. For example, some best management practices may be outdated or no longer needed under current management and use priorities.

<u>Restorative Benefit</u>
1. The continuation and improvement of freshwater flows from Copano Creek provide essential benefits to estuarine wetlands and bay waters in this area of Copano Bay. As sea-level rises, more estuarine marsh is expected to develop on adjacent low-lying prairies and increase the productivity of the bay system and support fish and wildlife diversity.

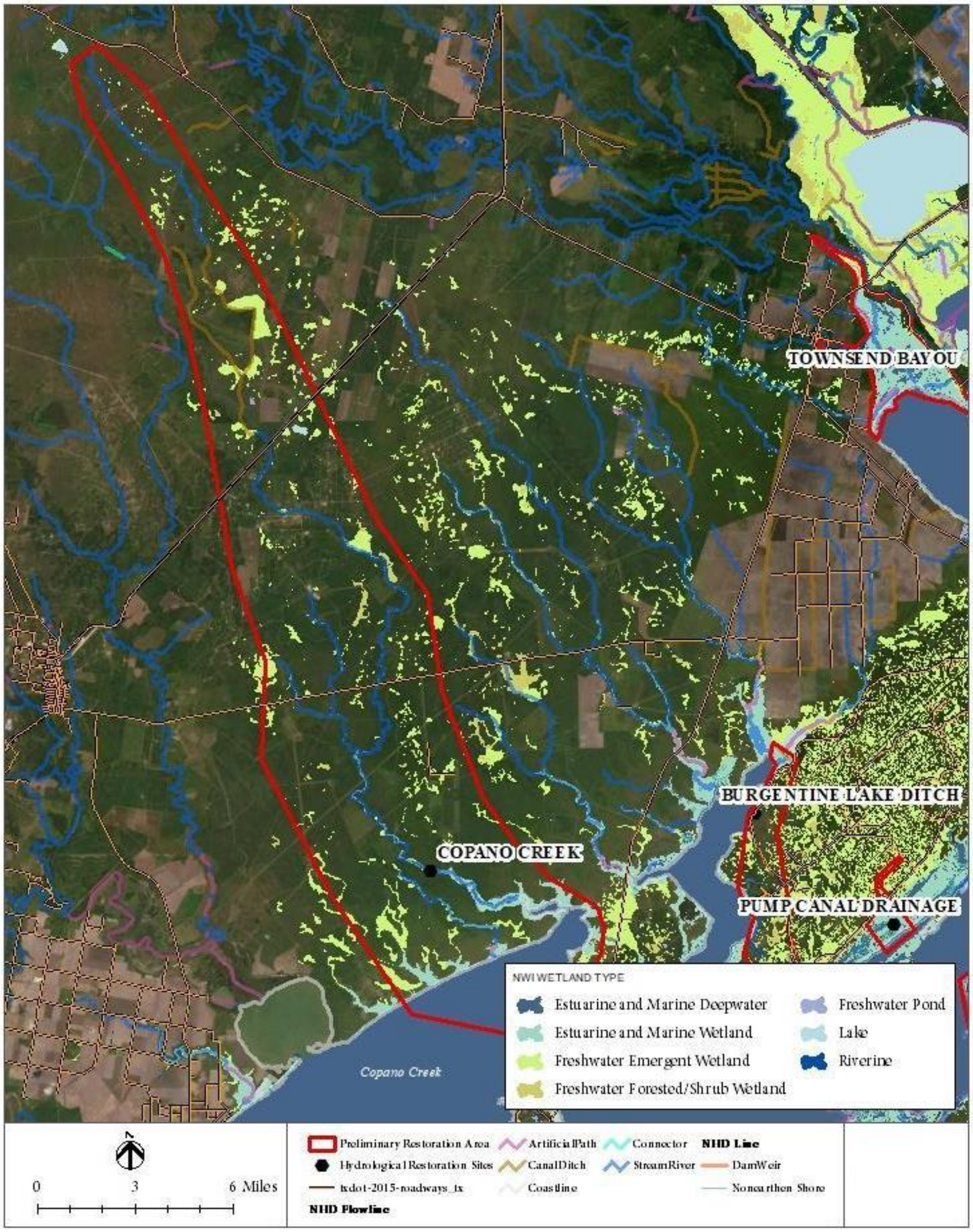

Figure 15. NHD and NWI data at Copano Creek and contributing tributaries.

