Final Report

Restoration of multiple wetlands in the Magnolia Beach area, Calhoun County: Phase I Planning

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Executive Summary

This project began the restoration of a large complex of salt marshes in the Magnolia-Indianola area of Texas. This project identified the root cause of marsh vegetation loss and fish death over several thousand acres, allowing a multi-phase restoration plan to be constructed. Additionally, various stakeholders were identified and incorporated into the restoration planning process. This project assisted in the acquisition of funds for the purpose of on-the-ground restoration. These actions have continued through subsequent phases. Overall, this project was a critical step towards planning the restoration, and it was a success.

Task 1. Stakeholder Planning Meetings

The following meetings were held over the course of this project. We do not provide names of individuals for confidentially sake, as several of them are private individuals. The following numbers are approximate and include phone meetings (in parentheses are in-person counts). These numbers are for this project only and do not include subsequent phases of this project that are under separate funding. Summaries of each meeting are provided (Appendix 1).

Local political officials:
2 meetings with County Judge (2)
11 meetings with County Commissioner (7)
Non-profit agencies:
5 meetings with Texas Ornithological Society
1 meeting with Nature Conservancy (1)
State and Federal agencies:
9 meetings with Texas Parks and Wildlife Officials (3)
3 meetings with National Oceanic and Atmospheric Administration
6 meetings with Texas Sea Grant (2)
Landowners:
9 meetings with landowner #1 (3)
1 meeting with landowner #2
1 meeting with landowner #3 (1)
1 meeting with landowner #4 (1)
Recreational Stakeholders:
1 meeting with 3 recreational sports stakeholders (1)
11 meetings with fisher folk (10)
1 meeting with bait shop owner (1)
1 large stakeholder meeting at Texas AgriLife Extension Service office in Port Lavaca, organized by Texas Sea Grant. Over 30 stakeholders in attendance (1)

As an additional component of this task, landownership records were queried. They were discussed with several of these stakeholders, in particular landowners and political officials. Rough versions of these records are included (Appendix 2).

Task 2. Hydrological and Ecological Restoration Planning

The marsh complex was dying because it was disconnected from full tidal flow at multiple locations. To identify the critical junctures where restoration would need to take place, we placed salinity and water level gauges throughout the area. GPS surveying was conducted in concert with these gauges. In addition, we used historical aerial photography, precipitation records, and sea level records to help ascertain the source of and extent of the problem. This work is in report form (Appendix 3).

Task 3. Financial Planning

Working with several stakeholders, we wrote proposals to acquire funds and begin on-the-ground restoration. These funds were successfully acquired from the Texas General Land Office – Coastal Erosion and Protection Response Act (CEPRA) program and the National Oceanic and Atmospheric Agency – Mississippi-Alabama Sea Grant Hydrological Restoration program. Total funds for on-the-ground work were $259,810. Applications and award letters are included (Appendix 4).

Due to the success of this planning project, restoration has been partially completed, with expected full completion of these projects by the end of 2015.

Task 4. Project Monitoring and Reporting

All quarterly reports were turned in. This Final Report serves as a final summary of this project. The Comprehensive Restoration Plan has been submitted to relevant stakeholders (Appendix 5).

Appendix 1

Summaries of Stakeholder Meetings

Summaries and Action Items from Meetings (names excluded for privacy):

County Judge – County Courthouse offices. Discussion on general need for wetland restoration. Discussion primarily on inlet filling in with sand, need to dredge. Action items: to meet with Commissioner.
County Judge – County Courthouse offices. Discussion on local politics and landowner identification on maps, port projects, role of Judge and Commissioner. Potential projects outlined on maps. Action items: to meet with Commissioner.

County Commissioner – County Courthouse offices. Discussion on general need for wetland restoration. Discussion of local flooding issues, history of the area, land ownership. Potential projects outlined on maps. Action items: further discussions with landowners.
County Commissioner – County Field Office. Discussion of landowner roles at Zimmerman Road barrier. Action items: further discussions with landowners.
County Commissioner – County Field Office. Discussion of potential removal of Zimmerman Road barrier, and plan for funding. Action items: further discussions with landowners and Texas Ornithological Society.
County Commissioner – Phone meeting. Discussion of funding on Fish Pass barrier, potential funds support from Texas Ornithological Society to cover costs. Action items: further discussions with Texas Ornithological Society.
County Commissioner – Field meeting. Identification and construction on Fish Pass barrier. Action item: monitoring.
County Commissioner – Field meeting. Identification of Magnolia Inlet barrier, discussion of construction requirements. Action item: grant writing, funds acquisition, obtain support letters.
County Commissioner – Phone meeting. Planning on funding for Magnolia Inlet barrier. Action item: grant writing, funds acquisition, obtain support letters.
County Commissioner – Phone meeting. Planning on funding for Magnolia Inlet barrier. Action item: grant writing, funds acquisition.
County Commissioner – County Field Office, and field site. Presentation of Appendix 3 results on the barrier problems. Action item: future construction under other projects.
County Commissioner – Phone meeting. Discussion on landownership and collaboration on Zimmerman Road and Magnolia Inlet projects. Action item: future construction under other projects.

Texas Ornithological Society – Phone meeting. Discussion on landownership and general restoration opportunities. Action item: contact County.
Texas Ornithological Society – Phone meeting. Discussion on potential funding of Fish Pass restoration. Action item: submission of white paper to Society's leadership committee.
Texas Ornithological Society – Phone meeting. Follow up discussion on potential funding of Fish Pass restoration. Action item: Identification and construction at Fish Pass with County.

Texas Ornithological Society – Phone meeting. Discussion on landownership and general restoration opportunities with new leadership. Action item: letter of support.
Texas Ornithological Society – Phone meeting. Discussion on landownership. Action item: build restoration planning document.

Nature Conservancy – Office meeting. Discussion on potential restoration and funding/collaboration opportunities at the various barriers. Action item: contact Guadalupe Blanco Trust.

Texas Parks and Wildlife Officials – Phone meeting. Discussion of general restoration opportunities at various barriers. Action item: future field visit.
Texas Parks and Wildlife Officials – Field meeting. Identification of salinities, discussion of potential conflicts. Action item: write funding grants, plan, obtain support letters.
Texas Parks and Wildlife Officials – Phone meeting. Discussion of funding potential from various agencies, continued discussion of salinities. Action item: future field visit.
Texas Parks and Wildlife Officials – Phone meeting. Discussion of bird usage and Texas Ornithological Society landownership. Action item: contact TOS.
Texas Parks and Wildlife Officials – Phone meeting. Discussion of potential conflicts. Action item: future field visit.
Texas Parks and Wildlife Officials – Phone meeting. Discussion of potential conflicts. Action item: future field visit.
Texas Parks and Wildlife Officials – Field meeting. Discussion of potential conflicts. Action item: deal with permit in the future.
Texas Parks and Wildlife Officials –Phone meeting. Discussion of bird usage and bird blinds at inlet restoration site. Action item: contact other officials at TPWD.
Texas Parks and Wildlife Officials –Phone meeting. Discussion of bird usage and bird blinds at inlet restoration site. Action item: contact landowner.

National Oceanic and Atmospheric Administration – Phone meeting. Discussion of general restoration opportunities at various barriers. Action item: future field visit.
National Oceanic and Atmospheric Administration – Phone meeting. Discussion funding opportunities. Action item: apply for grants, obtain support letters.
National Oceanic and Atmospheric Administration – Phone meeting. Discussion funding opportunities. Action item: apply for grants.

Texas Sea Grant – Discussion of general restoration opportunities at various barriers. Action item: future office visit. Action item: apply for grants.
Texas Sea Grant – Texas AgriLife Extension Office meeting. Discussion of general restoration opportunities at various barriers. Action item: apply for grants, plan for additional meetings to gather stakeholder input.
Texas Sea Grant – Field meeting. Discussion of stakeholder and fisherperson input. Action item: apply for grants, obtain support letters.

Texas Sea Grant – Phone meeting. Discussion of landownership. Action item: work with landowners.
Texas Sea Grant – Phone meeting. Discussion of landownership. Action item: work with landowners.

Landowner #1 – Phone meeting. Discussion of general restoration opportunities at various barriers. Action item: future field visit.
Landowner #1 – Phone meeting. Discussion of potential mitigation options, landowner collaboration at Zimmerman Road barrier. Action item: future field visit.
Landowner #1 – Field meeting. Discussion of property lines, collaboration at Zimmerman Road barrier. Action item: meet with County.
Landowner #1 – Phone meeting. Discussion of funding opportunities for barrier removals. Action item: write grants, obtain support letter.
Landowner #1 – Phone meeting. Discussion of Fish Pass work. Action item: obtain support letter and boundary surveys.
Landowner #1 – Phone meeting. Discussion of boundary surveys. Action item: write grants.
Landowner #1 – Phone meeting. Discussion of property ownership. Action item: work on funding and planning.
Landowner #1 – Phone meeting. Discussion of property ownership, permissions, potential mitigation actions. Action item: work on funding and planning.
Landowner #1 – Phone meeting. Discussion of property ownership, permissions, potential mitigation actions. Action item: work on funding and planning.

Landowner #2 – Phone meeting. Discussion of general restoration opportunities, property ownership, permissions. Action item: obtain letter of support.
Landowner #3 – Field meeting. Discussion of general restoration opportunities, property ownership, permissions. Action item: stay in contact.
Landowner #4 – Field meeting. Discussion of general restoration opportunities, property ownership, permissions. Action item: stay in contact.

Recreational sports stakeholders – Field meeting. Discussion of general restoration opportunities, recreation benefits and need for restoration to open up kayak trails. Exchange of contact information. Action item: stay in contact, obtain letter of support.

Fisher folk – Field meeting. Discussion of general restoration opportunities, recreation benefits and need for restoration to improve fishing and shrimping. Exchange of contact information. Action items: stay in contact, assist in obtaining water level and weather information over phone.
Fisher folk – Phone meeting. Discussion of water level and weather information. Action items: stay in contact.
Fisher folk – Phone meeting. Discussion of water level and weather information. Action items: stay in contact.

Fisher folk – Field meeting. Discussion of general restoration opportunities, recreation benefits and need for restoration to improve fishing and shrimping. Action items: stay in contact.
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Fisher folk – Field meeting. Discussion of general restoration opportunities, recreation benefits and need for restoration to improve fishing and shrimping. Action items: stay in contact.
Fisher folk – Phone meeting. Discussion of water level and weather information. Action items: stay in contact.

