The Galveston Bay Plan, 2nd Edition

The Comprehensive Conservation and Management Plan for the Galveston Bay Ecosystem

FINAL TCEQ APPROVED DRAFT

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A Plan for Galveston Bay

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This document represents the second edition of the Comprehensive Conservation and Management Plan (CCMP) for the Galveston Bay estuary, *The Galveston Bay Plan, 2nd Edition (GBP'18)*. Approved in 1995 by the Governor of Texas and U.S. Environmental Protection Agency (EPA), the original CCMP identified 17 Priority Issues affecting the ecological resources of the estuary and watershed, as well as the value each provides. It included 82 Actions to address those priorities.

GBP'18 is a revision of *The Galveston Bay Plan* (*GBP'95*) and addresses many of the same Priority Issues and Actions while also identifying new approaches to conservation and management. The Galveston Bay Estuary Program (GBEP) acknowledges the hard work and invaluable contributions of the many people and organizations that helped with this revision (Acknowledgements are provided on page 7).

Foreword from the Galveston Bay Estuary Program

The strength of the GBEP and in turn, the Galveston Bay Council and its subcommittees, comes from the collaborative partnerships that are a cornerstone of each initiative that helps to implement the Comprehensive Conservation and Management Plan (CCMP).

A plan is only as useful as the actions that are undertaken by partners to implement it. Since 1995, the partnership that makes up the Galveston Bay Council and its subcommittees has taken the mission of the GBEP to heart and has implemented *The Galveston Bay Plan (GBP'95)* to preserve Galveston Bay. Their unified purpose, to provide comprehensive ecosystem management through collaborative partnerships and to ensure preservation of the bay's natural resources, can be seen in the hundreds of projects and initiatives across the lower Galveston Bay watershed. These efforts taken together have resulted in over 29,000 acres of protected, restored, or enhanced habitat.

The Galveston Bay Plan, 2nd Edition (*GBP'18*) builds upon 30 years of factual and scientific information. It identifies specific Actions, Goals, and Objectives to address Priority Issues. The strategies and tools identified in this plan, in concert with the collaboration, coordination, and monitoring that occur through the Galveston Bay Council and its subcommittees, will ensure that we continue to Back the Bay for future generations to come.

Yellow-crowned night-heron.

TCEQ

GALVESTON BAY ESTUARY PROGRAM
A PROGRAM OF THE TCEQ

EPA United States Environmental Protection Agency

A LETTER FROM THE GALVESTON BAY COUNCIL

With Galveston Bay's inclusion in the National Estuary Program in 1989, Congress funded a stakeholder-based program to develop and implement a comprehensive conservation and management plan for the Galveston Bay ecosystem. *The Galveston Bay Plan (GBP'95)*, which was designed to be implemented over a 20-year period, was approved by the Governor of Texas and the EPA in 1995. *GBP'95* set forth goals and objectives for the restoration and preservation of the bay and defined the actions necessary to accomplish these goals. Through the collaborative partnerships and hard work of many stakeholders, including local governments, federal and state agencies, nonprofit organizations, academic institutions, and industries, much progress has been made in reaching these objectives and in protecting the bay's well-being.

In 2005, at the midpoint of the management plan's 20-year timeline, the Galveston Bay Council decided that an analysis of the priorities over the next 10 years should be undertaken. Man-made changes had affected the bay's ecosystem and changed some of the priorities of *GBP'95*. It was necessary at that time to identify the most urgent actions for implementing the management plan and for building the necessary partnerships to sustain the bay's future. The result of this analysis was the publication of the document, *Charting the Course to 2015: Galveston Bay Strategic Action Plan* (2009). This document was not meant to update or replace *GBP'95* but rather to help focus and guide its implementation.