8. *Italian Bend Ditch*

Background Information

Italian Bend Ditch is located within an extensive, low-elevation, coastal prairie area on the western side of Live Oak Peninsula east of Port Bay between Rattlesnake Point Road and Cape Valero Drive (Figure 16). Development has continued to occur on poorly-drained soils along the county roads, and the Ditch was excavated through the prairie to reduce drainage issues. Adjacent wetlands have been disconnected from natural sheetflow and have been invaded with brush and upland vegetation. While continued sea-level rise will inundate this area in the coming decades, storm surge from hurricanes can readily inundated this area today (as in the case of Hurricane Harvey). Ditches constructed as linear water conduit can also transport bay water into previously freshwater wetlands and neighborhoods and kill freshwater vegetation as well as upland trees and landscaping plants.

Restorative Action (FWS, ICF)

1. Design and implement a meandering configuration to the Ditch using excavated soils adjacent to the Ditch, restore these areas back to natural grade and elevations, and replant with native vegetation.

Restorative Benefit

1. Restore the natural upland/wetland mosaic of this area while still maintaining a drainage system for normal rainfall scenarios.
2. Restore hydrologic connection between drainage ditches and adjacent freshwater wetlands to increase water storage capacity during higher rainfall scenarios.

Figure 16. Aerial imagery of Italian Bed Ditch on Live Oak Peninsula.