Bait shop owner – Business location meeting. Discussion of general restoration opportunities, recreation benefits and need for restoration to improve fishing and shrimping. Discussion of history of the barrier at the Magnolia Inlet and correspondence with when fishing/shrimping began to decline. Action items: obtain letter of support, include write-up of historical knowledge in Appendix 3 report.

Stakeholder meeting – Texas AgriLife Extension Service office in Port Lavaca, organized by Texas Sea Grant. Over 30 stakeholders in attendance. Discussion of general restoration opportunities, history of the sites, landownership and collaboration opportunities, recreation benefits of fishing and shrimping, potential restoration construction, exchange phone numbers and contact information. Action items: obtain letters of support, stay in contact with specific landowners and fisher folk during construction phases, include write-up of historical knowledge in Appendix 3 report.

Appendix 2

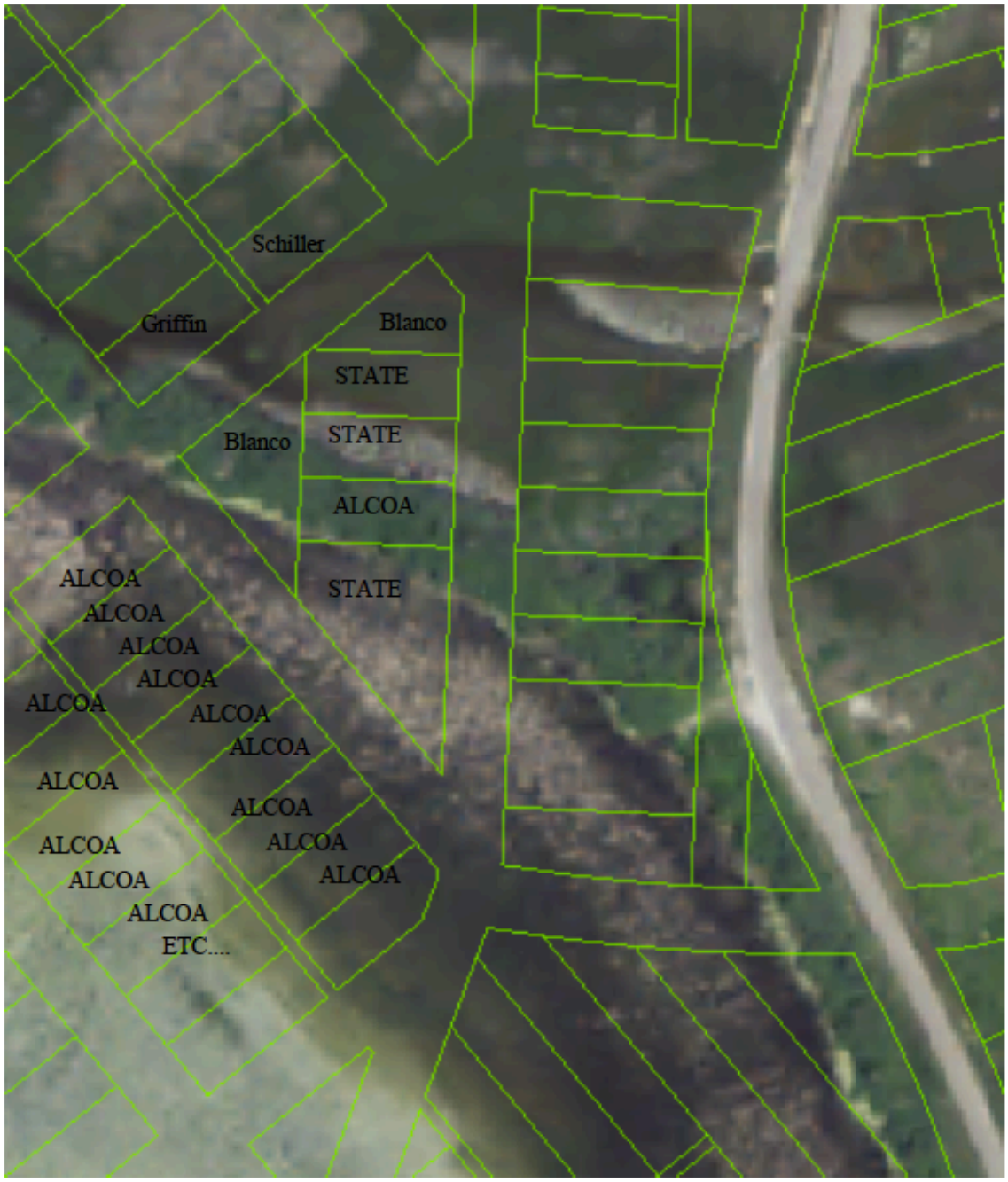
Examples of Property Ownership Maps

Magnolia Inlet Barrier (in 2013-2014)

Zimmerman Road Barrier (in 2013-2014)

Fish Pass Barrier (in 2013-2014)

Foester Lake Barrier (in 2013-2014)



Appendix 3

The hydrological barriers as a cause of salt marsh loss

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Abstract

The Magic Ridge Marsh located along Magnolia Beach, Texas has rapidly degraded over the last few decades. This marsh is greatly important to wildlife and dependent recreational pursuits such as bird watching at the Magic Ridge Sanctuary and fishing in the marshes and adjacent bay. In this study, it was determined to focus on the shell debris pile as aerial imagery along with local knowledge indicates that this is the point of hydrologic disturbance. In order to restore this ecosystem, the alterations to the hydrology must be understood and thus the multi stage approach was chosen to single out the environmental factors that influence the marsh. Land cover analyses were conducted in conjunction with analyses of precipitation and sea level rise beginning in 1958 and ending in 2012. Tide and salinity data from Marsh 2013 to August 2013 were obtained to determine tidal connectivity and salinity conditions within the marsh and bay. These data sets indicate that low marsh area decreased independently of sea level rise or precipitation. However the tidal data showed the marsh was disconnected for extended periods of time resulting in increased salinity within the marsh. The lack of tidal exchange indicates that a blockage to tidal infiltration exists. However, during the period from 1958 to 2012 no new construction or man-made alteration to the inlets of the marsh occurred. This indicates that a separate entity is responsible for the impoundment, which would be a plug of sediment and shell that has accumulated in the Magnolia Inlet.

Key Words: Hydrology, Marsh impoundment, Hypersaline, Tidal gauge,

Introduction

Salt marshes are some of the most productive ecosystems in the world (Buildstine, L. Keith 2002). However, many of these environments have been hydrologically altered by humans and these alterations can affect their sustainability under future conditions, including changing drought periods or relative sea level rise (RSLR) (Bromber, Silliman, & Bertness, 2009). As hydrology is modified, the health of the marsh plants, birds and fish using the area is also modified (Broome 1988, Day et al 1995,Boesch & Turner, 2007).

Hydrological alternation can include drainage for agricultural usage (Turner 1997, Warren 2002, Portnoy 1991), the construction of canals by oil and gas exploration activities (Ko and Day 2004, Roman et al 1995, Roman, Niering, Warrer, 1984, Boesch et al 1994), and mosquito diking (NOAA 2012). Hydrological alterations can cause chemical changes within the soil and water of the marsh ranging from decreased soil salinity levels in drained marsh soil to high salt levels in impounded salt marshes (Portnoy 1999), and they can also alter dissolved oxygen resulting in hypoxia and fish kills. Impoundment and hydrological disconnection can contribute to accelerated subsidence (Turner and Neill 1984), reduce rates of sedimentary accretion and freshwater mixing (Colon-Rivera et al. 2012), and result in re-distribution of vegetation distribution species (Sinicrope et al 1990). Hydrological restoration includes the removal of barriers to tidal flow, and can be a productive method to reverse or reduce marsh loss (Turner 1997, Burdick 1997). As shown by Warren et al (2002), the re-introduction of tidal action can rehabilitate a former salt marsh in stages, with the vegetation closest to the restored tidal edge experiencing greater immediate recovery, although some can still take up to 15 years for other functions to fully recover. Still, barrier removal can result in recovery over great areas, with only a small amount of cost and effort expended (NOAA 2012, Sinicrope et al 1990). As part of this increased emphasis by NOAA on the cost effectiveness of removing barriers as a manner of restoring marshes, we identified a large marsh complex that was suffering from hydrological disconnection. This marsh complex stretches from Magnolia Beach to Indianola, Texas.

Our primary objective was to quantify the amount of marsh loss, and then ascertain if this loss was related to hydrological barriers. We measured land cover changes in the marsh complex from 1958 to 2012, and then related these changes to RSLR, precipitation, and barrier location. We also identified the magnitude of the barriers to present-day hydrology in terms of their effect on changing water levels and salinity. Using this approach, we show the potential for removing relatively small barriers as a cost-effective solution to counter-act marsh losses across broad areas of land.

Methods

Study Area

Our study area is a complex of coastal salt marshes located on the west shore of Matagorda Bay near Indianola and Magnolia Beach, an area south of Port Lavaca, Texas (Figure 1). These marshes were historically connected to Matagorda Bay by at least two pathways; one natural inlet at the north end of the marsh known as Magnolia Inlet, and a second natural connection to the south that leads to Powderhorn Lake through an area known as Fish Pass.

The vegetation within the low (intertidal) marsh is characterized by *Spartina alterniflora,* with *Batis maritima and Salicornia virginica* dominant at slightly higher elevations or at more hydrologically isolated portions of the intertidal marsh. The low marsh transitions to unvegetated salt flat as elevation increases. A small bluff exists in many portions of the area, where the salt flat quickly transitions into upland vegetation, composed primarily of Tamaulipan scrub with *Opuntia sp.* and *Yucca gloriosa* along the periphery of the wetlands. Large salt flats are common in the portions of the marsh south of Zimmerman Road (Figure 2).

Prior to this study, it was becoming increasingly apparent to residents and coastal managers that the vegetation had been dying, there were less fish, and the marsh was eroding. The causes of the deterioration were not understood, but suspected to be due to hydrological barriers that block tidal flow. Three potential barriers were initially identified (Figure 3). The first barrier was a shell and mud debris pile spanning the width of Magnolia Inlet. This debris appeared to have grown to block the majority of the connection from Old Town Lake to Magnolia Bay. Another barrier existed at Fish Pass, and appeared to be a shell-hash road that stretched across the marsh surface constructed sometime prior to 1958 (Figure 4). This barrier was removed on May 27, 2013. Another potential barrier existed at Zimmerman Road, which also appeared to be a shell-hash road that stretched across the marsh surface, with construction prior to 1958. At Zimmerman Road, culverts were in place through a small gap in the road, though they appeared to be somewhat clogged with sediment.