When the 20-year timeline for *GBP'95* expired, it was time to undertake an in-depth analysis of the CCMP's original objectives, going beyond the most urgent actions defined in *Charting the Course to 2015*. Some objectives and ambitions of *GBP'95* were no longer viable and others had been attained. New Goals and Actions needed to be identified. A series of unforeseen events such as hurricanes and oil spills created new priorities. A complete revision of *GBP'95* to outline new Objectives was appropriate. As a result, *GBP'95,* with significant input from stakeholders and the public, has been revised to define the most important and pressing Goals that must be achieved over the next 10 to 20 years to preserve, restore, and protect the bay. An illustration of the way *GBP'95* is integrated into *GBP'18* appears in Appendix E: Technical Crosswalk.

The Council looks forward to implementation of *GBP'18*. We know that by working together with our stakeholders, we will ensure the bay's ecology and the economic benefits it provides for generations to come.

Sincerely,

The Galveston Bay Council Chairs and Subcommittee Chairs

LIST OF ACRONYMS & ABBREVIATIONS

ACS	Increase Access to Galveston Bay Ecosystem Information
B&P	Budget and Priorities Subcommittee
BBASC	Basin and Bay Area Stakeholder Committee
BBEST	Basin and Bay Expert Science Teams
BIG	Bacteria Implementation Group
BMP	Best Management Practices
CAP	Conservation Assistance Program
CCMP	Comprehensive Conservation and Management Plan
CIAP	Coastal Impact Assistance Program
Council	Galveston Bay Council
CWA	Clean Water Act
E. coli	*Escherichia coli*
enterococci	Enterococcus
EPA	United States Environmental Protection Agency
FEP	Full Execution Plan
FOG	Fats, Oils, and Grease
FWI	Freshwater Inflows
GBAN	Galveston Bay Action Network
GBEP	Galveston Bay Estuary Program
GBF	Galveston Bay Foundation
GBFIG	Galveston Bay Freshwater Inflow Group
GBP'95	*The Galveston Bay Plan* (1995)
GBP'18	*The Galveston Bay Plan, 2nd Edition* (2018)
GEBF	Gulf Environmental Benefit Fund
GIWW	Gulf Intracoastal Waterway
GLO	Texas General Land Office
GOMA	Gulf of Mexico Alliance
HARC	Houston Advanced Research Center
HC	Habitat Conservation
I-Plan	Implementation Plan
ISWG	Invasive Species Work Group
K-12	Kindergarten – 12th Grade
M&R	Monitoring and Research Subcommittee
mL	Milliliter
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
NEP	National Estuary Programs
NFWF	National Fish and Wildlife Foundation
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source
NRU	Natural Resource Uses Subcommittee

PCB	Polychlorinated Biphenyl
PEA	Public Education and Awareness
PEP	Public Engagement Plan
PHA	Public Health and Awareness
PPE	Public Participation and Education Subcommittee
PPT	Parts Per Thousand
PS	Point Source
PSU	Practical Salinity Units
QA/QC	Quality Assurance / Quality Control
QAPP	Quality Assurance Project Plans
RES	Applied Research and Monitoring
RESTORE	Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act
RMP	Regional Monitoring Plan
SAP	*Charting the Course to 2015: Galveston Bay Strategic Action Plan*
SAV	Submerged Aquatic Vegetation
SC	Species Conservation
SPO	Stakeholder and Partner Outreach
TAMUG	Texas A&M University-Galveston
TBD	To Be Determined
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
TMDL	Total Maximum Daily Load
TNRCC	Texas Natural Resource Conservation Commission
TPWD	Texas Parks and Wildlife Department
Trash Bash	River, Lakes, Bays 'N Bayous Trash Bash®
U.S.	United States
WBP	Watershed-Based Plans
WPP	Watershed Protection Plans
WRIM	Water Resources Information Map
WSQ	Water and Sediment Quality Subcommittee
WWTF	Wastewater Treatment Facilities

Acknowledgements

This document is a collaborative effort among many groups, committees, stakeholders, and individuals. Cooperation between groups and individuals has been paramount to the success of *The Galveston Bay Plan, 2nd Edition* (*GBP'18*) development process. Every person and group has played an important role in the process.

