E C O L O G I C A L   R E V I E W

East Sabine Lake Hydrologic Restoration, Construction Unit 1
CWPPRA Priority Project List 10
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This document reflects the project design as of the 95% Design Review meeting, incorporates all comments and recommendations received following the meeting, and is current as of July 11, 2003.

ECOLOGICAL REVIEW

East Sabine Lake Hydrologic Restoration (CS-32), Construction Unit 1

In August 2000, the Louisiana Department of Natural Resources (LDNR) initiated the Ecological Review to improve the likelihood of restoration project success. This is a process whereby each restoration project's biotic benefits, goals, and strategies are evaluated prior to granting construction authorization. This evaluation utilizes environmental data and engineering information, as well as applicable scientific literature, to assess whether or not, and to what degree, the proposed project features will cause the desired ecological response.

I. Introduction

The East Sabine Lake Hydrologic Restoration (CS-32) project is located in the western third of the Sabine National Wildlife Refuge (NWR) in Cameron Parish, Louisiana. The project area is bounded on the east by the Burton Sutton Canal, to the south by Starks South Canal, to the west by the eastern Sabine Lake shoreline, and to the north by the approximate northern boundary of Sabine NWR (Figure 1). The project area (21,188 acres) is primarily composed of intermediate and brackish marsh, the latter generally located along the Sabine Lake shoreline and extending inland for 1 to 2 miles (Chabreck and Linscombe 1997). Approximately 40% of the project area is now shallow open water habitat. The Hydrologic Investigation of the Louisiana Chenier Plain attributed land loss within the project area to saltwater intrusion from Green's Bayou and Willow Bayou, nutria herbivory, and the construction of oilfield canals (Louisiana Coastal Wetlands Conservation and Restoration Task Force 2002). The overall objectives of the project are to protect and restore intermediate and brackish marshes within the project area.

Coast 2050 predicted continued land loss within the project area and identified Sabine Lake shoreline erosion, interior marsh loss along the edges of open water, and altered hydrologic regimes as the primary causes [Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (LCWCRTF & WCRA) 1999]. The East Sabine Lake Hydrologic Restoration project intends to address these causes of land loss by reducing and/or stopping erosion along the eastern Sabine Lake shoreline, by creating marsh in shallow open water areas, and by controlling channel-induced saltwater intrusion. These proposed approaches are consistent with Coastwide Common Strategies and Regional Ecosystem Strategies identified in Coast 2050 (LCWCRTF & WCRA 1998).

The physical features of the East Sabine Lake Hydrologic Restoration project will be subdivided into two construction units which will proceed independently toward construction authorization as planning and engineering warrant. Six project features, including earthen terraces, a foreshore rock dike, vegetation plantings, and three water control structures, were organized into Construction Unit 1 (CU1) (Figure 1). It has been proposed that these project features proceed to construction in advance of Construction Unit 2 (CU2) which includes four actively managed water control structures. A numerical model of the project area, developed to predict the impact of the CU2 features, will aid in the design and operation of the actively managed control structures. Following model calibration, validation, and the subsequent modeling of alternatives, the project team will finalize designs for CU2 and prepare for a construction funding request. The exclusion of the physical features of CU1 from the modeling

Figure 1. East Sabine Lake Hydrologic Restoration (CS-32), Construction Unit 1

effort is not expected to affect the model results. This Ecological Review focuses entirely on CU1 of the East Sabine Lake Hydrologic Restoration project.

II. Goal Statement

1. Reducing excessive elevated salinities within the Double Island Gully, Pines Ridge, and Greens Lake portions of the project area.
2. Reducing water level variability within the Double Island Gully and Pines Ridge portions of the project area.
3. Reducing the erosion rate along the Sabine Lake shoreline by 50 % from Johnson's Bayou to a point north of Pines Ridge.
4. Stopping erosion of the Sabine Lake shoreline from the mouth of Willow Bayou to a point approximately 2,955 feet to the north.
5. Creating 68 acres of marsh in shallow open water areas by the end of the 20 year project life.
6. Increase fisheries and estuarine organism access without adversely affecting salinity levels in the western portion of Sabine NWR.