Land Cover Analysis

A series of land cover maps were created ranging over the time period from 1958 to 2012, and compared for land cover changes. Aerial photos were obtained from the Texas Natural Resource Information System (TNRIS) over a range of five unique dates, with variable resolutions (1958, 0.5 m, b/w; 1979, 5 m, CIR; 1996, 1 m, CIR; 2002, 3.5 m, TC; 2012, 1 m, TC). The span of the images was chosen to give a representative sequence of change to the landscape over the time observed, as well as on the resolution and quality of the images; any images possessing clouds or of greater than 5 m resolution were not considered. SPOT satellite panchromatic images (April 1991, April 1992, April 1993, all at 30 m) were also obtained (Figure 3).

Within a GIS (ArcGIS 10.1, ESRI), three different land cover classes (water, low marsh, and salt flats) were hand digitized at a consistent view scale of 1:2000. This digitization effort was double-checked by a second researcher who reconciled any differences that existed in landscape classifications over the span of years. Next, the total area of each land cover type was calculated in m^2, and converted into a

percentage of total landscape for comparison. Area calculations were conducted for the total marsh complex from the area immediately surrounding Fish Pass to Magnolia inlet, and still including the Zimmerman marsh.

An accuracy assessment was subsequently conducted on the digitization effort for the 2012 image. 50 points were sampled in the field using a handheld Trimble GPS unit, with each point taken within at least 15 meters of the edge of two intersecting land cover boundaries. At each point in the field, the true land cover was recorded and then compared to the 2012 classified cover type. The accuracy of the effort was 69.93 % for the entirety of the study area. However, most of this error was attributed to two sampling locations, Fish Pass (55.88% accuracy), and south end of the Zimmerman Road marsh (44.12% accuracy), where water was misclassified as salt flats, and vice-versa. This source of error was due to the fact that large expanses of salt flat are alternatingly covered with and without water, depending on the amount of rainfall, tides, runoff, etc., in these two portions of the marsh complex. The Magnolia Inlet portion of the complex had a total accuracy of 96.67% along with the area at the south end of Old Town Lake just north of Zimmerman road with 83.02% total accuracy. These two areas contained less salt flat which was the most stochastic landscape class, and thus resulted in much higher accuracies.

Hydrologic Analysis

Monthly average precipitation was obtained from the Port Comfort weather station in Port Comfort, Texas (#ID GHCND:USC00417140, 10.87 km away from study area) over a date range from 1957 to 2013. Monthly relative sea level was obtained from the National Oceanic and Atmospheric Administration (NOAA) buoy located in Rockport, Texas (#ID 8774770, 77.71 km away from study area) over a date range from 1948 to 2012. Moving averages were calculated on both data sets within a window of 12 months, and were subsequently graphed. The precipitation and sea level over specified date ranges were plotted and linearly regressed against time, in order to calculate rates of change (as measured by linear slope, with the goodness-of-fit measured by r^2). The dates of the classified aerial imagery were used as bounding dates for each calculation.

Water level and conductivity were measured every hour from March 26, 2013 to August 29, 2013, using CTD gauges (CTD-Diver, Schlumberger) placed on opposing sides of the 3 barriers of interest (Figure 2). Gauges were suspended on fishing line, within 3/4 inch diameter PVC pipes that were set vertically within the water column. The top of each PVC pipe was surveyed using survey-grade GNSS system composed of a Trimble R8 receiver, using the Fast Static method (average RMS=0.002 m, average horizontal precision= 0.008 m, average vertical precision=0.012 m). Gauge depth readings were subsequently converted into vertical NAVD88 units and graphed. Due to the slight errors in the GNSS height measurements, the data was matched for gauges on the opposing sides of barriers, using the high water mark on July 9, 2013 as the reference date, for the Fish Pass and Zimmerman road locations only. Finally, the outliers in the conductivity measurements were removed from the dataset for the Bay and North Fish Pass sensors. Values below 30 ms were removed from the bay values, and everything below 60 ms was removed from the North Fish Pass dataset.

Results

Low marsh decreased overall from 1958 to 2012 within the marsh complex (Figure 5A). Salt flats also decreased, and water increased. Low marsh and water were inversely related, in general. The period from 1958 to 1979 appeared to be an aberration to the general trend, with low marsh increasing quite strongly. The same trend was found for the areas bounded within each barrier (Figure 5B-D). The Magnolia Inlet area experienced the most drastic decrease in salt flat area when compared to the other regions within the marsh from the time period of 1958 to 1979. When assessed visually in our data set, it was apparent that this salt flat in Fish Pass had been converted to low marsh. This low marsh area was then subsequently lost between 1979 and 1996, converting to open water (Figure 5B).

A major low marsh loss event in the Zimmerman Road portion of the marsh complex visually appears to have occurred between 1991 and 1993, as recorded by the SPOT imagery (Figure 3A-C).

Over the entire period from 1957 to 2013, there was a noticeable decrease in the precipitation and an increase in relative sea level rise rate (Figure 6; Table 1). During this period the sea level rose an average of 0.5257 mm per month (R^2=0.4145) and the rainfall decreased at a rate of 0.0778 mm/yr (R^2=0.0054). After 1996, there was a rapid period of change in sea level rise. During the period from 1996 to 2002, the sea level increased on average at 1.0245 mm per month. During the subsequent period from 2002 to 2012, the sea level rise rate was at its lowest (0.231 mm increase per month), while precipitation had the largest decrease during this time frame (-1.1531 mm/month).

Wind direction and velocity play a strong role in controlling the tidal action within Matagorda Bay (Fig. 7A). Old Town Lake is hydrologically disconnected from Matagorda Bay for much of the year, and has an average water level of 38.20 cm with a standard deviation of 7.18 cm as compared to 30.61cm and 14.79 cm respectively in the open bay (Fig. 7B). For weeks at a time (for example 6/9/2013 to 6/24/2013), Old Town Lake appears to be evaporating, with no connection to the sea. In contrast, Zimmerman Road is not currently limiting tidal exchange, currently, as evidenced by the gauges at North Zimmerman and South Zimmerman (Fig. 7C). Still, the general trends and the evaporative time periods match those in Old Town Lake, indicating that these locations are suffering from the same apparent barrier as Old Town Lake. The barrier at Fish Pass presents a moderate hydrological barrier, as evidenced by the gauges at North Fish Pass and South Fish Pass (Fig. 7D). On May 7, 2013, a strong NW wind was observed (likely a cold front) which caused one of the lowest recorded water levels within the marsh. The connectivity between South Fish Pass and Powerhorn Lake is evident in the degree to which the water levels fluctuate based on wind direction. In this case on May 7, 2013 the water was pushed to the south and away from the South Fish Pass sensors. The opposite function is occurring in North Fish pass where you can see the bunching of water (55.49 cm in depth) in the same time frame that South Fish Pass can be observed to be draining (15.89 cm in depth). This indicates a reduced hydrologic exchange, in this case there was no hydrologic exchange. This wind driven water movement can be seen in the same timeframe in the Old Town Lake data along with the bay data. However, there is less change with regards to the

Zimmerman Road sensors due to the location. There is no exit for the water to the south for this location and thus a smaller degree of water movement occurs during a cold front event than in the south Fish Pass and Old Town Lake locations.

Precipitation, evaporation, or tidal flow connectivity may each play a role in controlling the conductivity (as a proxy for salinity) within Old Town Lake (Fig. 7A). Over the course of the year, the average conductivity in Old Town Lake (56.98 ms) was much greater than that in Matagorda Bay (44.03). Moreover, Old Town Lake exhibited more considerable fluctuations (range of 49.996 ms) compared with Matagorda Bay (range of 18.16 ms). Increases in salinity can be noted throughout the summer months for Old Town Lake, and are obvious on 6/18/2013 in Figure 8. Conductivity fluctuations were similar between North Zimmerman and South Zimmerman (Fig. 4B), with their averages (59.96 ms, 57.06 ms, respectively) similar to that in Old Town Lake (56.98 ms). North Fish Pass and South Fish Pass (Figure 8C) followed similar temporal patterns in the first portion of the record prior to May 27, 2013, though at different averages (96.77 ms, 59.89 ms, respectively). In the second portion of the record, and 100.40 ms and 72.84 ms for North Fish Pass and South Fish Pass respectively.

Discussion

Overall, there was a large loss of low marsh from 1958 to 2012. As the low marsh retreated, it was generally replaced by water. However, there was an increase in overall marsh vegetation between the 1958's and 1979's. Yet, this marsh was lost between 1979 and the 1996, returning the marsh to a vegetation level comparable to 1958. However, the marsh loss trend continued from 1979 to the present-day.

The loss of the low marsh vegetation is likely correlated with the high salinity levels within the marsh (Figure 4). The majority of this low marsh is occupied by *Spartina alterniflora,* which suffers when salinity levels are higher than 325 mol m^{-3} NaCl (approximately 37 ms) (Adams & Bate, 1995; Naidoo, McKee, & Mendelssohn, 1992) Our records show salinities above this value nearly all of the time in Old Town Lake and the rest of the marsh, but also show salinities reaching up to 120 ms particularly in the portions of the marsh with the most loss, such as North Fish Pass. In particular, evaporation occurs in the summer during high temperatures, and this worsens the conditions for vegetation and nekton. The result is the low marsh is converted to open water.

Many salt flats converted into low marsh between 1958 and 1979 in the Magnolia Inlet portion of the study area, resulting in a large increase in low marsh in 1979. Similar conversion of salt flats along the Central Texas Coast has been attributed to subsidence as caused by extensive hydrocarbon extraction activities during the 1950's-1979 time period (White, Waldinger, & Calnan, 2006).

However between 1979 and 1996 the marsh areas experienced a decrease of approximately 10% in total area throughout. A second period of change negatively affected the marsh area. This change was from a low marsh to open water. This region was either experiencing further subsidence, reduced rainfall, or a blockage to normal hydrological functions. During this time frame there was not a large increase in relative sea level. This indicates that subsidence is likely not the sole

mechanism for landscape conversion. While there was a general decrease in rainfall, there was not a significant change (-0.2472 mm of precipitation a month). This suggests that the shell and mud debris pile reached a critical height and began to separate the marsh from the bay. This is confirmed by the local knowledge that the debris pile grew extensively in the 1990's. The SPOT image analysis indicates that the change occurred in 1992 and was solidified in 1993 (Figure 3). This growth in the debris pile forms a dam that reduced the frequency of tides that are capable of over topping the debris pile and infiltrating the marsh. Thus water infiltration only occurs at higher tides. When these tides retreat, the volume of water held within the marsh is larger than historic volumes as the water ceases to exfiltrate the marsh. This would negatively affect the marsh is two key ways. The first being extended periods of low marsh flooding, and the second being hyper salinity through water evaporation. The first factor would result in systematic retreat of the low marsh as the volume of water increased as the debris pile grew. This process would be compounded with increased salinity within the marsh.