The GBEP is grateful to members of the Technical Advisory Committee, the Council and its subcommittees, and those who committed great amounts of time and energy into development of *GBP'18.* The members of the Water and Sediment Quality (WSQ) subcommittee, Natural Resources Uses (NRU) subcommittee, Public Participation and Education (PPE) subcommittee, Monitoring and Research (M&R) subcommittee, and Budget and Priorities (B&P) subcommittee supported and directed the process; without them, development of this plan would not have been possible.

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>
> *-Open House Attendee, October 2017*

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Introduction

Estuaries are "nature's nurseries." Without a well-functioning estuary, water quality would be affected, flooding and erosion would persist, there would be little local seafood in restaurants, and recreational and commercial fishing would dramatically decline.

Snowy plover (photo credit: Justin Bower).

The Galveston Bay estuary is a dynamic and important coastal resource, critical to the environmental and economic well-being of the nation. It is the most significant natural resource in the Houston-Galveston area, and its ecological services and quality-of-life are intricately entwined in the social and economic fabric of the region. However, the Galveston Bay estuary, like many other estuaries in the country, faces significant natural and man-made challenges related to habitat loss, water quality, and species decline.

The 1995 Comprehensive Conservation and Management Plan (CCMP), also known as *The Galveston Bay Plan* (*GBP'95*), led the GBEP and its partners for over two decades of significant conservation, restoration, and education work to protect the Galveston Bay estuary. One previous update, *Charting the Course to 2015: Galveston Bay Strategic Action Plan (SAP)*, occurred 10 years into implementation of *GBP'95.* The *SAP* narrowed the focus of the GBEP through 2015.

Because many Actions identified in *GBP'95* were successfully implemented and new issues emerged, a revision is needed. *The Galveston Bay Plan, 2nd Edition* (*GBP'18*) is a revision of *GBP'95*, preserving its strengths and building on its partnerships and successes. Efforts include identifying new issues facing the estuary and watershed that are not adequately addressed by *GBP'95* or the *SAP*. It also updates Actions that are out-of-date or do not reflect the best solutions that are now available. More than 150 members of the Galveston Bay community, representing local governments, industry, academia, nonprofit organizations, resource agencies and the public, donated their time and talents to develop *GBP'18.* For more information on how *GBP'95* is integrated into *GBP'18*, see Appendix E: Technical Crosswalk.

ABOUT THE GALVESTON BAY ESTUARY

Galveston Bay is the largest of 12 estuaries in Texas and is the seventh largest in the nation. In 2004, Galveston Bay was the most biologically productive estuary in Texas, producing nearly one-third of the commercial fishing income for the state (Environmental Protection Agency [EPA], 2004, p. 250). Its ports, transportation and petrochemical industries, and proximity to rich petroleum reserves in the Gulf of Mexico, Caribbean Sea, and South America form the core of its economy, with tens of thousands of people employed in key water-based industries.

Galveston Bay attracts people to the region. Therefore, the region's prosperity is tied to the viability of the bay. Galveston Bay does more than support the human and environmental infrastructure that drives the economy; it also enhances the quality of life of those living around it. Galveston Bay is a fishing and birding destination. The bay and watershed offer recreational opportunities, such as swimming, canoeing, birding, or observing the dolphins from the Galveston-Port Bolivar ferry.

The western side of the Galveston Bay estuary is adjacent to one of the most heavily urban, industrialized areas in the nation, while the eastern side remains largely rural. Approximately 5.4 million people live in the five counties surrounding Galveston Bay (U.S. Census Bureau: Population Division, 2016).