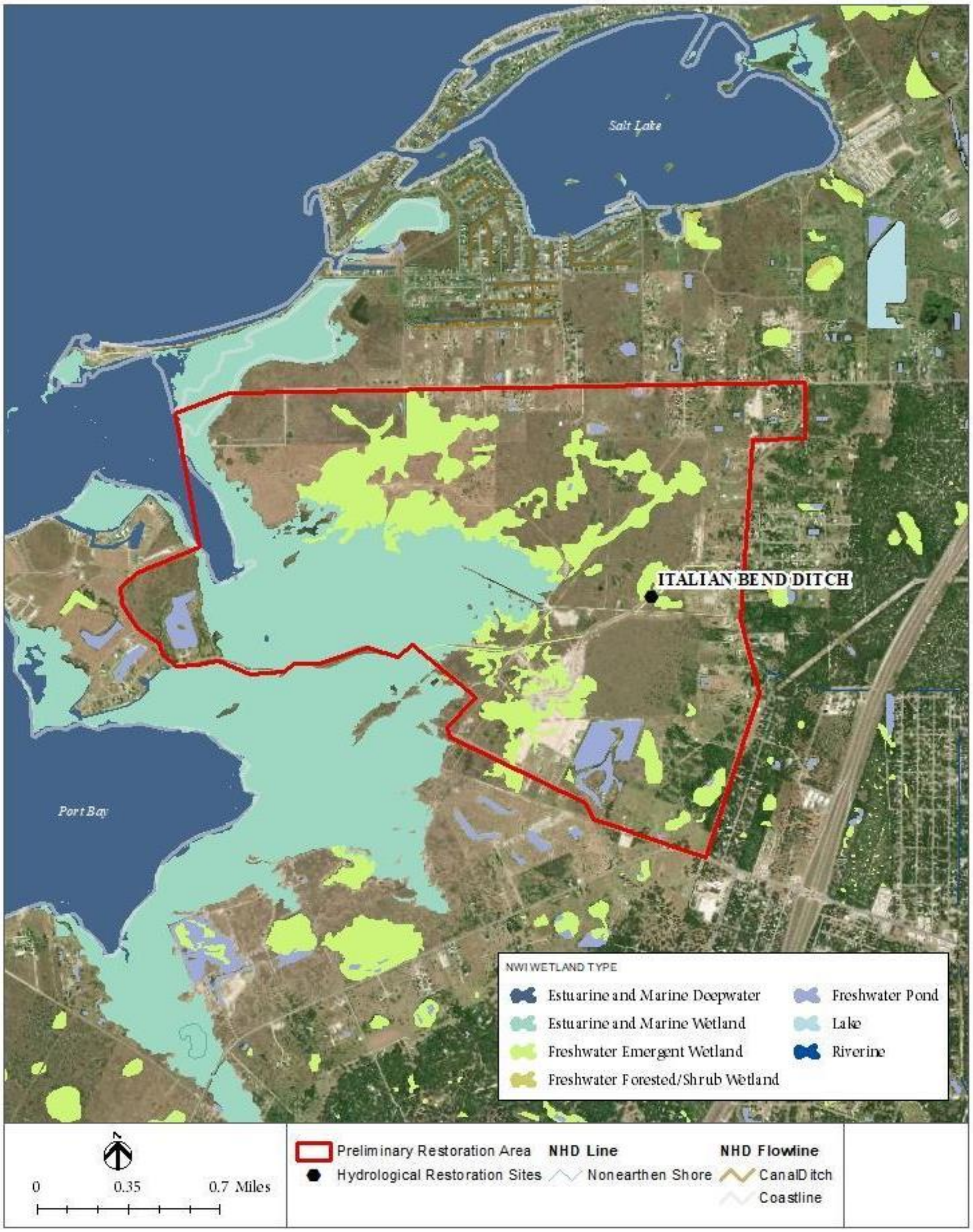

Figure 16A. NHD and NWI data of Italian Bed Ditch on Live Oak Peninsula.