To begin the reversal of this process of marsh loss, the past hydrologic processes that maintained the marsh must be restored. It was determined that the structure responsible for the modified hydrology is the shell and mud debris in Magnolia Inlet (Figure 4). This separation has caused reduced tidal action within the impounded marsh, resulting in extended periods of disconnection time. This process continues to inflate the salinity levels within the marsh until tidal inflow events are able to dilute the salinity levels within the marsh. Channelization of the shell and mud debris pile could improve the tidal action within the marsh and alleviate the elevated salinity levels. The connection will also allow for greater volumes of water to be exchanged, thus will help to more completely mix the vast volume of water.

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Table 1: Sea level rise rate, precipitation change, and precipitation averages over time frames of interest.

date	Slope sea Level (mm/month)	r^2	slope precip (mm/month)	r^2	precipitation averages (mm/month)
1958-1979	0.8815	0.1512	0.0851	0.00004	238.10468
1979-1996	0.6063	0.0974	-0.2472	0.0044	236.7637188
1996-2002	1.0245	0.0367	-0.0503	0.00003	214.8487222
2002-2012	0.231	0.0071	-1.1531	0.0431	207.8296303
Overall	0.5257	0.4145	-0.0778	0.0053	229.0516

Figure legends

Figure 1: Research site location and surrounding water bodies with water flow direction.

Figure 2: Research site with locations of blockages indicated with triangles and tidal gauge locations with stars.

Figure 3: Apparent land cover change from 1991 to 1993. Courtesy of TNRIS.

Figure 4: Figures (A, B) denote the timeframe used as a comparison of landcover change overtime ranging from 1958 to 2012. Courtesy of TNRIS.

Figure 5: Land cover changes for 1958, 1979, 1996, 2002, and 2012: total area of the marsh complex (A), and impounded areas lying behind the barriers at Fish Pass (B), Zimmerman road (C), and Magnolia Inlet (minus those areas also behind Fish Pass and Zimmerman Road) (D).

Figure 6: Monthly precipitation and sea level plotted against percent marsh area. The blue line denotes a 12 month moving average for precipitation. The black line denotes a 12 month moving average for sea level rise. The black dashed line indicates the percent low marsh within the study area as compared to the other landscape classes.

Figure 7: Local wind speed and direction, and water level in the open bay adjacent to the marsh (A). Water level fluctuations on opposing sides of each suspected barrier (B-D).

Figure 8: Graphs comparing salinities on the opposing sides of the three suspected barriers affecting the marsh complex.

Fig. 1


Matagorda
Bay
Gulf of
Mexico
Old Town Lake
Foster Lake
Powder Horn
Lake

Fig. 2

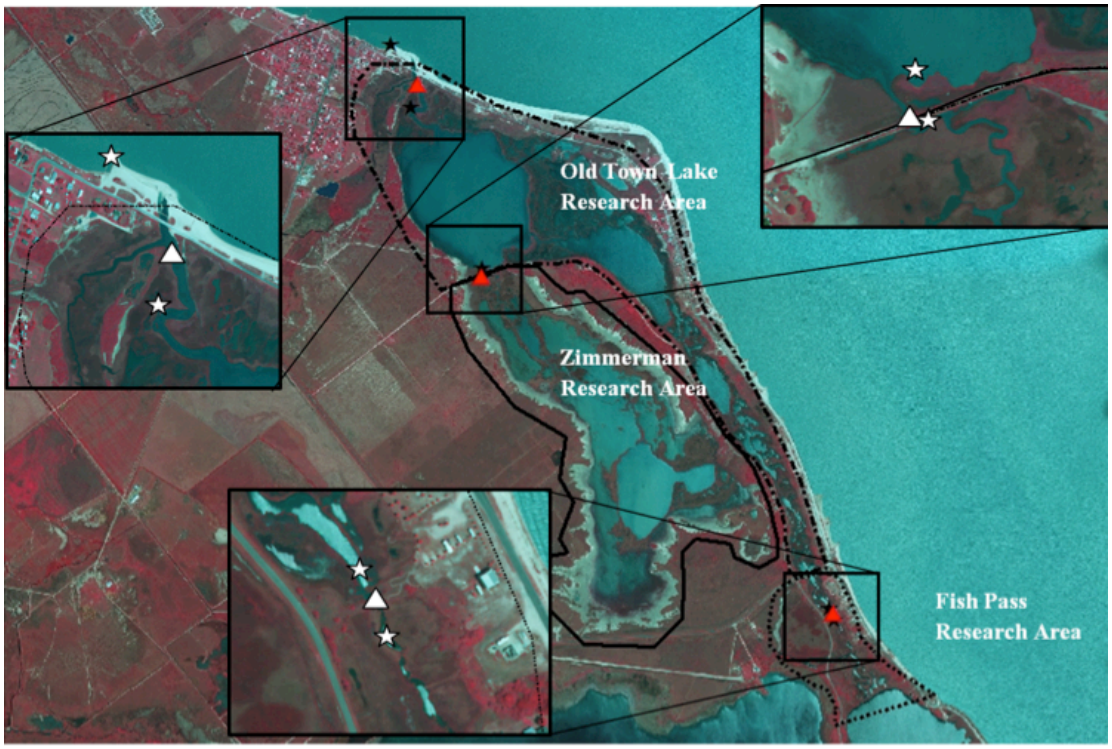
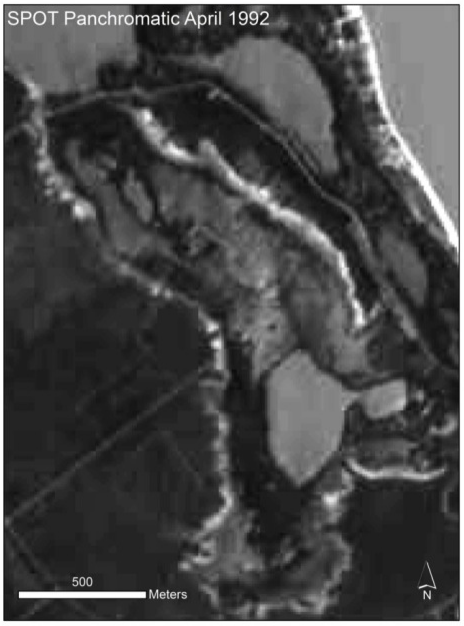

Old Town Lake
Research Area
Zimmerman
Research Area
Fish Pass
Research Area

Fig. 3

(A)


SPOT Panchromatic April 1991
500
Meters
N

(B)


SPOT Panchromatic April 1992
500
Meters
N

(C)


SPOT Panchromatic April 1993
500
Meters
N

Fig. 4

Fig. 5

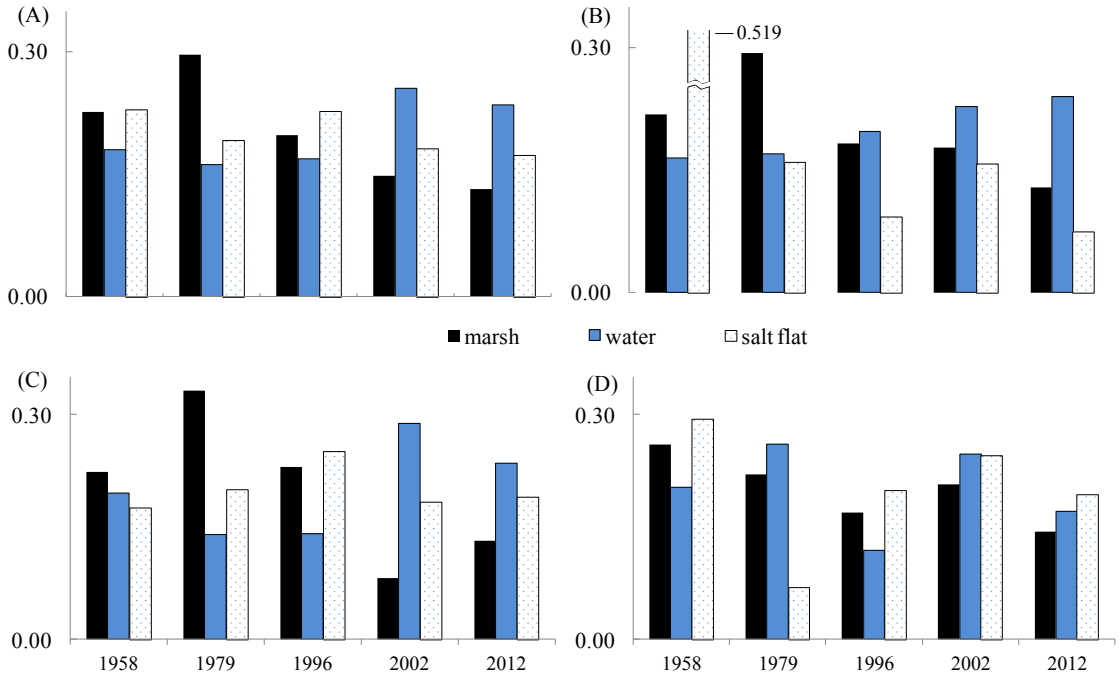
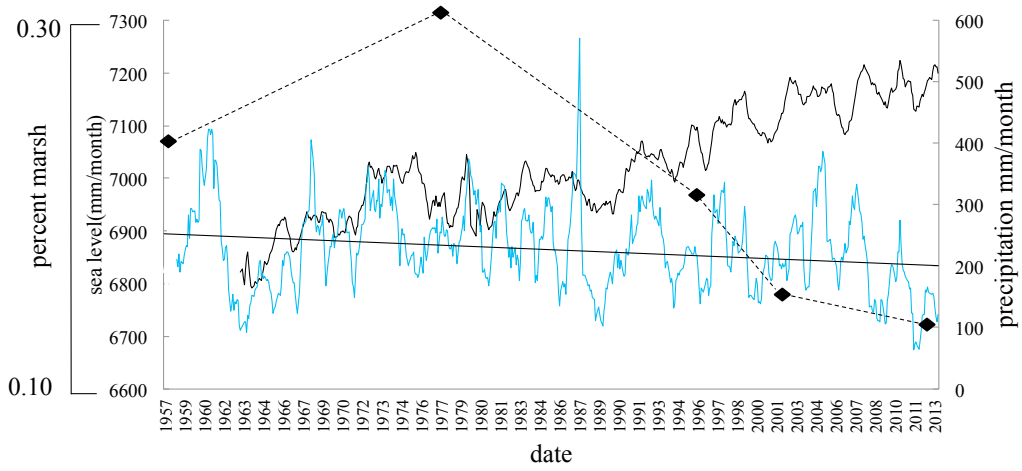