III. Strategy Statement

- Reduction in salinity and water level variability achieved through the construction of a rock weir in a bayou at Pines Ridge at the intersection of an east-west oil and gas canal.
- Reduction in salinity and water level variability achieved through the construction of a plug at Double Island Gully in the southeastern portion of Section 16 and Starks South Canal.
- Reduction in Sabine Lake shoreline erosion achieved through the planting of smooth cordgrass (*Spartina alterniflora*) from Johnson's Bayou to a point north of Pines Ridge (approximately 58,000 linear feet).
- Stop Sabine Lake shoreline erosion through the construction of a foreshore rock dike from the mouth of Willow Bayou to a point approximately 2,955 linear feet to the north.
- Creation of 68 acres of marsh and reduction of area salinity through the construction of approximately 150,000 linear feet of vegetated earthen terraces in the Greens lake area.
- Increased fisheries and estuarine organism access to the western portion of Sabine NWR and restoration of Bridge Bayou's hydrologic integrity achieved through the construction of three 24 inch diameter culverts with flapgates at the intersection of Bridge Bayou and the cattle walkway.

IV. Strategy-Goal Relationship

Rock Weir and Plug—Reduction in Salinity and Water Level Variability

The construction of a rock weir located in a bayou at Pines Ridge and a plug at Double Island Gully is expected to reduce both the flow of higher salinity water into the project area and water level variability behind the structures by restricting hydrologic exchange. The porous nature of typical rock weirs and plugs would not immediately prevent saltwater intrusion nor completely stabilize water levels behind the water control structures. However, the rock weir located in a bayou at Pines Ridge will contain a vinyl sheet pile core and the rock plug at Double Island Gully will be constructed with an earthfill core so as to prevent hydrologic exchange below the constructed elevation of the water control structures. The proposed features will likely affect the desired salinity and water level variability reduction.

Vegetation Plantings—Reduction of Shoreline Erosion

The planting of smooth cordgrass will reduce erosion along the 58,000 linear foot section of eastern Sabine Lake shoreline by stabilizing exposed soils and damping wake- and wind-induced waves.

Foreshore Rock Dike—Stopping Shoreline Erosion

The construction of a foreshore rock dike will effectively stop erosion along the 2,955 linear foot section of eastern Sabine Lake shoreline by dissipating wake- and wind-induced waves. By halting shoreline erosion, the narrow band of marsh separating Willow Bayou from Sabine Lake will be maintained.

Terraces—Marsh Creation and Reduction in Salinity

The construction of terraces will not only result in the direct creation of marsh habitat, but will also facilitate marsh building by trapping suspended sediments in the shallow open water areas adjacent to the terraces. The terraces will also reduce erosive wave energy thereby protecting the surrounding edges of interior fringing marshes. Vegetation plantings on the crown [marshhay cordgrass (*Spartina patens*)] and slope (smooth cordgrass) of terraces will aid in stabilizing and consolidating the deposited spoil.

Culvert Structure—Increase Aquatic Organism Access

Bridge Bayou was plugged by dredged material placed in the construction of the cattle walkway prior to the establishment of Sabine NWR in 1937 (Marty Floyd, personal communications, March 26, 2003). Currently, Bridge Bayou contains one 24 inch diameter open culvert. The proposed enlargement of the structure includes three 24 inch diameter culverts with flapgates in place of the existing 24 inch plastic culvert. This increase in cross sectional area equates to the carrying capacity of the bayou in its current state according to field surveys conducted by the Natural Resources Conservation Service (NRCS). The additional capacity of the structure will increase fisheries accessibility and hydrologic exchange in Bridge Bayou which influences approximately 400 acres of brackish marsh (Clark et al. 2000).

V. Project Feature Evaluation

Consultations with LDNR design engineer Clark Allen have confirmed that each of the proposed project features are sound in principle and will likely affect the desired ecological response. However, in order to proceed with finalization of the designs the following information will be required:

- Water level data for Sabine Lake should be retrieved in order to determine the appropriate height of the foreshore rock dike. Wave height should also be considered so as to construct a barrier that is not overtopped more than is deemed desirable.
- Provide data, surveys or anecdotal evidence that supports the contention that substrates at the Sabine Lake shoreline, Pines Ridge, and Double Island Gully are adequate to sustain the proposed rock structures.
- Provide data, surveys or anecdotal evidence that adequately confirms the suitability of Greens Lake area soils for use in terrace building.