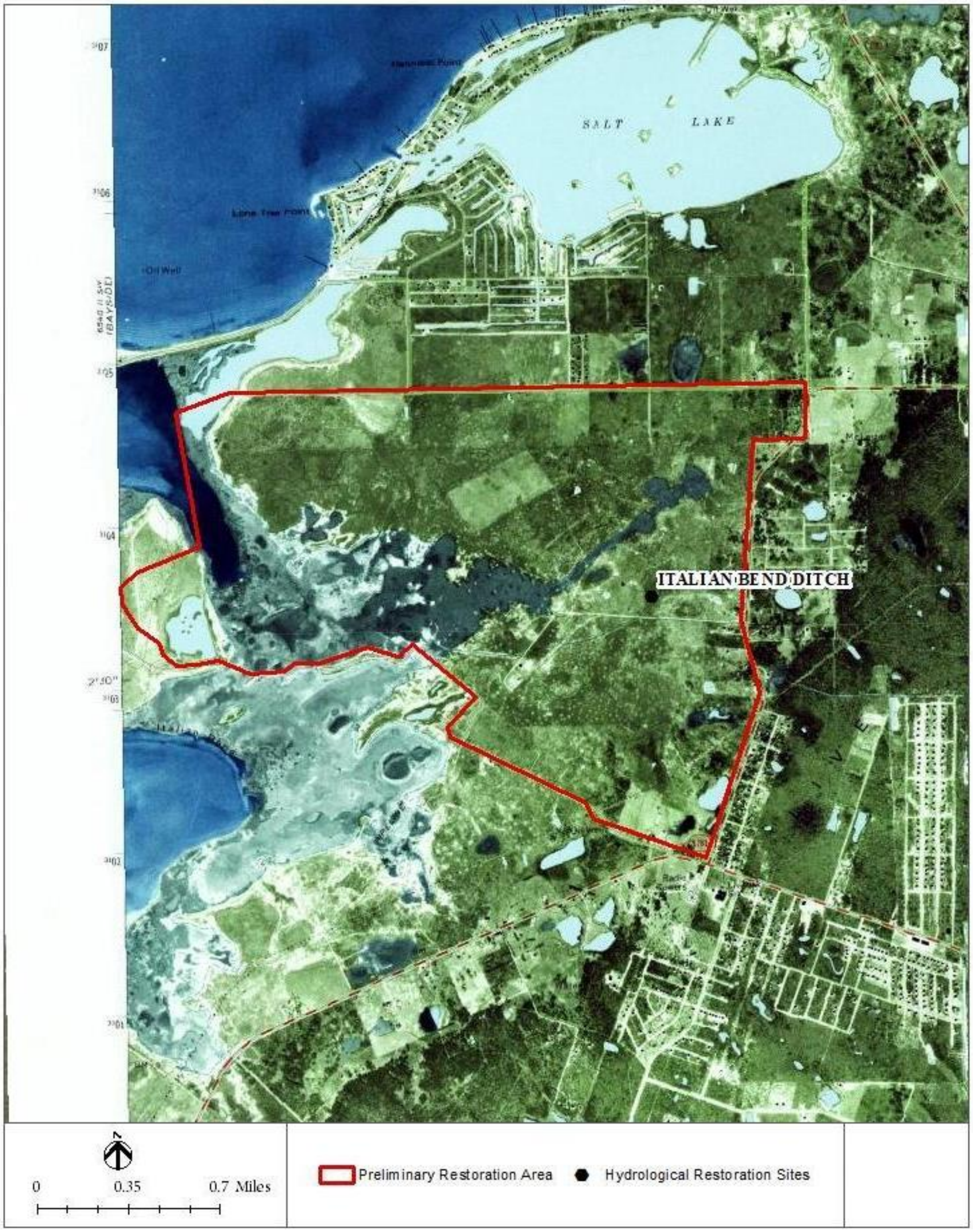

Figure 16B. Historical USGS topographic quadrangle (1:24,000) of Italian Bed Ditch on Live Oak Peninsula.

9. *Port Aransas Nature Preserve*

Background Information

The Port Aransas Nature Preserve (the Park) protects approximately 1,280 acres and encompasses an area formerly known as Charlie's Pasture (Figure 17). Coastal habitats within the Port Aransas Nature Preserve provide a unique refuge for wildlife within the City of Port Aransas, a highly developed coastal town within the Nueces-Corpus Christi Bay system. The Park is situated on the backside of Mustang Island with the northern boundary located along the southern shoreline of the Corpus Christi Ship Channel (Figure 17). This shoreline is reinforced from the ship channel by concrete bulkhead and large rock revetment to prevent erosion of coastal habitats within the Park. During Hurricane Harvey in 2017, the northern shoreline of the Park was breached by strong storm waves that damaged the shoreline protection and has allowed continuous exposure of the Park to ship wakes, high tides, and storm events. The lack of shoreline protection along the northern boundary has affected algal flats previously protected by upland and prairies now being eroded by wind and waves effects (Simpson 2019).

Restorative Action (FWS, City of Port Aransas, CBBEP, ICF)

1. Restore shoreline protection along the ship channel to minimize continued erosional impacts to natural estuarine wetlands

Restorative Benefit

1. Protect algal flat habitats essential for shorebirds and wading birds and upland coastal habitat and development from erosion as a consequence of large ship waves and strong currents.

Figure 17. Aerial imagery of the Port Aransas Nature Preserve.

Figure 17A. NHD and NWI data at the Port Aransas Nature Preserve.

