PORT OF HOUSTON AUTHORITY
BAYPORT SHIP CHANNEL IMPROVEMENTS
HARRIS AND CHAMBERS COUNTIES, TEXAS

Compensatory Mitigation Plan

for

Oyster Mitigation

for the Proposed Bayport Ship Channel Improvements

July 2013

1.0 OBJECTIVES

The primary objective of the mitigation project is to replace the oyster reef habitat that would be removed by construction of the Bayport Ship Channel (BSC) improvements through restoration of oyster habitat on Fisher's Reef in Trinity Bay, Chambers County, Texas. Specifically, the mitigation plan proposes to add approximately 3,710 cubic yards (cy) of cultch to 4.6 acres on Fisher's Reef to compensate for the direct impacts associated with the proposed deepening and widening of the BSC. The restoration would increase the existing oyster habitat in Trinity Bay by providing 4.6 acres of hard surface area available for natural recruitment of oyster larvae. Fisher's Reef was impacted by Hurricane Ike-induced sedimentation in 2008. The oyster reef restoration would replace oyster reef that contributes to important ecological benefits to Galveston Bay. Benefits include provision of aquatic habitat structure for several fish and invertebrate species, improvement of water quality and clarity as well as general re-establishment of essential fish and invertebrate habitat. The proposed site at Fisher's Reef is shown in Figure 1.

2.0 SITE SELECTION CRITERIA

The two Fisher's Reef areas selected were chosen for maximum water depth and minimum sediment overburden based on post-Hurricane Ike TPWD side-scan sonar data and sub-bottom profiling data collected by Texas A&M University at Galveston. One reef footprint is in a shellfish harvesting area, and the other reef footprint is in waters restricted from shellfish harvest, thus allowing for research on harvested versus non-harvested adjacent oyster reefs. The Fisher's Reef area was recommended by the Texas Parks and Wildlife Department (TPWD) as the preferred location for oyster reef restoration at the request of the Beneficial Uses Group (BUG). Following Hurricane Ike, the TPWD side-scan sonar surveys found that approximately 50 percent of the reefs in Galveston Bay were covered by hurricane-induced sedimentation eliminating or substantially reducing their function. This triggered an ongoing restoration effort by TPWD to reverse these losses. As the selected site is in Galveston Bay, the mitigation occurs in the same bay system that the impacts would occur in, and where restoration efforts have been planned and targeted by the resource agency with primary responsibility for oyster reef conservation. Direct on-site mitigation is not applicable in this situation as replacement reef cannot be appropriately located in the deepened navigation channel. The restoration relies on natural oyster larvae recruitment and growth, and would be self-sustaining. This method has been successfully used on past similar restoration projects in Galveston Bay and around the nation.

3.0 SITE PROTECTION INSTRUMENTS

The Fisher's Reef area is located within Galveston Bay, for which, in general, the submerged land is State-owned and managed by the Texas General Land Office (TxGLO). Natural resource use or impact is subject to regulation by various governmental agencies including but not limited to TPWD, USACE, National Marine Fisheries Service (NMFS), and the U.S. Environmental Protection Agency (USEPA).

Any activity impacting the resources regulated by those agencies within the proposed mitigation area would be regulated by these governmental agencies. This would include development or fill of the Waters of the U.S., and oyster reefs that would present or restored there.

4.0 BASELINE INFORMATION AND IMPACTS

Galveston Bay is characterized as a relatively large shallow bay with an extensive interconnected system of deeper navigational ship channels. With the exception of ship navigation channels and the Mid Bay constriction caused by Redfish Bar, both natural and anthropogenic oyster reefs constitute the largest physiographic feature in Galveston Bay. Remaining portions are comprised of sand, mud, silt and clay particles, and shell, with little bottom relief. Only very small portions of the Bay contain any sea grasses, limited to the West Bay and Smith's Point area of the Bay, which excludes the area impacted and the proposed mitigation site. The project area (BSC improvement area) and Fisher's Reef are typical Galveston Bay habitat.