(A)
0.30
0.00
(B)
0.30
0.00
0.519
marsh
water
salt flat
(C)
0.30
0.00
(D)
0.30
0.00
1958
1979
1996
2002
2012
1958
1979
1996
2002
2012

Fig. 6


0.30
0.10
percent marsh
7300
7200
7100
7000
6900
6800
6700
6600
sea level(mm/month)
600
500
400
300
200
100
0
precipitation mm/month
1957
1959
1960
1962
1963
1964
1966
1967
1969
1970
1972
1973
1974
1976
1977
1979
1980
1981
1983
1984
1986
1987
1989
1990
1991
1993
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1996
1997
1998
2000
2001
2003
2004
2006
2007
2008
2010
2011
2013
date

Fig. 7

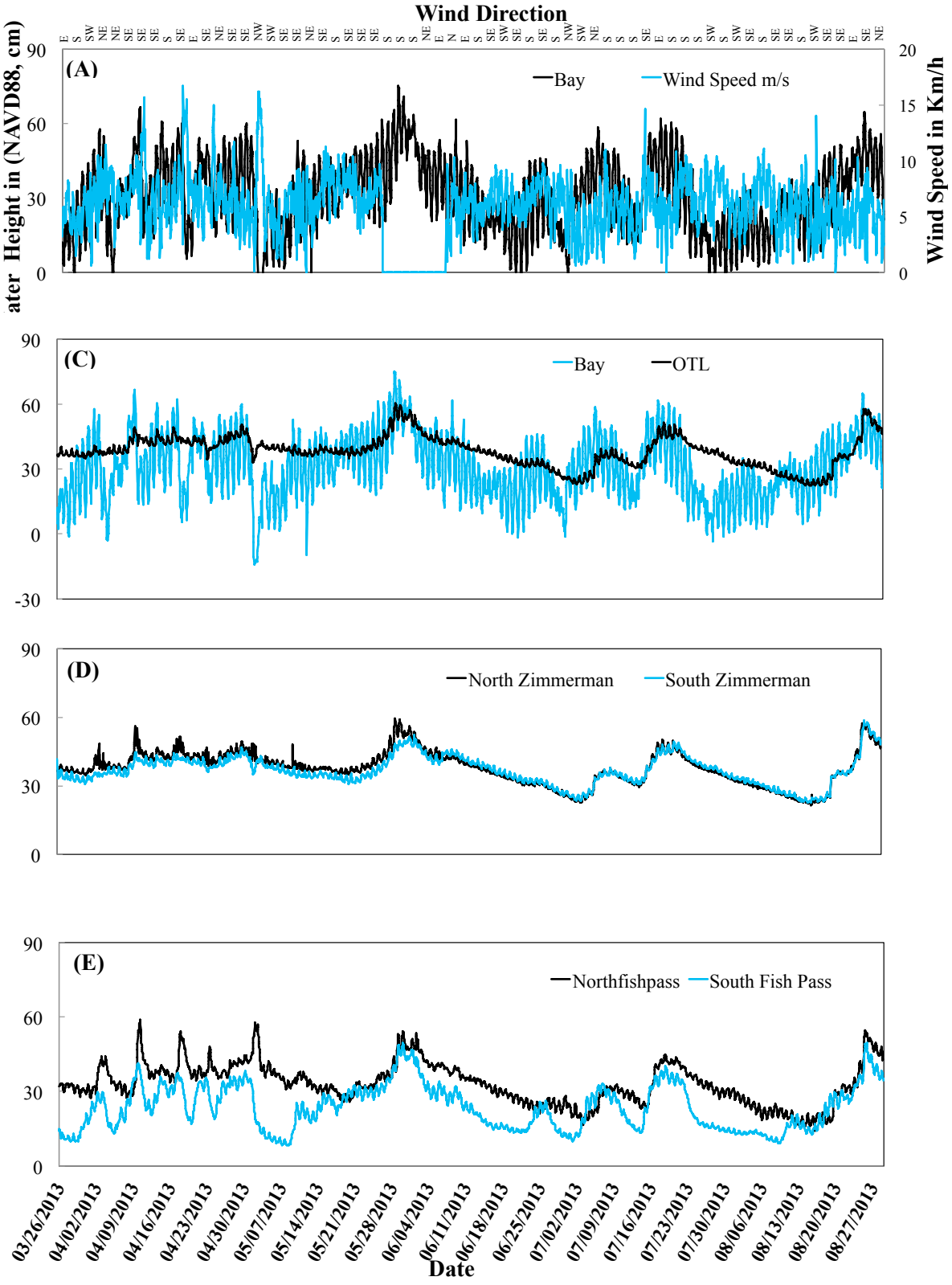
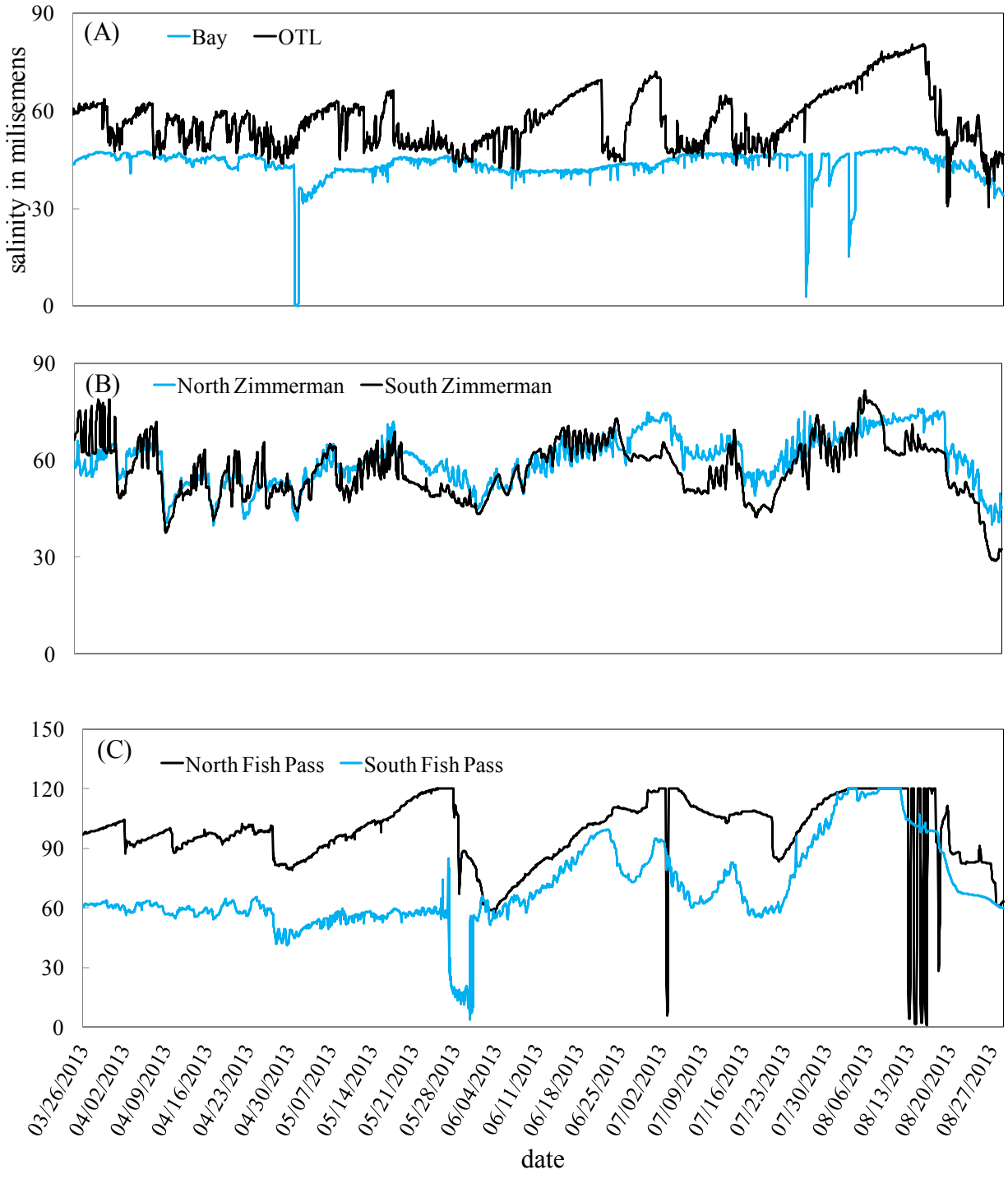

Wind Direction
(A)
Bay
Wind Speed m/s
ater Height in (NAVD88, cm)
Wind Speed in Km/h
(C)
Bay
OTL
(D)
North Zimmerman
South Zimmerman
(E)
Northfishpass
South Fish Pass
03/26/2013
04/02/2013
04/09/2013
04/16/2013
04/23/2013
04/30/2013
05/07/2013
05/14/2013
05/21/2013
05/28/2013
06/04/2013
06/11/2013
06/18/2013
06/25/2013
07/02/2013
07/09/2013
07/16/2013
07/23/2013
07/30/2013
08/06/2013
08/13/2013
08/20/2013
08/27/2013
Date

Fig. 8


(A)
Bay
OTL
salinity in milisemens
90
60
30
0
(B)
North Zimmerman
South Zimmerman
90
60
30
0
(C)
North Fish Pass
South Fish Pass
150
120
90
60
30
0
03/26/2013
04/02/2013
04/09/2013
04/16/2013
04/23/2013
04/30/2013
05/07/2013
05/14/2013
05/21/2013
05/28/2013
06/04/2013
06/11/2013
06/18/2013
06/25/2013
07/02/2013
07/09/2013
07/16/2013
07/23/2013
07/30/2013
08/06/2013
08/13/2013
08/20/2013
08/27/2013
date

Appendix 4

Text of Proposals Written and Award Letters Received for Subsequent Phases of On-the-ground Restoration

TEXAS GENERAL LAND OFFICE
JERRY PATTERSON, COMMISSIONER

November 20, 2013

Rusty Feagin
Associate Professor
Texas A&M AgriLife Research
Sponsored Research Services, 3578 TAMU
College Station, TX 77843 - 3578

Dear Mr. Feagin,

The Magnolia Inlet marsh restoration project submitted to the Texas General Land Office (GLO) for funding consideration through the Coastal Erosion Planning and Response Act (CEPRA) has been selected as a Cycle 8 priority project. The project goal summary for this project was received and evaluated by the GLO, and funding for the amount of $99,064 has been awarded. Understanding that costs for construction and other services may have changed since the original submission, the overall scope of work may need to be scaled appropriately to available CEPRA and partner funding.