VI. Assessment of Goal Attainability

Rock Weir and Plug

The construction of a rock weir with a vinyl sheet pile core in a bayou at Pines Ridge and an armored earthen plug at Double Island Gully, are intended to reduce the flow of higher salinity water into the project area and to reduce water level variability behind the structures. Establishing clearly defined success criteria and targets (e.g. a 2 ppt salinity reduction or a 3 inch reduction in water level variability) by which to evaluate the project features has proven difficult due to the lack of empirical data. Rogers (1989) found no significant difference in marsh salinities between study areas in which rock weirs were employed and those without weirs. And although confounded by differences in elevation between study sites, Rogers (1989) indicated that rock weirs appeared intermediate between fixed-crest weirs and open, natural drainage areas at maintaining water levels. It seems logical that rock weirs will slow exchange of waters of different salinity concentrations and impede hydrologic flow through the structure, but available scientific and grey literature gives little indication as to the expected observed benefit. Project scientists and engineers have indicated that the addition of a vinyl sheet pile core to the rock weir in a bayou at Pines Ridge and an armored earthen plug at Double Island Gully will restrict hydrologic exchange through the structures, thereby providing more control over saltwater intrusion and water level variability.

In addition to its intended purpose, the rock weir at Pines Ridge will provide a number of secondary benefits. The rock weir, with a sill elevation of one foot below average water level, may allow for more estuarine organism movement over the structures as compared to fixed-crest weirs and culvert-structures (Broussard 1988, Rogers 1989). Unlike fixed-crest weirs, slotted weirs and flap-gated culvert-structures which require active management, rock weirs are passive. Rock weirs have also proven to be extremely durable and can be constructed at one-third the cost of comparable wood or steel structures (Broussard 1988). The rock weir at Pines Ridge and the armored earthen plug proposed for Double Island Gully will also serve to impede the access of unauthorized individuals onto the Sabine NWR.

Vegetation Plantings

The large-scale use of vegetation plantings as a shoreline restoration technique in Louisiana began in 1986 through the Louisiana Geological Survey/Coastal Vegetation Section (Bahlinger 1995). Prior to 1986, NRCS (formerly the Soil Conservation Service), in conjunction with the Soil and Water Conservation Districts, had been using vegetation test plantings along Louisiana shorelines since the late 1970s. These earlier planting efforts led to the establishment of the Plant Materials Center in Golden Meadow, Louisiana. Established in 1986, the Plant Materials Center was specifically designed for studying plants suitable for Louisiana marshes.

Marsh vegetation increases shoreline stability by dissipating wave energy, anchoring fragile soils, and creating a depositional environment. Consequently, vegetation plantings have been widely used in the United States for shoreline protection as a low cost alternative to hard structures since the mid 1950's (Knutson et al. 1981). Smooth cordgrass is a species widely selected for erosion abatement due to its tolerance of a wide range of intertidal environments (Knutson 1977) and its ability to stabilize shorelines (Benner et al. 1982, Knutson et al. 1982). In models developed by the United States Army Corps of Engineers, the energy of 6-inch waves was dissipated 64% within the first 8.2 feet of smooth cordgrass marsh (Knutson et al. 1982).

The intent of the vegetation planting component for CU1 of the East Sabine Lake Hydrologic Restoration project is to reduce erosion rates along the Sabine Lake shoreline by 50% from Johnson's Bayou to a point north of Pines Ridge over the 20 year project life. Unfortunately, there have been no vegetation planting projects conducted on Louisiana's Sabine Lake shoreline that could provide project scientists and engineers with quantitative or qualitative evidence as to the attainability of the stated goal. To demonstrate the applicability and viability of smooth cordgrass plantings on the Sabine Lake shoreline, the local Soil and Water Conservation District, LDNR, and NRCS have proposed to plant 500 trade gallons at each of three selected test locations in June 2003. The three test sites are to be located within the project boundary of the East Sabine Lake Hydrologic Restoration project between Coffee Ground Cove and Willow Bayou (T12S and T13S, R14W in Cameron Parish). The trade gallons of smooth cordgrass will be planted on five foot centers for a total of 7,500 linear feet of plantings along the Sabine Lake shoreline. The results of data gathered from the test plantings will assist project scientists in identifying suitable environments for the vegetation plantings.