4.1 Baseline Benthic Habitat Survey

The benthic habitat was characterized for the BSC improvement area in 2011 by side-scan sonar surveys groundtruthed by aquatic science divers. The results are detailed in the technical report *Bayport Ship Channel Improvements Galveston Bay, Texas Draft Benthic Habitat Characterization Report* dated December 2011, that was transmitted to the USACE Galveston District on April 25, 2012. Based on the survey results and observation data, the habitat was classified according to substrate density and live oyster cluster spacing. Figure 2 shows the results of the survey near the proposed channel improvements. Table 1 summarizes the habitat in the footprint of the proposed BSC improvements and within the 500-foot buffer of the area of new work dredging. The BSC improvement area consists mostly of soft bottom with few areas of hard bottom composed mostly of varying densities of dead oyster shell (hash) interspersed with varying sizes and densities of clusters of live oysters. As shown in the table, only a small percentage is consolidated reef. Fisher's Reef area is currently mostly soft muds caused by sedimentation from Hurricane Ike.

4.2 Direct Impacts

Oyster habitat within the project footprint is found in the area of new work dredging for the 100-foot (ft) widening portion of the proposed project. The BSC was previously deepened in 2003 to approximately -51 ft Mean Low Tide (MLT) from approximately Station 150+00 to 210+00, during mining of the channel bottom for levee-building materials. These station limits cover the length of the channel where oyster habitat is present along the south margin of the channel, and the south side slope already reflects a deepened profile. Because of this, no new work dredging will be required for this proposed project to deepen the BSC where oysters are present along the south of the channel, and no direct impacts would occur south of the channel. Therefore, direct impacts to oyster habitat would occur from the 100-ft widening, and mitigation is proposed for these direct impacts. The class and category descriptions of the oyster

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habitat to be mitigated for direct impacts, the acreages of each class, and their corresponding percentages, are shown in Table 1.

4.3 Indirect Impacts

Indirect impacts to oyster from turbidity from new work dredging required for construction of the proposed project are expected to be minimal.

Numerous studies indicate that dredge-induced turbidity plumes are, more often than not, localized, spreading less than a thousand meters from their sources and dissipating to ambient water quality within several hours after dredging is completed (Higgins et al., 2004). A literature review performed for the California Coastal Commission found that most studies indicated that in almost all cases, the vast majority of re-suspended sediments resettle close to the dredge within an hour (Anchor Environmental CA L.P., 2003). Observations from this report included that sediment concentrations are greater at the bottom of the water column, and rapidly decrease with distance from the dredge. When properly operated, suspended concentration levels away from the cutterhead dissipate exponentially towards the surface with little turbidity actually reaching surface waters, and in many cases, at concentrations no greater than those generated by commercial shipping operations or during severe storms (Higgins et al., 2004). One recent study measuring total suspended solids (TSS) concentrations during dredging of the Calcasieu Channel and Pass found no discernible differences in concentrations upstream, parallel to, and downstream of the dredge, indicating the dredging operation had no influence on TSS (USACE New Orleans District 2007). Results of earlier densitometry surveys from this study indicated silt suspension during maintenance dredging was confined to the deep parts of the channel.

The vast majority of suspended particles would settle close to the dredge, which greatly reduces the volume available for re-deposition at distances from the dredge. Therefore the amount of material that would be available for resettling on reef at distance would be expected to be small and only have minimal effects in terms of covering reef. Because new work dredging is not needed for deepening along the segment with oyster reef adjacent to the channel along the south, the 500-ft buffer for indirect impacts was defined for the area of new work for 100-ft widening. The 500-ft buffer around the 100-ft widening new work area is shown in Figure 2.