FIGURE 1
GALVESTON BAY WATERSHED

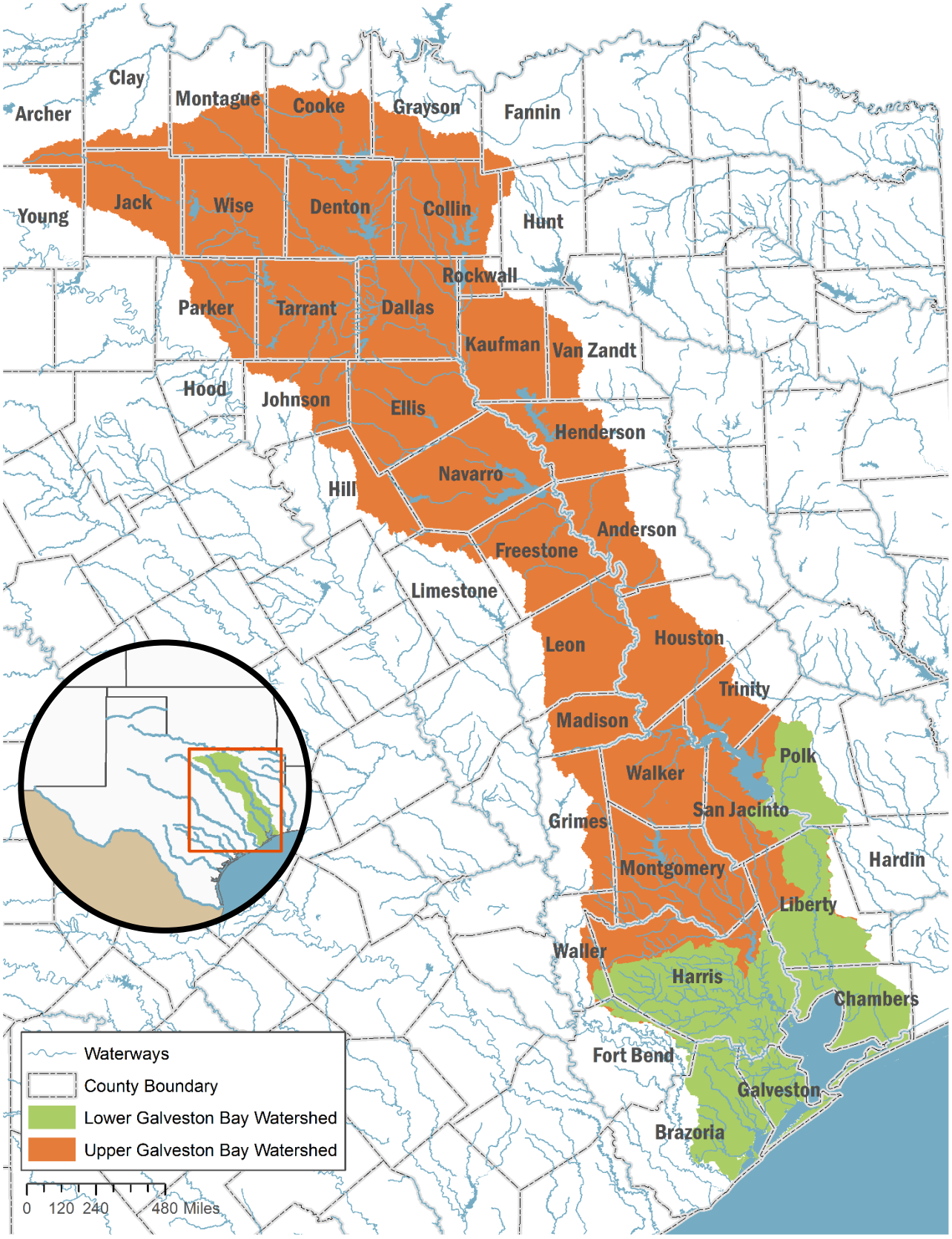