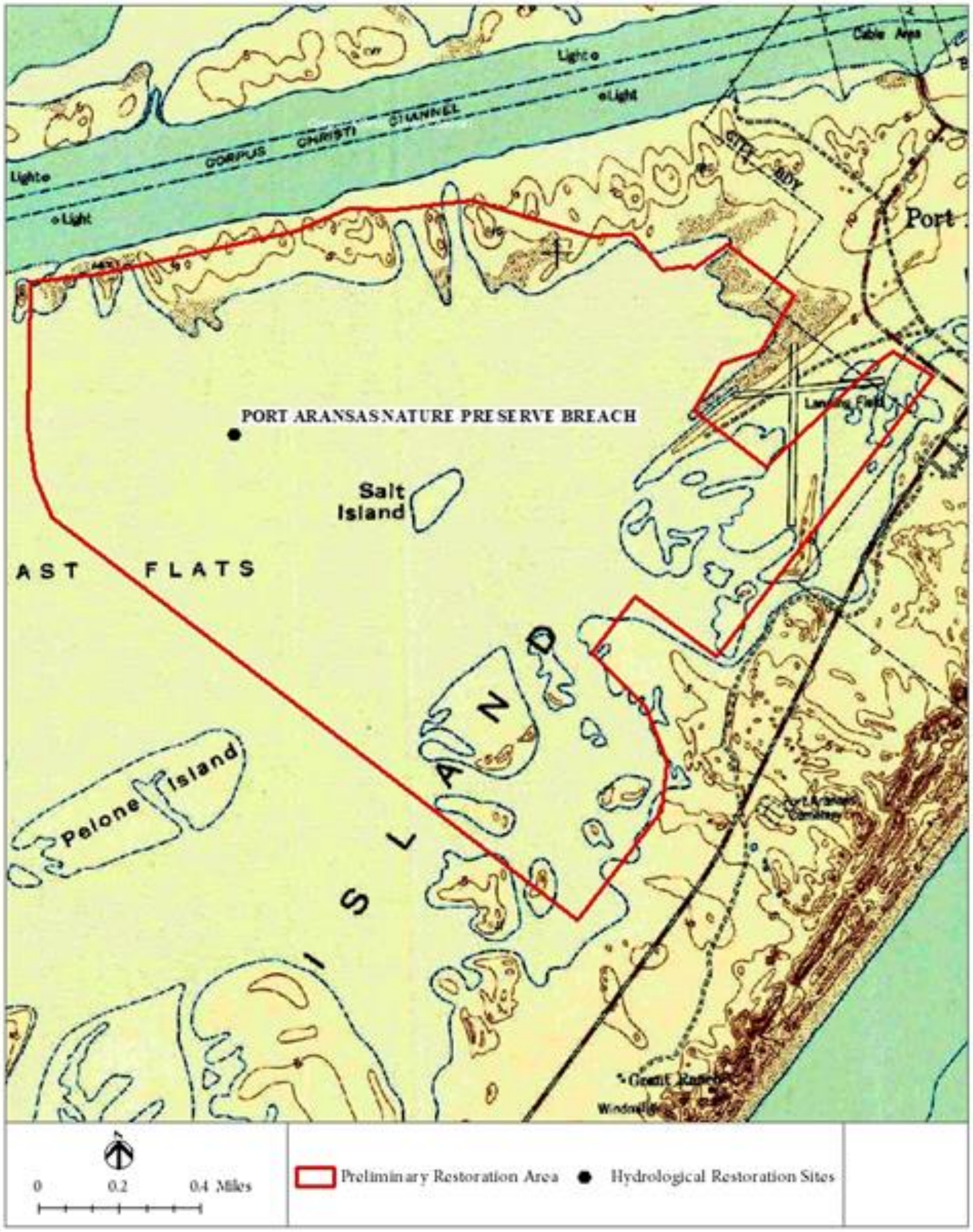

Figure 17B. Historical USGS topographic quadrangle (1:24,000) of the Port Aransas Nature Preserve.

10. *Nueces Delta Preserve*

Background Information

The Nueces Delta Preserve (the Preserve) is located near Odem, Texas in the North Corpus Christi Bay sub-basin (HUC 12110201). Recognizing the importance of the Nueces Delta and various wetland and upland habitats surrounding it, the CBBEP started purchasing, managing, and protecting lands that now comprise the Nueces Delta Preserve since the early 2000s (Figure 18). The Delta is an approximate 10,500 acres of wetlands, river and bay shorelines, riparian and prairie habitat, open water, and islands within the Nueces-Corpus Christi Bay system (Figures 18A and 18B). The protection of this area has provided several opportunities to restore and enhance areas that ultimately benefits the Delta and adjacent bay habitats as well as serve as a model for habitat protection and restoration for other Texas coastal areas.

The Preserve is located within the former McGregor Ranch. As such, the Preserve includes various agricultural roads that have severely altered the natural state of various habitat types. For example, in the 1960s an agricultural road was created in a low-lying area that is tidally influenced from Nueces Bay. These roads often included culverts to allow water flow, but many of these culverts are damaged and no longer functioning, or no longer of the right size to allow adequate flow. As such, water becomes impeded and forms brackish lakes, such as Goose Lake, which can become hypersaline during low flow drought conditions.