With the exception of a few smaller complexes, oyster habitat within the part of Upper Galveston Bay that the project is located in, is almost exclusively located directly adjacent to the navigations channels of the BSC and HSC. This is clearly observed in the 1991 historical mapping of reef by Texas A&M University at Galveston (TAMUG)[shown in Figure 3], and was corroborated in the oyster survey side scan sonar data that was later groundtruthed by diver for the Benthic Habitat Characterization Report for this project. The channel margins are covered with extensive reef, and the trend is observed along the HSC south of the project area. The HSC was widened and deepened under the HGNC project between 1998 and 2008, and extensive HSC adjacent reef was still observed in the sidescan sonar data for this project in 2011.

Considering the previous information discussed, and considering that these channels are periodically dredged for maintenance (which would involve higher percentages of unconsolidated fines), the new work dredging required for construction of the proposed project and subsequent maintenance dredging would not be expected to result in reef losses due to turbidity effects, only minimal impacts would occur, and pre- and post-construction monitoring for turbidity impacts is not proposed for the new work dredging. There are approximately a total of 35 acres of oysters within the 500-ft buffer, with 19 acres in the north part of the buffer and 15.8 acres in the south part of the buffer. Consolidated reef habitat includes less than 4 acres and is restricted to a relatively small area located in the northern section of the buffer zone.

Table 1: Oyster Hardbottom Habitat Impacts

Preferred Channel Alternative				
	Channel Direct Impacts		500 Foot Buffer Zone	
Habitat Classification	Acres	% total area	Acres	% total area
Class 1	0.28	6.1%	0	0%
Class 2	1.4	30.3%	16.12	47%
Class 3	2.75	59.5%	14.47	42%
Class 4	0.19	4.1%	3.93	11%
Total	**4.62**	100%	**34.52**	100%

Class descriptions:

- Class 4-Consolidated Reef - Habitat defined as consolidated reef and/or habitat with numerous, closely spaced, large oyster clusters <15 percent visible substrate between oyster clusters if not completely consolidated reef.
- Class 3-High Density Shell Hash with or without Oyster Clusters - Habitat defined as predominantly Category III and/or Category IV shell hash substrate with or without visible oyster clusters.
- Class 2-Low Density Shell Hash with Oyster Clusters - Habitat defined as predominantly Category I and/or Category II shell hash substrate with visible oyster clusters.
- Class 1-Low Density Shell Hash without Oyster Clusters - Habitat defined as predominantly Category I and/or Category II shell hash substrate without visible oyster clusters.

Substrate categories:

- Category IV – 75-100% of the seafloor covered in oyster shell hash
- Category III – 50-<75% of the seafloor covered in oyster shell hash
- Category II – 25-<50% of the seafloor covered in oyster shell hash
- Category I - >1-<25% of the seafloor covered in oyster shell hash

5.0 CREDIT DETERMINATION METHODOLOGY

In discussions with TPWD, a ratio of one acre of mitigation replacement cultch to one acre of existing hard bottom impacted was determined to be acceptable. The reasons this replacement ratio is acceptable are the substrate density being impacted is less than the 100% substrate coverage of the mitigation proposed, the rapid recruitment expected and previously observed on artificial cultch restoration projects locally and elsewhere, the small percentage of consolidated reef impacted, and the resultant expected consolidated reef growth for the mitigation. Reef growth in this part of the bay

is very limited by suitable substrate. The mitigation project will improve conditions by providing this clean substrate.

As summarized in the table above, approximately 96% of the impacted acreage consists of areas where 1-25%, 25-50% and 50-75% substrate coverage predominates. The mitigation would be a solid 100% coverage of artificial cultch, which would provide more attachment surface area per acre than the substrate impacted. Rapid recruitment of oyster spat on the artificial cultch is expected and was observed with the previous oyster mitigation in Galveston Bay that employed the same proposed method for the Houston and Galveston Navigation Channel (HGNC) Project. Substantial growth was observed within 3 months as documented in post-construction monitoring. The live oyster density observed during post-construction monitoring for the HGNC was commensurate with the consolidated reef live oyster cluster spacing observed during the groundtruthing-by-diver for this project. Consolidated growth would be expected on the mitigation cultch. The mitigation ratio is a one to one ratio of hard bottom area to hard bottom area and not a direct one to one replacement ratio of living oysters. However, as discussed, the cultch material will be readily colonized by oyster larvae, and the resultant live oyster density would be expected to be greater than that impacted.