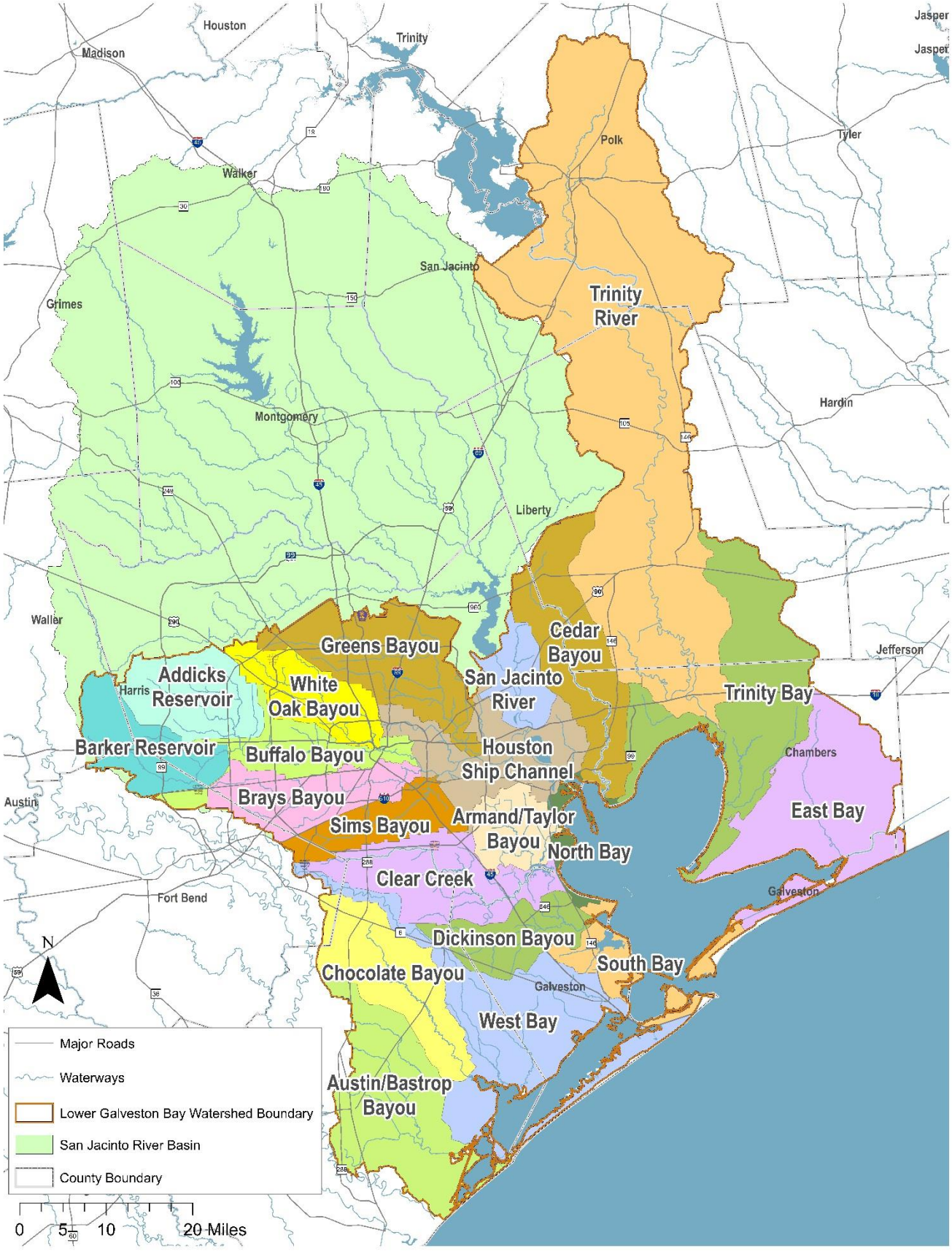