A CEPRA project manager will be contacting you shortly to develop a project cooperation agreement and to confirm cost-share and budgets, which at this time are preliminary estimates. Once the project begins, we will be reviewing project timelines quarterly to ensure that your project and all other Cycle 8 priority projects can be successfully and expeditiously completed before the end of the biennium August 31, 2015.

We look forward to working with you to restore and enhance our Texas coast. If you have any questions, please feel free to contact Kevin Frenzel at (512) 463-2482 or via email at kevin.frenzel@glo.texas.gov.

Sincerely,

Helen S. Young
Deputy Commissioner, Coastal Resources Program
Texas General Land Office

Mississippi-Alabama Sea Grant Consortium
Science Serving America's Coasts

Stephen H. Sempier
Deputy Director

703 East Beach Drive
Ocean Springs, MS 39564

Phone: 228-818-8830
FAX: 228-818-8841
E-mail: stephen.sempier@usm.edu
http://masgc.org

January 15, 2014

Rusty A. Feagin
Dept. Ecosystem Science & Management
Texas A&M University
1500 Research Pkwy., Ste. B223
College Station, TX 77845

Dear Dr. Feagin:

I'm pleased to inform you that your project, *Fish Pass Tidal Hydrology Restoration*, has been selected for conditional funding. Funding for your project is contingent upon:

- **Environmental Compliance.** Final award is dependent upon the project successfully passing the National Environmental Policy Act (NEPA) process. The NOAA Restoration Center is working on this, and you may receive additional information requests from NOAA with regards to the potential environmental impacts of the project.

The federal funds for *Fish Pass Tidal Hydrology Restoration* are currently anticipated to be $160,746 with a non-federal match of $161,625. The NOAA Restoration Center, which is the original source of these federal funds, indicated that the project funds can be used as federal match for other programs. We understand that you will use the project, entitled *Fish Pass Tidal Hydrology Restoration,* as match for a related state project funded by the Texas General Land Office Coastal Erosion and Planning Response Act (CEPRA) entitled *Magnolia Inlet.*

We look forward to working with you as you undertake this project. We are very careful with our federal investment and anticipate meaningful impacts from your work.

Sincerely,

Steve Sempier
Deputy Director

cc: Loretta Leist
Devaney Cheramie
LaDon Swann
Jamie Schubert

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

MAR 10 2015

MEMORANDUM FOR: NOAA Community-based Restoration Program Record

FROM: F/HC3- Christopher D. Doley
Division Chief, NOAA Restoration Center

SUBJECT: University of Southern Mississippi Partnership Activities- Explanation of Inclusion under the Community-based Restoration Program Programmatic Environmental Assessment and Supplement (PEA/SPEA) and Findings of No Significant Impact (FONSI)

The Community-based Restoration Program, under the authority of the Fish and Wildlife Coordination Act, 16 U.S.C. 661, as amended by the Reorganization Plan No. 4 of 1970, and the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, is proposing to fund this restoration project through the 2010 University of Southern Mississippi Partnership that is not anticipated to have any significant environmental effect.

After reviewing the proposed project, we have determined that the proposed actions described below fall within the scope and effect of activities analyzed in the February 6, 2002 Programmatic Environmental Assessment (PEA) for the Community-based Restoration Program Implementation Plan and the June 23, 2006 Supplement (SPEA). Further, following application of the criteria used to determine the significance of potential environmental impacts, in accordance with NOAA Administrative Order 216-6, Commerce Department Administrative Order 216-6, and the Council on Environmental Quality Implementing Regulations for the National Environmental Policy Act, we have concluded that the proposed action would not have a significant effect, individually or cumulatively, on the human environment and, therefore, an environmental impact statement will not be prepared.

The **Fish Pass Hydrologic Restoration Project,** undertaken by Texas A&M University will restore 473 acres of fisheries habitat. This will be accomplished by removing two hydrologic barriers that reduce tidal flow into large marsh complex. This has resulted in ponded water levels and marsh loss. Actions that will be funded through the NOAA- University of Southern Mississippi Partnership are:

- Remove the tidal hydrology barrier at Fish Pass
- Survey elevation and water flow speeds, salinities, and levels before and after hydrological restoration
- Monitor biological requirements and changes induced by the opening of two barriers, Fish Pass and Magnolia Inlet

The NEPA analysis for the project's development phase was completed on March 19, 2014. All permits/consultations have been obtained. This construction and monitoring phase of the proposed activities, including any related educational or administrative actions, has now been assessed for significant effects, and has been found to fall under the CRP PEA and SPEA. The project will have no significant individual or cumulative effects on the environment as documented on the CRP's NEPA checklist and is covered under the associated FONSIs.

CEPRA Project No.:_____
(Agency Use Only)

PROJECT GOAL SUMMARY (PGS) APPLICATION FORM

For Erosion Response Project Funding Under the
Coastal Erosion Planning and Response Act (CEPRA) Cycle 8

Potential project partners must submit all required information using this form.

Applicant Information

Application Type: ◉ Regular Submission ○ Emergency Submission

If emergency submission, briefly explain the emergency situation the project proposes to mitigate:

PGS Application Submittal Date (mm/dd/yy): 07/01/13 Date Received:_____
(*Agency Use Only*)

Project Title: Magnolia Inlet

Name of Potential Project Partner: Texas A&M AgriLife Research

Physical Address: Sponsored Research Services, 3578 TAMU

City: College Station Zip+4: 77843 - 3578

Point of Contact (POC): Rusty Feagin Title: Associate Professor

Phone: 979 - 862 - 2612 ext.: Fax: - -

Email: feaginr@tamu.edu

Authorizing Official (if different from POC): Jane Zuber Title: Director, Contracts & Services

Project Type (check all that apply)

☐ Beach Nourishment ☐ Dune Restoration
☐ Shoreline Protection X Marsh Restoration or Protection
☐ Study/Research Project ☐ Debris Removal
☐ Demonstration Project ☐ Storm Damage Mitigation Project
☐ Post-Storm Damage Assessment Project
☐ Other (describe):

For Beach Nourishment and Dune Restoration projects only: N/A

Does project incorporate beneficial use of dredged material (BUDM)? ○ Yes ○ No N/A

Is a sand source identified for beach nourishment? ○ Yes ○ No N/A

Project Description (500-word limit)
Provide a narrative of the project description that addresses each of the following:

Describe the location and geographic scope of the erosion problem:

A large expanse of salt marsh wetlands is disintegrating from Magnolia Beach to Indianola in Calhoun County (see maps below). The wetlands are suffering due to a lack of tidal flow, due to a sediment-oyster blockage at the Magnolia Inlet. Behind the blockage, the water is hypersaline, the vegetation is dying, and the marsh is eroding. Erosion is also happening on the nearby shoreline of Old Town Lake by wind-driven waves.

Describe the desired outcome(s) of the proposed project:

This project will remove a portion of the blockage, restore tidal flow, and stop the erosion of the interior wetlands and adjacent inlet shoreline. Portions of the removed material will be transported and used as living shoreline protection in Old Town Lake.

Discuss any prior erosion response work, including a listing of any known erosion response studies and investigations in the vicinity of the proposed project, and whether the proposed project compliments existing erosion response measures:

In 2011, Calhoun County and Atkins Global identified the broad need for erosion response in the "Calhoun County Shoreline Access Plan", and in particular at this location in "Appendix B: Magnolia Inlet". In 2012-2013, Texas A&M AgriLife Research instrumented the eroding wetlands with tidal and salinity gauges, and began conducting meetings with local citizens and private landowners, in preparation for the funded GLO-CMP project "Restoration of multiple wetlands in the Magnolia Beach area, Calhoun County: Phase I Planning". Work began on restoring these eroding wetlands through hydrological restoration in May 2013, when Calhoun County and Texas A&M AgriLife Research removed a blockage at a nearby location known as "Fish Pass" (see map). These efforts have forged the team and necessary groundwork for the proposed project at the "Magnolia Inlet".

Describe the proposed work sequencing including, if applicable, whether the proposed project will be divided into phases (e.g. reconnaissance study, preliminary engineering, alternatives analysis/feasibility study, permitting, engineering design, construction):

The proposed work will be divided into overall project management, survey work, permitting, engineering design, and construction. Overall project management and survey work will be completed by Texas A&M AgriLife Research, with subcontracts to the other participants. Permitting and engineering design will be completed by Atkins Global. Construction will be completed by Calhoun County. Permission to operate at the described locations has been authorized by Mr. Keith Schmidt, the property owner.

Recommend the preferred erosion response alternative that would address the problem, if known:

As an alternative, the marsh to the side of the blockage could be excavated, allowing the tidal flow to go around the sediment-oyster plug. However, this action is less likely to achieve adequate flow and the consequences could be unsustainable and unpredictable due to alterations in inlet flow pattern.

Project Benefits

Describe the effect and benefits of the proposed project on public safety, access and public infrastructure and property threatened by erosion:

The proposed project will allow storm waters to drain more easily from the interior marshes, through the natural inlet, rather than backing up within the tidal network. There are several low-lying roads surrounding these marshes, for example, the primary road Ocean Drive is overtopped during extreme rain events without proper outflow through the inlet. This project will solve a part of the overall hydrological and storm drainage problem in this area, though other projects may be needed to ultimately meet County and private landowner goals. Additionally, clearing the blockage will enable small kayaks and canoes to paddle through the inlet again, thereby enhancing recreation and fishing access for the public.

Describe the effects and benefits of the proposed project on private infrastructure and property threatened by erosion:

Much of the marsh that is eroding is privately-owned. In particular, the Texas Ornithological Society and Audobon Society own the Magic Ridge Sanctuary. This project will help stop its erosion by restoring tidal flow and reducing hypersalinity. The removal of the blockage from the inlet will better protect Mr. Keith Schmidt's property as well.

Describe the effects and benefits of the proposed project on natural resources threatened by erosion:

The eroding wetlands are utilized by a large number of avian species, including the endangered Whooping Crane. Eight cranes were sighted in 2002 nesting in the marsh complex. Other birds include shorebirds, neotropical migrants, gulls, terns, pelicans, and waterfowl. Avian food resources are threatened and in short supply, as aquatic organisms cannot pass through the tidal blockage.