Restorative Action

1. Remove corrugated culverts and other man-made infrastructure that impede natural flow downstream.
2. Replace under-sized culverts to improve water exchange in Goose Lake.
3. Continue to support brush management activities that improve freshwater connectivity between groundwater and interconnected streams and tributaries.

Restorative Benefit

1. Restore the natural functions of a coastal river delta in a holistic approach where completion of each restoration project increases habitat diversity and productivity at a landscape and integrated level.
2. Provide a site where examples of various restoration actions can be showcased to other landowners who are seeking information and input on restoration practices and partnership opportunities.

Figure 18. Aerial imagery of the CBBEP Nueces Delta Preserve (approximate).

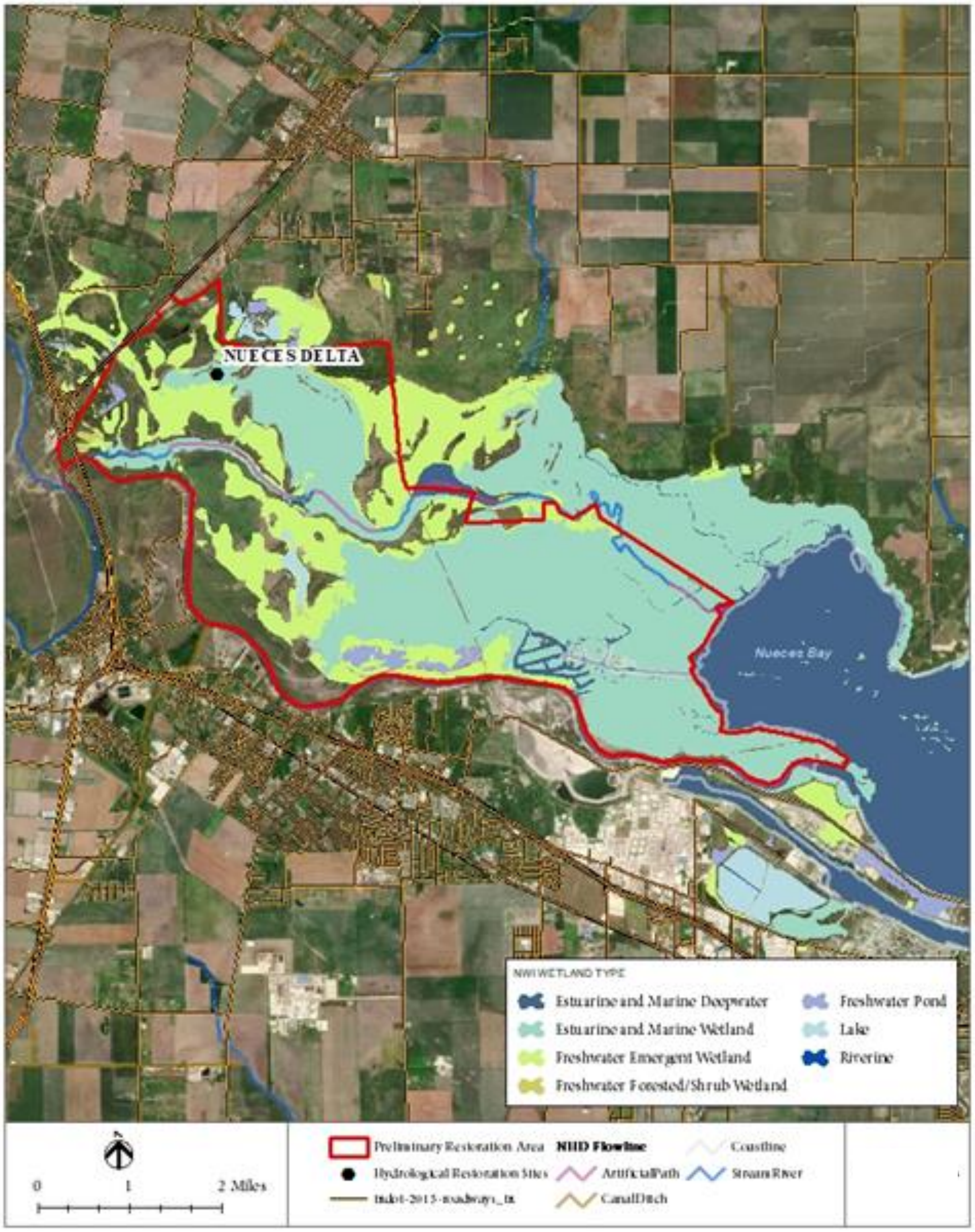

Figure 18A. NHD and NWI data at the CBBEP Nueces Delta Preserve (approximate).