Although not located along the Sabine Lake shoreline, five vegetation planting projects utilizing smooth cordgrass have been implemented along the shorelines of Calcasieu Lake (approximately 25 miles to the east of Sabine Lake) as part of the LDNR/NRCS/Soil and Water Conservation Committee (SWCC) Vegetation Planting Program. Both Sabine and Calcasieu lakes, the dominant water bodies within the Calcasieu-Sabine hydrologic basin, have a complex hydrology primarily driven by riverine freshwater inflows at the north end, Gulf of Mexico tides, precipitation, and wind effects on water level and directional flow. There is some east-west water exchange between the two lakes through the Gulf Intracoastal Waterway (GIWW) and interior marsh canals (e.g., North Starks and South Starks canals on the Sabine NWR), but Sabine Lake typically remains fresher due to the Sabine River's greater discharge [historic daily mean discharges for the Sabine River near Ruliff, Texas are three times greater than those of the Calcasieu River near Kinder, Louisiana (Goree et al. 2001)] and the rapid loss of Calcasieu River freshwater inflows down the Calcasieu Ship Channel (USDA 1994). Although soil conditions may vary, inferences can be drawn from the five Calcasieu Lake projects due to the lake's geomorphic similarity and hydrologic connection to Sabine Lake. These projects are summarized in Table 1. Reduced survivorship of the Cameron Creole smooth cordgrass plantings has been attributed to nutria herbivory and disease. And although inconclusive, results from the West Turner's Bay Shoreline and Kelso Bayou project sites suggest that water depth (> 6 inches) and high wave energies may have been the causes of reduced plant survival. Unfortunately, with the exception of the Cameron Creole planting which was monitored four times over a 13 month period, the remaining four projects were monitored one time only 31—49 days following planting.

Foreshore Rock Dike

It has been proposed that a rock dike be constructed to stop shoreline erosion of the Sabine Lake shoreline from the mouth of Willow Bayou to a point approximately 2,955 feet to the north. This structure, by preventing wake- and wind-induced waves from reaching the shoreline, will preserve the integrity of the narrow band of marsh that separates Willow Bayou from Sabine Lake. Rock dikes have been used extensively along the Louisiana coast to damp wave energy reaching coastlines with great success. Published results of some projects funded

Table 1. Vegetation planting projects implemented along the shoreline of Calcasieu Lake by the LDNR/NRCS/SWCC Vegetation Planting Program

Project Name	Location	Date Planted	Date Monitored	Species Planted	Length of Plantings	# of Plants	Technique	Soil	Water Depth	% Survival	Field Observation
Cameron Creole	Southeast of Calcasieu Lake	6/6/92	9/92-7/93	*Spartina alterinflora*	12,000’	12,000 stems	1 row 1’ apart	Clovelly muck	3”	37% 9/92 37% 12/92 31% 4/93 15% 7/93	Herbivory damage and disease a major problem
North Grand Lake Marsh	North Calcasieu Lake	6/28/95	8/16/95	*Spartina alterniflora*	5,000’	1,020 trade gallons	1 row 5’ apart	Gentilly Muck	4”	96.8%	None
North Grand Lake Marsh #2	North Calcasieu Lake	6/29/98	7/30/98	*Spartina alterniflora*	7,500’	1,500 trade gallons	Multiple rows 5’ apart	Gentilly Muck	4”	97.5%	Tall stems broken but new growth
West Turner’s Bay Shoreline	Northwest Calcasieu Lake	7/20/99	8/26/99	*Spartina alterniflora*	6,000’	1,200 trade gallons	1 row 5’ apart	Udifluvents	6-12”	50.0%	Subject to high wave energy and shells
Kelso Bayou	West Calcasieu Lake	7/20/99	8/26/99	*Spartina alterniflora*	1,500’	300 trade gallons	1 row 5’ apart	Scatlake Mucky Clay	12-24”	37.5%	None

under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) that have successfully used rock dikes are highlighted, below.

- The Boston Canal/Vermilion Bay Shoreline Protection (TV-09) project was designed to abate wind-driven wave erosion along Vermilion Bay and at the mouth of Boston Canal (Thibodeaux 1998). Results indicate that the rock breakwaters have been effective in promoting sediment deposition and retaining this sediment behind the breakwater. While the reference area has continued to erode, the project area has prograded.