6.0 MITIGATION WORK PLAN

The following are elements of the mitigation work plan:

- Geographic boundaries of the project – The project site and approximate boundaries are shown in Figure 1. The mitigation for the proposed project is shown as conceptual, since the 4.6 acres of mitigation will specifically be located within the 30-acre TPWD restoration site considering review of detailed local site condition information and consultation with TPWD staff during construction design.
- Construction methods, substrate elevation, and slopes – The mitigation work plan proposes to add approximately 3,710 cy of cultch to 4.6 acres, to result in an approximate 6-inch thick layer of cultch above the bay bottom. This profile was recommended by the TPWD. The cultch would be clean limestone, crushed concrete rubble, or other suitable substrate as deemed acceptable by the TPWD. Limestone is anticipated to be used. The cultch would most likely be barged to Fisher's Reef and then placed evenly on the bay bottom at Fisher's Reef over the indicated acreage. Proper sloping for stability will be determined for the specific cultch material used, but is nominally identified as a 2 horizontal: 1 vertical side slope ratio.
- Timing and sequence – The mitigation would be constructed concurrent with the construction of the proposed channel improvements. Therefore, mitigation would be built at the time impacts occur. With the area and volume of material

involved, it is anticipated the mitigation would be constructed in a single phase, under a single mobilization. Seasonally, the construction will be timed to be completed a short time before the spawning season to ensure recruitment of spat soon after the substrate is available. Spawning season is late spring to early fall in Galveston Bay.

- Foundation – Proper analysis will be performed and measures taken to determine and ensure vertical stability of cultch material in the soft bay bottom. This will be determined after the specific cultch material is determined and local site conditions analyzed. Historic knowledge of the site indicates that suitable foundation exists.
- Other elements considered – Other mitigation work plan elements listed in 40 CFR 230.94(c)(7), such as source of water or methods to establish the desired plan community, are not applicable.

7.0 MAINTENANCE PLAN

Once the cultch has been placed on the bottom of the Fisher's Reef area of Galveston Bay, no further maintenance of the project area would be required. The cultch should stay exposed for colonization by oyster larvae and other aquatic organisms. The substrate will develop on its own into mature reef with market-size oysters expected in two to three years similar to that experienced with the HGNC oyster restoration. However, other unusual events, such as another major hurricane like Hurricane Ike could cover the area, as well as natural reefs. No specific long term maintenance for these unusual events is planned.

8.0 ECOLOGICAL PERFORMANCE STANDARDS

The object of this restoration is to replace oyster habitat by a one to one ratio. Success would be defined as an increase in reef acreage of at least 4.6 acres. Pre-restoration and post-restoration side scan-sonar data would be collected and processed into ArcGIS data layers. Restored reef acreage would be quantified by subtracting pre-restoration reef acreage from post-restoration reef acreage to determine the amount of habitat restored. The functional endpoint would be oyster density (oysters per square meter [oysters/m^2]). Oyster density would be measured using the diver quadrat method twice a year (pre- and post-oyster harvest season) for three years. Self-contained Underwater Breathing Apparatus (SCUBA) divers would sample random points along a transect line by placing a 0.5 square meter quadrat on the bay bottom and placing all shells and live oysters from within the quadrat into a mesh bag. All live oysters within the quadrat would be enumerated and measured for shell length. Success would be defined as a post-restoration oyster density equal to or greater than densities observed during a pre-construction survey of a nearby control site chosen by TPWD.