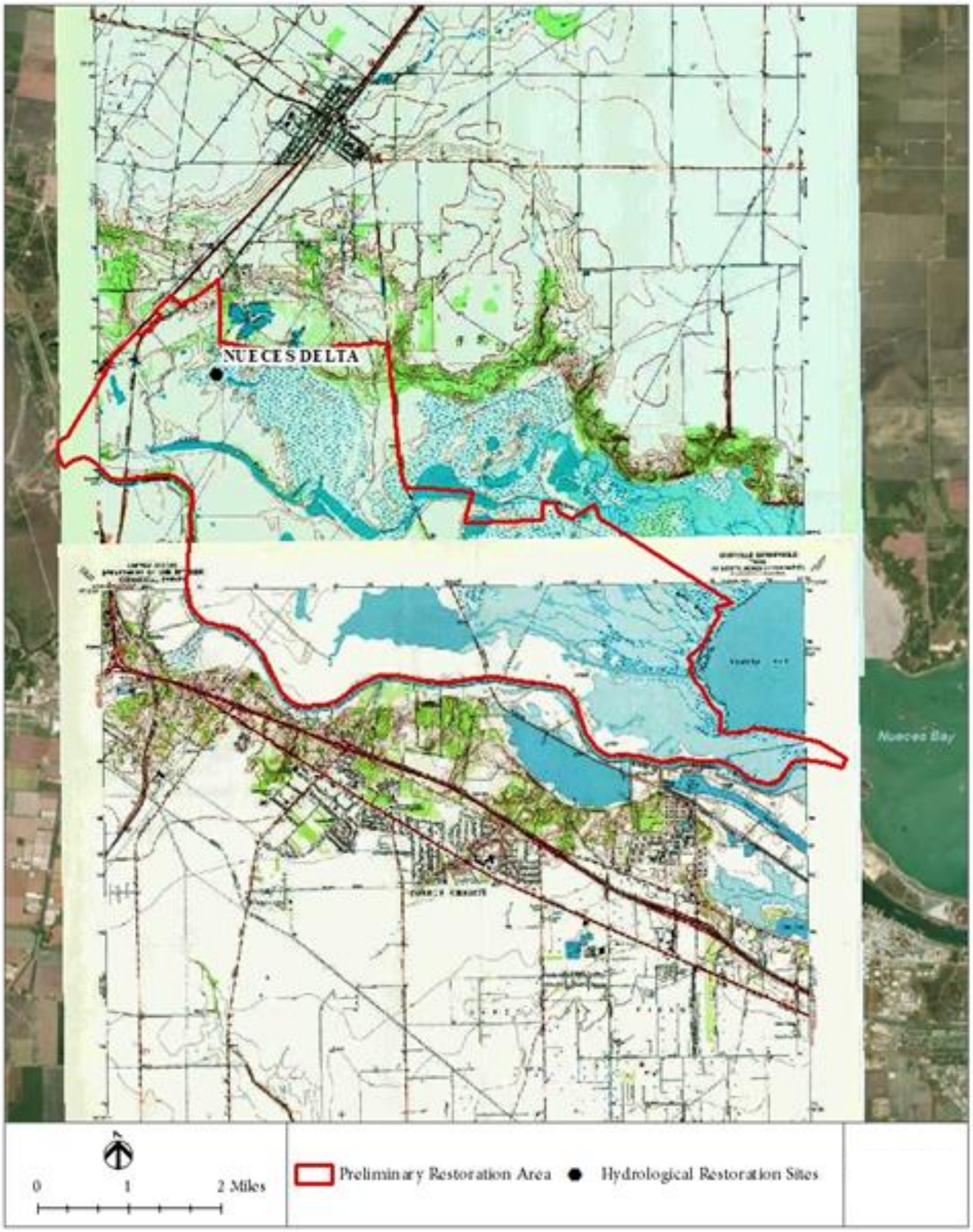

Figure 18B. Historical USGS topographic quadrangle (1:24,000) of the CBBEP Nueces Delta Preserve (approximate).