- The Freshwater Bayou Wetlands (ME-04) Phase 1 project was designed to reduce boat wake-induced shoreline erosion along the west bank of Freshwater Bayou Canal between Schooner Bayou Canal and Humble Canal. One year after construction, results showed that the rock dike had successfully prevented or significantly reduced wave-induced erosion of the protected segment of canal bank, as compared with the unprotected reference area (LDNR 1998). However, maintenance needs have been high on this structure, and its effectiveness has decreased over time. The rock used in the project became available at a greatly reduced cost when emergency authorization was granted to dismantle the Wax Lake Outlet weir. However, the rock was of a smaller grade than what was specified in the U.S. Army Corps of Engineers’ (USACE) design plan. And although the rock dike was built in accordance with the design plan, the rocks have been moved by wave energy over time (Raynie and Visser 2002).

- The Clear Marias Shoreline Protection (CS-22) project is located along the northern bank of the GIWW in Cameron Parish, Louisiana, between the Alkali ditch and Goose Lake. The project was designed to prevent the GIWW from coalescing with interior ponds by protecting the shoreline from boat wake-induced wave energy. It was expected that this action would simultaneously protect interior freshwater marshes from higher salinity water in the GIWW. Three years after construction, the project area shoreline had prograded, while the reference area had continued to erode. Preliminary results indicate that the breakwater has been effective in preventing further erosion of the GIWW levee and trapping sediments behind the structure (Miller Draft Report).

- The Cameron Prairie Refuge Protection (ME-09) project is located along the northern levee of the Gulf Intracoastal Waterway (GIWW), which borders the southern boundary of the Cameron Prairie National Wildlife Refuge. As with the Clear Marias (CS-22) project, this project was designed to protect the interior freshwater marsh from the deleterious effects that would result if the GIWW levee were to continue to erode away. Results indicate that the structure has been successful in damping wave energy (Barrilleaux and Clark 2002). While the reference area continued to erode, shoreline accretion was measured behind the rock dike. Six years after construction, the structure appeared to be in good condition and no breaches of the levee were found.

  Although less relevant to the East Sabine Lake Hydrologic Restoration project, the Cameron Prairie Refuge structure's ability to protect interior wetlands has been called into question. Ocular review of aerial photography indicated that interior marsh degradation persists (Raynie and Visser 2002). However, debate continues on whether or not actual wetland loss has occurred since differences in water levels and photography dates confound the interpretation (Raynie and Visser 2002). If marsh loss is indeed confirmed within the Cameron Prairie Refuge Protection project area, it suggests that factors other than shoreline erosion and saltwater intrusion may be contributing to interior wetland loss.

The above breakwater projects were all successful in preventing shoreline erosion; sediment accretion behind the structures also commonly occurred through occasional wave overtopping. Results indicate that all have been successful in achieving their goals of slowing or preventing further shoreline erosion. However, after reviewing the performance of past shoreline protection projects Raynie and Visser (2002) made the following recommendations for future projects:

1. Pre-construction geotechnical investigations are essential to a project's success.
2. Post-construction inspections are extremely important.
3. It should not be assumed that shoreline protection structures will remedy the problem of interior wetland loss.

The last recommendation alludes to the fact that hydrologic restoration may be required in addition to shoreline protection in order to stabilize interior marshes. Further, rock dike features do not provide a hydrologic barrier; although the rock dike may damp wave energy, it may not prevent higher salinity water from reaching interior wetlands (Raynie and Visser 2002). It should be noted that the proposed foreshore rock dike is only intended to stop erosion of the Sabine Lake shoreline and not for hydrologic restoration.

Earthen Terraces

Bay-bottom terraces are relatively new marsh management techniques which use existing bottom sediments to form a system of ridges at marsh elevations that encourage sedimentation (LDNR 1993). The primary functions of bay-bottom terraces is to create marsh on the terraces themselves, aide in the accretion of marsh in areas near the terraces through sediment deposition, increase marsh edge habitat for the benefit of fish and invertebrate species, promote the growth of submerged aquatic vegetation and protect nearby marsh shorelines from erosion by reducing wave energy (LDNR 1993; Turner and Streever 2002). Relevant literature and monitoring data were used to evaluate the effectiveness of terraces in achieving their specified objectives.