9.0 MONITORING REQUIREMENTS

Monitoring of the restoration sites would be conducted pre- and post-restoration to assess the success of the project. Criteria for restoration success would include one structural and one functional endpoint. The structural endpoint would be the number of reef acres restored. Oyster density, the functional endpoint, would be measured using the diver quadrat method twice a year (pre- and post-oyster harvest season) for three years. SCUBA divers would sample random points along a transect line by placing a 0.5 square meter quadrat on the bay bottom and placing all shells and live oysters from within the quadrat into a mesh bag. All live oysters within the quadrat would be enumerated and measured for shell length. When the success criteria are met, the monitoring would cease and the mitigation project would be determined to be successful.

10.0 LONG-TERM MANAGEMENT PLAN

After the mitigation project is determined to be successful, management of the Fisher's reef area would be returned to the owners of the site and regulators of the bottom of Galveston Bay, which are the various governmental agencies including but not limited to TPWD, TxGLO, USACE, NMFS, and USEPA.

11.0 ADAPTIVE MANAGEMENT PLAN

Any time during the monitoring period, if the success of the mitigation plan appears not to be meeting the success criteria; the permittee would notify the TPWD and USACE District Engineer as soon as possible, so that the mitigation can be evaluated and measures pursued to address deficiencies of the mitigation. Discussions on meeting the success criteria would be included in each monitoring report.

12.0 FINANCIAL ASSURANCES

The Port of Houston Authority (the Applicant) is an autonomous governmental entity created in 1927 by a special act of the Texas Legislature (article III, section 52 of the Texas Constitution, Act of 1927, 40th Legislature, R.S., Chapter 97, § 1, 1927 Texas General Laws 256, 256-57), with a mission to provide, operate, and maintain waterways and cargo/passenger facilities. Its mission is also to promote trade and generate favorable economic effects upon, and contribute to, the economic development of the Port of Houston Authority, the City of Houston, and the communities of Harris County and the Texas Coastal Region. This mission is to be accomplished in a manner that provides sufficient funds to cover the mitigation operational expenses and capital investments. A preliminary cost estimate for the mitigation is approximately $1.09 million, which is approximately 1.3 percent of the $79.4 million cost to construct the proposed channel improvements. It is anticipated the mitigation funding source will be the same as that for the proposed project construction. The Applicant has a long track record of successfully participating in and funding mitigation and restoration (e.g. beneficial use) as part of its sponsored projects, including the HGNC Project.