Moreover, several hundred acres of vegetated habitat have been eroded into open water, reducing the extent of this nursery habitat for fish, crab, and shrimp. Over 64 plant species and 350 aquatic animal species are living in the wetlands and adjacent portions of Lavaca Bay and West Matagorda Bay.

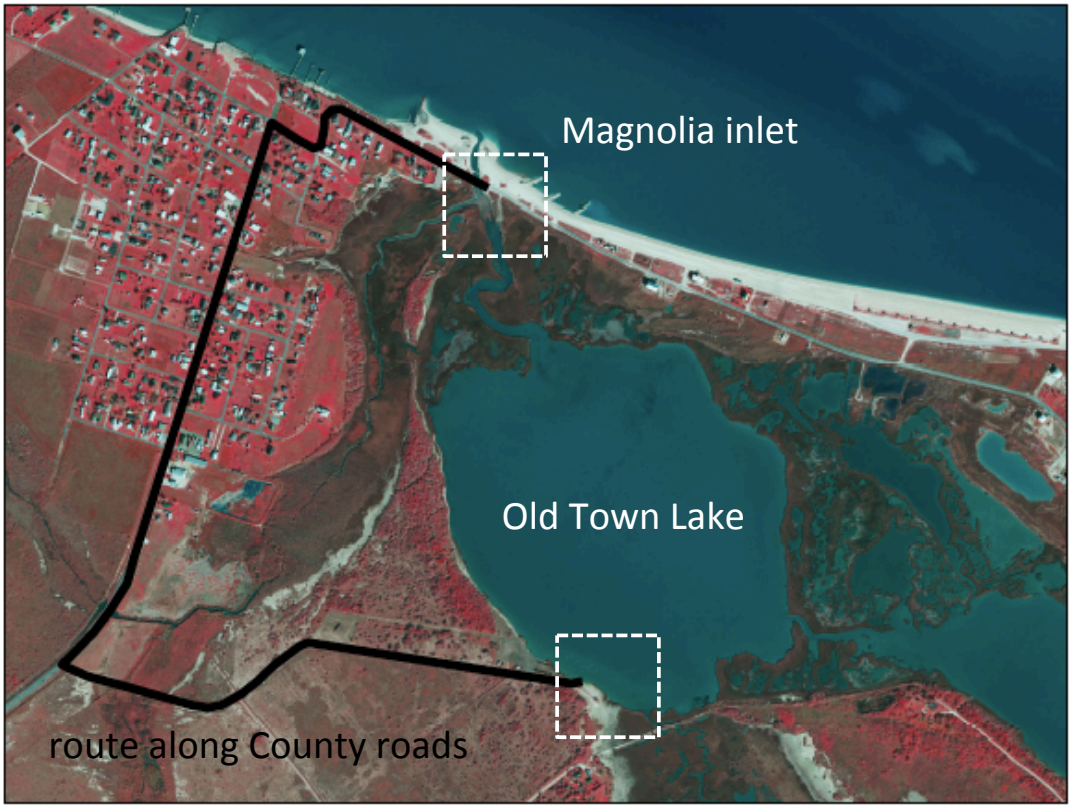
Describe whether the proposed project will provide for the beneficial use of dredged material from the construction and maintenance of navigation inlets and channels of the State:

We anticipate that a portion of the sediment-oyster plug will require appropriate placement after removal, for permit approval. Any required portions will be placed in Old Town Lake to reduce erosion of the shoreline as a living protection measure.

Describe how project costs are reasonable relative to benefits:

The acreage and linear feet of marsh erosion stopped by this project is very high compared to the dollar expenditure, when compared with many CEPRA projects. On an acres-saved-per-dollar-expended basis, or linear-feet-of-shoreline-erosion-prevented-per-dollar-expended basis, hydrological restoration is extremely cost-effective because it stops the disintegration of marsh in impounded water bodies that have become hypersaline. In addition, we use the remnant material as living shoreline protection.

Magnolia Inlet Project



0 625 1,250 2,500 Feet

0 125 250 500 Feet

Proposal Narrative – Fish Pass Tidal Hydrology Restoration

I. Rationale

A large expanse of salt marsh wetlands is disintegrating from Magnolia Beach to Indianola in Calhoun County (Fig. 1). The wetlands are suffering due to a lack of tidal flow, due to multiple hydrological restrictions. As a result of anthropogenic barriers, the water is hypersaline, the vegetation is dying, and the marsh is eroding. Approximately 45,830 linear feet of shoreline is eroding and 473 acres of marsh have already been lost. Fish kills have occurred. Endangered Whooping Cranes have nested in this marsh.

The Texas Ornithological Society and the Audubon Society own the adjacent Magic Ridge Sanctuary. Local citizens and tourists utilize this marsh for fishing, crabbing, and kayaking. The general area has multiple historical markers and trails that traverse the marsh, due to location of the nearby historical town of Indianola.

Multiple tidal barriers need to be removed to restore full tidal flow and marsh health. A long-term plan being implemented by several collaborators seeks to first remove the "Magnolia Inlet" and "Fish Pass" barriers, and then eventually remove the nested "Zimmerman Road" barrier. Once the hydrology is corrected, other partners may build marsh terraces or mounds. For this specific project, our focus is on the "Fish Pass" barrier. However, this project also leverages its funds with an associated project at the "Magnolia Inlet".

II. Approach

Goals and Objectives

The overall project goal is to restore tidal hydrology to the marsh complex that lies between Magnolia Beach and Indianola, Calhoun County, Texas. Specific objectives of this project include:

(1) Remove and document the tidal hydrology barrier at Fish Pass
(2) Survey elevation and water flow speeds, salinities, and levels before and after hydrological restoration
(3) Monitor biological requirements and changes induced by the opening of two barriers, Fish Pass and Magnolia Inlet

Restoration Project Design and Methods

Fish Pass will be opened, with monitoring following the Gulf of Mexico Hydrologic Restoration Monitoring Parameters handbook. Fish Pass is currently occupied by a berm that may have been originally constructed as an informal road. It is approximately 3 meters wide and 2 meters in height. Restoration will be conducted in collaboration with Calhoun County officials. The entirety of the current hydrological barrier is on County property. Culverts, rip-rap, or vegetation will be placed for reinforcement, as

determined by survey and hydrological design work. The optimal configuration will require native vegetation plantings on the small upland location disturbed by the work. The adjacent marsh itself will not be touched.

Surface elevations will be surveyed with survey-grade GPS. The surface elevation information will be used to calculate upland barrier removal depth, width, and volume. Water flow speeds will be measured on either side of the barrier before hydrological restoration, and through the new pass afterwards. This work will supplement salinity and water level records, which are funded from an associated project. The hydrological information will be used to calculate the optimal depth and width to minimize erosion, yet maintain the opening with minimal reinforcement.

Status of Project in Terms of Permitting

This project is related to the Magnolia Inlet project. Funds from another source are paying for that permit and it will be obtained by Atkins Global as a Nationwide Permit 27: Aquatic Habitat Restoration, Establishment, and Enhancement Activities. For this project at Fish Pass, permitting may not be required as the barrier is composed entirely of uplands. However, this project will be discussed during the permitting process by the relevant agencies on the Corp's advisory committee as part of the larger-scale project and long-term plan for this complex of marshes. Many of the individuals on that committee have already visited both project sites.

Monitoring Plan

In addition to the hydrological parameters mentioned above under *Restoration Project Design and Methods*, biological requirements and changes will be monitored around all three distinct hydrological barriers, following the Gulf of Mexico Hydrologic Restoration Monitoring Parameters handbook. Two of these barriers will be opened during the time span of our monitoring effort: the Fish Pass barrier (funded by this source) and the Magnolia Inlet barrier (funded by a match source).

Monitoring will include vegetation, aquatic nekton, and avian wildlife. Several 1 m^2 quadrats will be monitored for vegetative species and percent cover changes, on each side of each barrier. For nekton, drop traps and seine nets will be used following standard methodology of the National Marine Fisheries Service. Monitoring stations will be set up to observe avian habitat usage. The barrier removal design will incorporate this knowledge.

III. Expected Outcomes and Application of Results

We expect that monitoring will show that salinity will drop in the currently impounded marshes, and water levels will be able to decrease on outgoing tides. Marsh vegetation mortality will decrease, and erosion will slow. Counts of fish and nekton will increase within the marsh, due to the opening of this access point. We expect that the

associated opening of Magnolia Inlet will help secondarily, such that proper circulation is restored throughout the system.

IV. Community Engagement and Outreach

Role and Expertise of Partners in this Project
The partners in the larger effort, that includes multiple funding sources include:

- Texas A&M AgriLife Research/Texas A&M University (Rusty Feagin, leading and organizing effort)
- NOAA/TxGLO Coastal Management Program – CMP (funding water level/salinity work, community organization, big picture planning. contact: Melissa Porter, program manager)
- TxGLO Coastal Erosion Planning and Response Act Program - CEPRA (funding Magnolia Inlet barrier restoration. contact: Carla Kartman, program manager)
- Calhoun County (equipment usage, manpower, owner of portions of relevant lands. contact: Commissioner Roger Galvan, Judge Mike Pfeiffer)
- Atkins Global (permitting for Magnolia Inlet project through CEPRA funds. contact: Juan Moya, Tom Dixon)
- Private Landowner (Keith Schmidt, owner of portions of relevant lands for Magnolia Inlet project)
- Texas Ornithological Society (owner of portions of nearby lands. contact: Jim Hailey)
- Texas Sea Grant (Rhonda Cummins, community organization and outreach)

Many other individuals from state and federal agencies have been or are being consulted, but are not formal partners. For this project alone, only the County is a formal partner and owns the land where the project will take place.

Community Involvement
The local community will be involved in this project. Calhoun County elected officials and private citizens are actively involved in the larger restoration effort (see *Role and Expertise of Partners in this Project*). Feagin will continue to meet with them approximately every 3 months during this project.

Outreach Plan
Rhonda Cummins of Texas Sea Grant and Feagin will hold a workshop for local citizens in early 2014. The purposes will be (a) to develop and record narrative histories of the barriers, the marsh, the fish, and the birds of the area. They will specifically seek verbal accounts of its past health versus present deterioration. (b) educate the public about the restoration efforts. (c) enlist local citizens to help in the larger restoration effort in the future. Portions of this outreach effort are being funded by the NOAA/TxGLO CMP project (see *Role and Expertise of Partners in this Project*).