Site Summary

Table 2 provides a summary of the hydrologic sites and relevant characteristics considered during stakeholder meetings. These characteristics included the approximate area (i.e., restoration acres) to be affected by potential restoration projects, an estimated size range, complexity, and number of landowners. Restoration acres is depicted in each site figure as a thick red line; i.e. estimated boundary. Complexity refers to the perceived complexity of implementing a restoration project based on multiple stakeholder's experience working within the CBBEP area, as well as the size of the restoration acreage and number of landowners.

Table 2. Summary of proposed hydrologic restoration sites.

Report Site No.	Project Name	Restoration Site (Acres)	Complexity (1 to 5)	No. of Landowners
1	Sea-Dan Ditch 1	2,445	3	1
1	Sea-Dan Ditch 2	1,360	3	1
1	Sea-Dan Ditch 3	7,085	3	3
1	Welder Flats Road	1,820	1	1
2	Townsend Bayou	5,170	5	10+
3	West Marsh	18,820	5	1
4	Pump Canal	1,040	5	1
5	Burgentine Lake	4,180	5	1
6	Lamar Marsh	296	2	3
7	Copano Creek	88,385	5	5

Report Site No.	Project Name	Restoration Site (Acres)	Complexity (1 to 5)	No. of Landowners
8	Italian Bend Ditch	1,880	1	4
9	Port Aransas Nature Preserve	1,280	3	2
10	Nueces Delta	10,800	1	1

Table 3. Property owners for each proposed restoration site.

Report No.	Project Name	Landowner Information[1]
1	Sea-Dan Ditch 1	Sea-Dan Ranches, LTD
1	Sea-Dan Ditch 2	Sea-Dan Ranches, LTD
1	Sea-Dan Ditch 3	Cliburn Seadrift Properties LLC, Sea-Dan Ranges LTD, and Seadrift Ranch Partners.
1	Welder Flats Road	Cliburn Seadrift Properties LLC
2	Townsend Bayou	Wade Ruddock, Beverly Fletcher, Joann M. Barber, Norma P. Barber Trustee, Patricia Gene Chopelas, Larry Landgraf, Rebecca Carville, O'Connor Martin Ranch LTD., (1 unknown), TPWD Guadalupe Delta WMA, Michael Janysek, Christopher Colville, Steven Chris Landgraf, Pamela Ford, and Howard Colville. Miller Creek area - Tivoli Cemetery, Pamela Ford, and 3 unknowns
3	West Marsh	Aransas National Wildlife Refuge
4	Pump Canal	Aransas National Wildlife Refuge
5	Burgentine Lake	Aransas National Wildlife Refuge
6	Lamar Marsh	Primary landowner east of SH-35 is the Pecan Street Land Trust, followed by KKB Hidden Oak RV Land LLC, and Ronald C. McCann. TPWD owns the portion of land west of SH- 35.
7	Copano Creek	Tatton Ranch (owner John Frances) is located within the southern portion of the site and encompasses the mouth of Copano Creek, Turtle Pens, and into the Aransas National Wildlife Refuge. Braman Ranches, LLC. occupies a large portion of land located south of FM-774. Additional private landowners include the Lamberts, Dunn Ranch Land Trust, O'connor Ranch Land Trust, the Welders, and multiple unknown property owners
8	Italian Bend Ditch	Habitat Preservation Group, LLC (ditch), Rockport Property Entity, and EVC-CC Land Holders LLC. C.J. Schneider owns the property that receives water from the modified ditch.
9	Port Aransas Nature Preserve	City of Port Aransas
10	Nueces Delta	Coastal Bend Bays & Estuaries Program

[1] Property information obtained from county appraisal district websites and Huntstand website

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