FIGURE 2
LOWER PORTION OF THE WATERSHED



THE GALVESTON BAY WATERSHED

The watershed that flows into Galveston Bay covers approximately 24,000 square miles, accounting for nine percent of the State of Texas' total square mileage.

The watershed reaches as far north as the Dallas-Fort Worth area, draining to the Trinity River, which ultimately flows into Galveston Bay. It encompasses parts of 44 Texas counties and is divided into two portions: the upper watershed and the lower watershed (see Figure 1 on page 13).

The upper watershed covers approximately 20,000 square miles upstream of the Lake Livingston Dam on the Trinity River and the Lake Houston Dam on the San Jacinto River. The upper watershed contributes freshwater to Galveston Bay and influences the estuary through 3,642 miles of rivers, streams, and bayous, although less directly than the lower watershed (Texas Commission on Environmental Quality [TCEQ], 2014, TCEQ_AU_Line_14).The lower watershed downstream of Lake Livingston and Lake Houston covers approximately 4,000 square miles in Brazoria, Chambers, Fort Bend, Galveston, Hardin, Harris, Jefferson, Liberty, Polk, San Jacinto, and Waller counties. The lower watershed influences the estuary through 1,295 miles of rivers, streams, and bayous (TCEQ, 2014, TCEQ_AU_Line_14).

During development of *GBP'18*, some stakeholders expressed interest in working within both portions of the watershed. Interest in expanding the focus of the GBEP was also explored during development of *GBP'95*. However, it was determined that pollutant loads of the Trinity River were largely attenuated by Lake Livingston, prior to discharge into Galveston Bay (Galveston Bay National Estuary Program [GBNEP], 1992, p. 78). Due to the more direct influence the lower watershed has on the estuary – particularly Brazoria, Chambers, Galveston, Harris, and Liberty counties – coupled with limited resources, the lower portion of the Galveston Bay watershed remains the primary focus of the GBEP and *GBP'18.*

Although the lower watershed is the primary focus of *GBP'18*, the GBEP will continue to work with stakeholders in the upper watershed to enhance information exchange and explore future coordination, education, and awareness activities.

Mass of assorted shorebirds at Bolivar Flats (photo credit: Jason Leifester).

HISTORY OF THE GALVESTON BAY PLAN

Officially established in 1989, the GBEP is one of two National Estuary Programs (NEP) in Texas and one of 28 in the United States (U.S.). As a non-regulatory program administered by the Texas Commission on Environmental Quality (TCEQ), the GBEP is tasked with coordinating and tracking the implementation of the CCMP.

Between 1950 and 1987, the Galveston Bay estuary and its watershed experienced a loss of over 35,000 acres of wetlands and 1,800 acres of submerged aquatic vegetation (SAV) (White, Tremblay, Wermund, & Handley, 1993, pp. 8, 85.). To address issues of water quality, wetland loss, and concern regarding proposals to increase the depth of the Houston Ship Channel, Galveston Bay was recognized as an estuary of national significance in 1987 (McFarlane et al., 1989) and local stakeholders created the regional program (known as Galveston Bay National Estuary Program until 1999) to help balance human use and enjoyment with the need to preserve the Galveston Bay estuary.

What is the National Estuary Program?

The NEP, administered by EPA, was established under the authority of Section 320 of the 1987 amendments to the Federal Water Pollution Control Act (now known as the Clean Water Act [CWA]) with the intent to protect and restore nationally significant estuaries.

In 1999, the Texas Legislature passed the Texas Estuaries Act (House Bill 2561; Senate Bill 708). The purpose of the Act was to recognize estuaries of national significance on the Texas coast and to authorize the use of state funds to implement CCMPs. It also required seven state agencies to participate and aid estuary programs in implementing approved CCMPs. Through this legislation, the TCEQ, formerly the Texas Natural Resource Conservation Commission (TNRCC), was designated as the lead administrator of the GBEP.

Both reports are available on the GBEP's website: **www.gbep.texas.gov**.

PREVIOUS PLANS

1995 THE GALVESTON BAY PLAN

In April 1995, the GBEP published *GBP'95*. It was drafted over five years by the GBEP and a partnership of state and federal agencies, local governments, industry, nonprofit organizations, stakeholders, interest groups, and the public.

Through *GBP'95's* development, the partnership identified 17 Priority Issues, conducted scientific studies, and established 82 Actions. Public feedback from more than 3,000 residents was considered before approval by the Governor of Texas and the Administrator of the EPA.

2009 STRATEGIC ACTION PLAN

In 2009, the Council and the GBEP published the *SAP*, an evaluation of *GBP'95*, which consolidated the 17 Priority Issues and new or emerging issues into three priority Focus Areas in a shorter, easier-to-read format.