- The Sabine Terraces project was implemented in 1990 with the goal of reducing fetch distance, increasing organic matter production by vegetation, promoting sedimentation in the terrace cells and acting as a wave dampening device for the surrounding marsh. One-hundred and twenty-six levees 1.5 feet high were constructed in an opened ended checkerboard pattern in two similar ponds. The vegetation used to stabilize the terraces (smooth cordgrass) exhibited a high average survival rate ten months after planting ranging from 82.9 % to 88.9 % for sprig and 88.9 % to 96.3 % for plug plantings (ponds one and two respectively) (LDNR 1993). Within two years of vegetation plantings all terraces exhibited 100 % vegetation cover and plants had laterally spread to adjacent areas (LDNR 1993). In year three, the average vegetated width of terraces increased by 126 % (LDNR 1993). Attempts to establish submerged vegetation were not as successful, with no observed survival of widgeongrass (*Ruppia maritima*), 23% survival of shoal grass (*Halodule beaudettei*), and 3 % survival of turtle-grass (*Thalassia testudinum*) one year following planting (LDNR 2002). It appears that terraces do reduce wave energy, increase edge habitat and promote the standing crops of smooth cordgrass, but it is unknown whether this is a result of sloughing off of terrace sediments or actual sediment deposition (Turner and Streever 2002).

- Rozas and Minello (2002) conducted a study to assess the biological significance of terraces by comparing nekton abundances in terraced areas, natural marsh and open-water habitat at the Sabine terracing project site. The results of this study showed that most species were more abundant in natural marsh areas [brown shrimp (*Farfantepenaeus aztecus*), blue crab (*Callinectes sapidus*), and grass shrimp (*Palaemontes spp*.)]. In contrast, white shrimp (*Litopeneeus setiferus*) appeared to be more abundant in terraced areas compared to natural marsh, but terraced areas supported higher standing crops of nekton species compared to open-water habitat.

- The Galveston Bay Estuary Program implemented the Modified Galveston Terracing project at Pierce Marsh in 1999. One-hundred and fifty-three terraces were constructed and planted with smooth cordgrass in subsiding areas of Galveston Bay, Texas. Terrace construction resulted in the creation of 62 acres of intertidal and subtidal habitat and nine linear miles of fringing marsh (Shead and Goldber 2001). One year after construction vegetation had become well established. Currently, outer terraces which are exposed to higher wave energy and wake from heavy boat traffic are starting to erode and more terraces are needed to further reduce wave fetch. Overall, the terraces have been used effectively to create marsh and slow erosion in subsiding areas of Galveston Bay. In the future projects it is advised that an irregular checkerboard pattern be used during construction to create a more natural looking marsh area.

Similar projects conducted by the Louisiana Department of Natural Resources and their associated Federal sponsors have included terraces in order to promote the accretion of marsh habitat, reduce wave energy, and increase the area of marsh to water interface. These projects include Four-Mile Canal Terracing and Sediment Trapping (TV-18), Grand-White Lake Land Bridge Protection (ME 19), Plowed Terraces Demonstration (CS-25), Little Vermilion Bay Sediment Trapping (TV- 12) and GIWW-Perry Ridge West Bank Stabilization (CS-30). These projects should achieve results similar to the previously mentioned studies.

VII. 95% Design Review Recommendations

Based on the investigation of similar restoration projects and a review of engineering principles, the proposed strategies of the East Sabine Lake Hydrologic Restoration project will likely achieve the desired ecological goals. At this time, the level of design of the project's physical effects and likelihood of goal attainability warrant continued progress toward Phase 2 approval. However, it is recommended that prior to the formal request to proceed to Phase 2 that the following outstanding issues be addressed adequately:

- Further refine the project goals by establishing clear success criteria for the reduction of excessive elevated salinities and water level variability within small portions of project area (Double Island Gully, Pines Ridge, and Greens Lake) over the 20 year project life.
- What will the monitoring protocol consist of for the three vegetation test plantings along the Sabine Lake shoreline? How long will the test plots be monitored prior to proceeding with the entire planting scheme?
- Water level data for Sabine Lake should be retrieved in order to determine the appropriate height of the foreshore rock dike. Wave height should also be considered so as to construct a barrier that is not overtopped more than is deemed desirable.
- Provide data, surveys or anecdotal evidence that supports the contention that substrates at the Sabine Lake shoreline, Pines Ridge, and Double Island Gully are adequate to sustain the proposed rock structures.
- Provide data, surveys or anecdotal evidence that adequately confirms the suitability of Greens Lake area soils for use in terrace building.

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