13.0 REPORTING

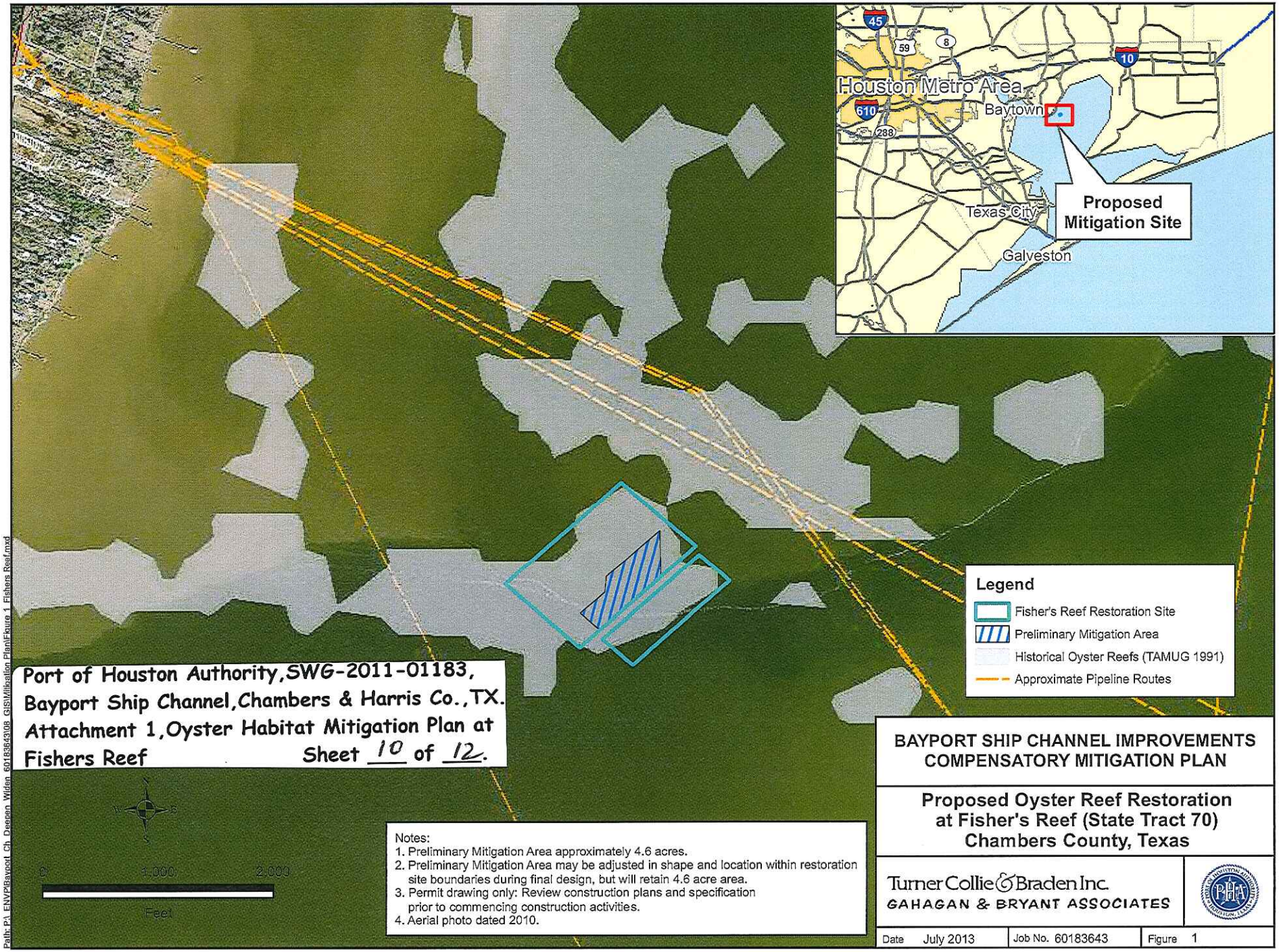
The first report to TPWD and USACE would include the findings of the restored reef acreage as determined by side-scan sonar, and would be submitted no later than 90 days after placement of the reef substrate. The results of all monitoring activities would be summarized annually. The subsequent three annual reports over the 3-year monitoring period would include the oyster density findings of the SCUBA divers, including when the post-restoration oyster density success criteria was met.

14.0 REFERENCES

Anchor Environmental CA L.P. 2003. Literature Review of Effects of Resuspended Sediments Due to Dredging Operations. Technical report prepared for Los Angeles Contaminated Sediments Task Force Los Angeles, California. Anchor Environmental CA L.P., Irvine, California.

Higgins, C.T., C.I. Downey, and J.P. Clinkenbeard. 2004. Literature Search and Review of Selected Topics Related to Coastal Processes, Features, and Issues In California. Technical report prepared for the California Coastal Sediment Management Workgroup [CSMW]. California Geological Survey, California Department of Conservation.