Marina in Clear Lake (photo credit: Cassidy Kempf).

REGIONAL ECONOMIC DRIVERS

Beginning in the late 1800s, the Houston-Galveston region grew from a few small coastal cities to the home of the fourth-largest city in the U.S. with a vibrant regional economy. Just miles from the bay is the Texas Medical Center, the largest medical center in the world, which contributes $10 billion to the local economy annually (City of Houston, 2018). Also located in the region is the National Aeronautical and Space Administration's Lyndon B. Johnson Space Center, where the nation's space missions are controlled, and more than 60 colleges, universities, institutes, and technical schools.

The Houston-Galveston region is home to 570 chemical plants, accounting for 40 percent of the nation's annual base petrochemicals manufacturing capacity, employing 38,200 individuals (Ellis et al., 2017, p. 18). Houston is the leading domestic and international center for virtually every segment of the energy industry—exploration, production, transmission, marketing, finance, service, trading, supply, offshore drilling, and technology. The 10 oil refineries in the region process approximately 40 percent of the state's total crude oil production and 12.1 percent of the total capacity in the U.S. (Ellis et al., 2017, p. 21).

Enhancing and preserving bay and estuary health while supporting a vibrant economy is a delicate balance.

COMMERCIAL FISHING AND SHELLFISH HARVESTING

According to the Texas Parks and Wildlife Department (TPWD), Galveston Bay provided approximately 25 percent of statewide commercial bay landings (catch that is brought ashore) by value and weight (compared to other Texas bays in 2016) (Jensen, Texas Parks and Wildlife Department, personal communication, February 16, 2018). The largest commercial fisheries in Galveston Bay harvest blue crabs, oysters, and shrimp. For Galveston Bay, blue crabs were the top species landed by weight in 2016, comprising 37 percent of the catch, followed by shrimp (32 percent) and oysters (24 percent). Oysters were the most valuable fishery at $4.1 million, followed by shrimp ($2.1 million) and blue crabs ($1.4 million).

In 2016, the bay produced just over 700,000 pounds of oysters, with a dockside wholesale value of $4.1 million. Oyster harvest has decreased by approximately 88 percent since the mid-2000s, due in large part to sediment deposited on oyster reefs after Hurricane Ike in 2008, drought, flood, disease, increased predation, high fishing pressure, and fishing area closures. Prior to that, Galveston Bay was the largest oyster producer in Texas. Efforts are underway to restore this cultural and economic resource. Flooding due to Hurricane Harvey in 2017 caused extremely low salinities for an extended period, resulting in high oyster mortalities in East Bay and the western part of lower Galveston Bay where Dickinson Bayou drains, according to TPWD's fishery data. This resulted in a limited number of areas available for oyster harvest in 2018. In addition, many leaseholders were also affected and expect decreased production.

Commercial fishing vessel in Galveston Bay (photo credit: Justin Bower).

TOURISM

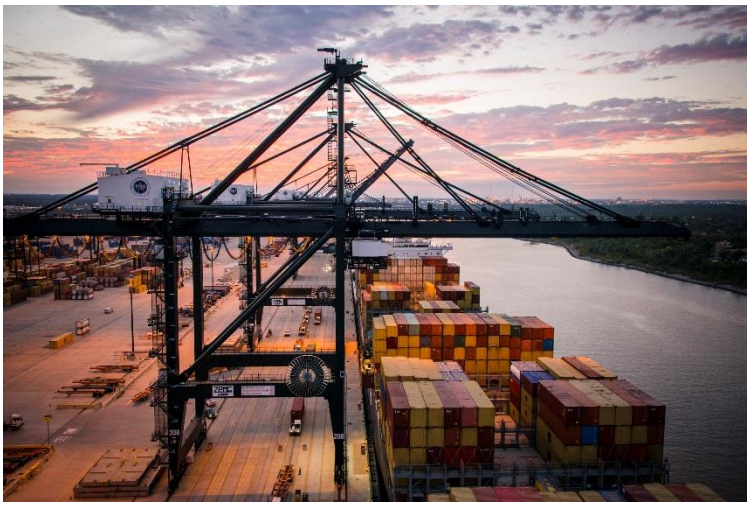
Tourism in and around Galveston Bay generates an estimated $7.5 billion in travel and payroll dollars annually (EPA, 2004). In 2015, tourism on Galveston Island generated $153 million in tax revenues, with $73.8 million accruing to state and local governments (Galveston Island). Ecotourism, or tourism that is based on nature rather than man-made attractions, is the tourism industry's most rapidly expanding sector. Recreational activities include duck hunting, saltwater fishing, swimming, nature viewing, pleasure boating, camping, picnicking, and sightseeing.