Appendix 5

Comprehensive Wetland Restoration Plan for Interconnected Marshes and Critical Habitats in the Magnolia Beach-Indianola Area

Comprehensive Wetland Restoration Plan for Interconnected Marshes and Critical Habitats in the Magnolia Beach-Indianola Area

A large expanse of wetlands suffer from a lack of tidal flow at various points in the tidal channel network, stretching from Magnolia Beach to Indianola Beach, in Calhoun County, Texas. As a result, the impounded water has become hypersaline, causing the vegetation to die and the land to erode. From 1979 to 2015, several hundred acres of land have converted into open water. In addition, fish and shrimp are unable to enter and exit the marshes, and cannot access this important nursery habitat.

These degrading wetlands extend across multiple public and private properties, and involve multiple recreational stakeholders. Several local, state, and federal governmental agencies have jurisdiction over portions of these lands. Thus, restoration will require a concerted plan that involves all parties.

The problem is that multiple obstructions block the tidal flow and the marsh is dying. We list these obstructions in the order in which we recommend that they be remediated. We also list further subsequent actions that could be taken to improve the wetlands.

Potential Actions:

(1) Fish Pass. This barrier is approximately 4 feet high and appears to be an old road or berm composed of shell hash. It completely blocks flow along a series of marshes, stretching several miles in length from Old Town Lake down to Powderhorn Lake.

Recommendation: This obstruction was removed by the County as recommended.

(2) Magnolia Inlet. This barrier is a large pile of shell and mud debris, and does not allow water to escape from the marshes, leaving the daily tidal range in the marshes at only a few cm. This is the most important barrier to remove, as it appears to control the majority of exchange between Old Town Lake and Lavaca Bay.

Recommendation: This obstruction is being removed by the County as recommended, slated for June 2015.

(3) Zimmerman Road. This barrier is composed of a road berm about 4 feet high and several clogged culverts. However, it does not appear to directly prevent hydrological exchange. Tidal records show that the water is moving

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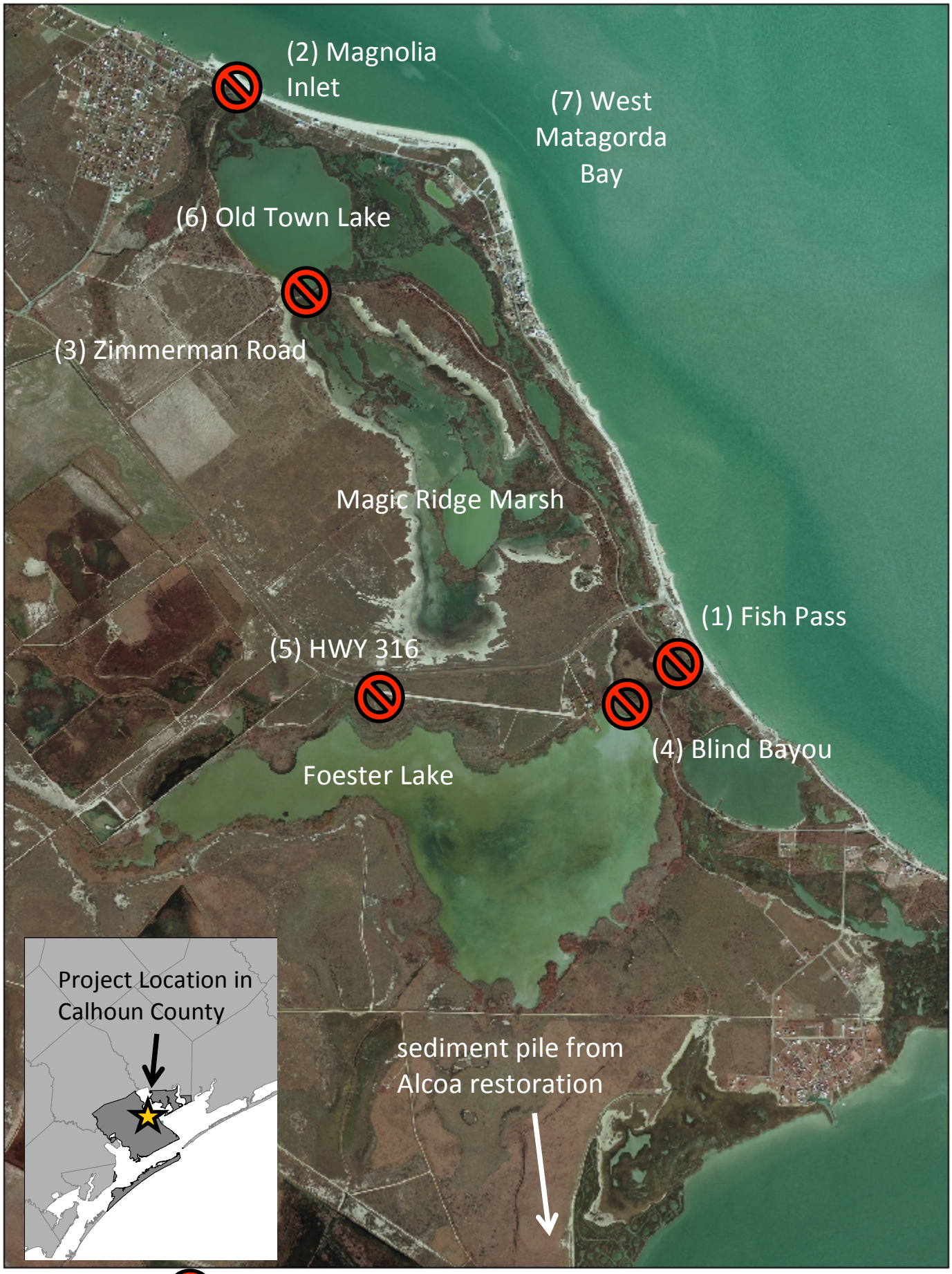

= blocked historical tidal or inflow connection

adequately (though across the very small tidal range that is already restricted by the Magnolia Inlet). It is very possible that once the Magnolia Inlet barrier is removed, the effects of this secondary barrier will become obvious. Since this barrier may impound the Magic Ridge Marsh, which has experienced great amounts of marsh loss since the 1970's, it will be an important next step. The County owns this road, and thus the barrier is public property, and could be easily removed. However, a private landowner has a temporary right-of-way on a section of this road.

Recommendation: Efforts should be made to encourage this landowner to remove this barrier, pass it back to the County, or the County can simply wait until the granted rights expire. The culverts should then be removed. Removing the road would be even better, but if this is done the marsh edge on the south side of Old Town Lake (adjacent to the road) should be protected; the fill could be used to create a submerged living shoreline protection measure.

(4) Blind Bayou. A road berm about 4 feet high surrounds the eastern edge of Foester Lake, restricting its freshwater from flowing into Blind Bayou. On the south side of Foester Lake, a small overflow channel allows freshwater to flow down to Powderhorn Lake.

Recommendation: Cut a 75 foot long overflow ditch across the berm, at the same elevation as the other opening, to allow freshwater to pass back to Blind Bayou. This would not disrupt Foester Lake, and would reduce its flooding during large rain events. It would not increase flooding in the Blind Bayou area either, given that it would be a small cut opening out into the large marsh expanse that connects to Powderhorn Lake. It would, however, occasionally provide needed freshwater and nutrients to the area.

(5) Magic Ridge Marsh/Hwy. 316. Highway 316 cuts off sheet flow of water that comes overland from the coastal prairie and several abandoned rice farms, that would otherwise flow into the southern end of the Magic Ridge Marsh. There is evidence that the large amount of marsh loss in the Magic Ridge Marsh basin from 1979 to 2015 occurred when this incoming freshwater was re-directed into Foester Lake.

Recommendation: Cut a 800 foot overflow ditch opening at the same elevation as the openings described above, place culverts under 316, to allow freshwater to pass to Magic Ridge Marsh. This would not disrupt Foester Lake, and would reduce its flooding during large rain events. One potential issue is land ownership. A single landowner would need to be consulted on the Foester Lake side, though there is some reason to believe the owner would allow it. Although all action on the Magic Ridge side could occur on County land or Texas Ornithological Society land (a willing partner), a private construction yard located nearby would require some discussions to assure them that

flooding of their property would not occur.

(6) Old Town Lake Shoreline Protection and Marsh Creation. The shores of Old Town Lake are eroding an average of several feet per year, due to wind-driven wave erosion.

Recommendation: Shorelines should be protected using hard material, such as shells extracted from nearby upland locations. These would likely support additional habitat, as well as reduce wave erosion. In addition, new marsh could be created around the edges of Old Town Lake, in concentric rings protected by an inner-most ring of shoreline protection. Sediment could be trucked in from a large pile left by a separate Alcoa restoration project near Indianola. The potential acreage for restoration is quite large in this ecosystem.

(7) Bayshore Erosion Protection. The bay shores along Lavaca Bay and West Matagorda Bay may be altered due to ship-driven motion of sediments. This could potentially disrupt tidal flow at the Magnolia Inlet, and affect the marshes that lie within the large complex, though this remains to be seen or proven.

Recommendation: The jetties at Magnolia Inlet should be extended to deeper water, to avoid siltation of the tidal channel. An angle at the tip would prevent wave-driven sediment from moving up the channel. Potential living shoreline breakwaters (reefs) should be created offshore in shallow waters.

Benefits of these actions: Multiple stakeholders have an interest in restoring the hydrology and wetlands:

First, flooding of land will decrease for all of these actions, as it allows water to run to sea level and out to the bay. The obstructions currently block and impound water. Only Action (6) would require further elevation modeling to be sure. The rest of the actions would reduce flooding for all stakeholders.

Second, land erosion would decrease. Marsh vegetation would recover as salinities decrease, and flow is unobstructed. Private landowners would no longer have their land converting into water.

Third, birds, shrimp, and fish would benefit. The fisheries in West Matagorda Bay and Lavaca Bay would benefit by adding this nursery back into the system used by aquatic organisms.. This would benefit the local economy. Local bait shops in Magnolia Beach-Indianola would also benefit as the marshes would be revitalized.

Fourth, recreational opportunities would benefit. Several local citizens fish, kayak, bird-watch, or hunt. The removal of hydrological barriers opens up access to public lands. Mosquitos should also be reduced, as tidal flow becomes more regular, and

waters are less stagnant.

Funds to complete this work should be sought from the Coastal Erosion Planning and Response Act (CEPRA), Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), NOAA, Formosa's Environmental Trust Fund, Alcoa, Calhoun County Port Authority, National Fish and Wildlife Federation (NFWF), and the RESTORE Act. Portions of land could be bought from private landowners looking to sell, to create a large, contiguous area of public lands in this marsh complex.

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