U. S. Army Corps of Engineers, New Orleans District. 2007. Calcasieu Lake Suspended Solids Sampling and Analyses.



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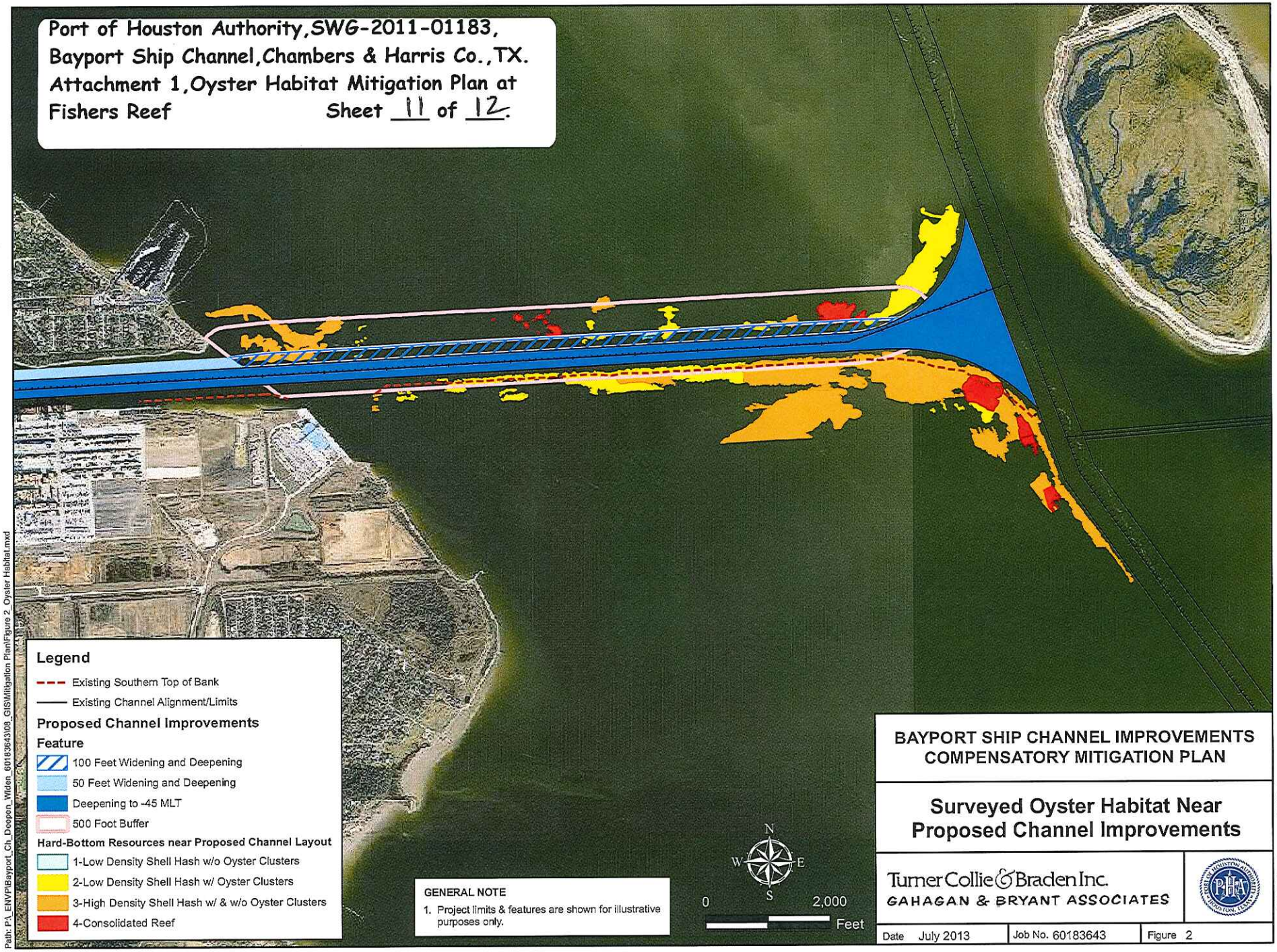

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BAYPORT SHIP CHANNEL IMPROVEMENTS
COMPENSATORY MITIGATION PLAN

Surveyed Oyster Habitat Near Proposed Channel Improvements

Turner Collie & Braden Inc.
GAHAGAN & BRYANT ASSOCIATES

Date	Job No.	Figure
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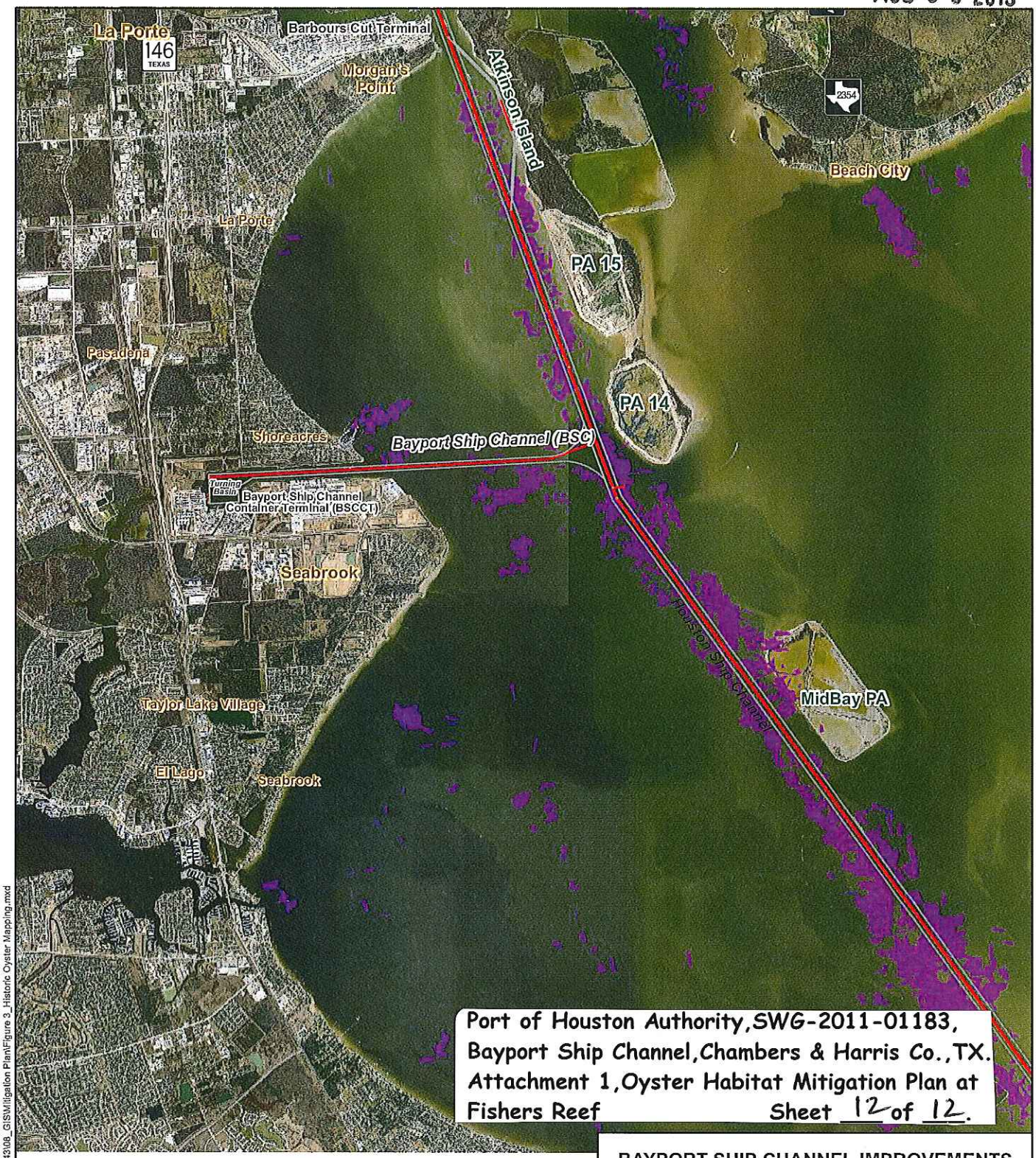

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Legend

- Existing Channel Limits
- Channel Centerline
- Oyster Reefs (TAMUG 1991)

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Feet

BAYPORT SHIP CHANNEL IMPROVEMENTS COMPENSATORY MITIGATION PLAN

Historic Oyster reef in Upper Galveston Bay

Turner Collie & Braden Inc.
GAHAGAN & BRYANT ASSOCIATES

Date	Job No.	Figure
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