Birding has become a very popular outdoor activity along the Texas Coast. Chambers County, for example, is visited by tourists primarily for natural attractions such as bird watching at High Island or wildlife viewing at the Anahuac National Wildlife Refuge. The region is part of the Upper Texas Coast - Great Texas Coastal Birding Trail, a network of interconnected trails from Beaumont to the Brazosport area. Visitors can view egrets, herons, roseate spoonbills, and many other birds, as well as heron rookeries and old-growth forests.

SHIPPING, INDUSTRY & PETROLEUM

There are three deep-draft ports in the lower Galveston Bay watershed: The Port Houston, Port of Galveston, and Port of Texas City. All three ports influence the economic viability of the region and rely on their proximity to the Gulf of Mexico and / or Galveston Bay.

The Port Houston and Port of Galveston are ports of entry, respectively contributing $73 billion and $2.9 billion to the gross state product and employing a combined 529,400 people (Texas Comptroller of Public Accounts, 2017a, 2017b).



Container terminal at the Port Houston (photo credit: Port Houston).

In 2015, Port Houston modified the channels at both its Bayport and Barbour's Cut container terminals to accommodate larger ships coming from the expanded Panama Canal. The Army Corps of Engineers announced plans in 2017 to expand the Houston Ship Channel to accommodate larger ships in anticipation of increased freight traffic.

Since release of *GBP'95*, the Port of Galveston has expanded to become a cruise port for year-round cruises. According to the Port of Galveston, approximately 1.8 million passengers sail from its two cruise terminals, with an economic impact of $2.3 billion (Port of Galveston).

The Gulf Intracoastal Waterway (GIWW), which runs through East and West Galveston Bay, is a 1,100 mile-long, protected, navigable, inland waterway canal that connects ports all along the Gulf of Mexico from St. Marks, Florida, to Brownsville, Texas. It is the nation's third-busiest inland waterway, and serves as a major shipping and boating conduit on the upper Texas coast.

The Texas portion of the GIWW consists of 406 miles of waterway, with the main channel being 379 miles long, spanning from the Sabine River to Brownsville. The Texas portion of the GIWW handles 63 percent of its total traffic. In 2014, over 86 million short tons of cargo were moved. Most of this cargo was classified as petroleum- and chemical-related products (Texas Department of Transportation, 2016, p. 2).

According to the Texas City Terminal Railway Company (2018), the privately owned Port of Texas City is the 15th-largest port in the U.S. and the 4th-largest in Texas, with waterborne tonnage exceeding 50 million net tons.

In addition to the direct economic benefits provided by Galveston Bay, the estuary also supports coastal resilience. Wetlands store water and reduce shoreline erosion. The channels and floodplains that drain the watershed also protect infrastructure and associated property. Open-space protection for flood-damage mitigation and other collateral benefits are recognized as ecological services. There are also mental and physical health benefits associated with proximity to the natural environment, such as those coming from bird watching, hiking, and other outdoor activities.

CHANGES THAT INFLUENCE GALVESTON BAY

Changes in land use and regional population, as well as natural and man-made disasters, have all played a part in the health of the bay system.

Regional Population Growth

In recent years, the state of Texas saw a significant increase in the number of people immigrating from out-of-state, with a smaller number of Texans emigrating to other states. Statewide, the Texas population grew by a net 1.1 million people between 2005 and 2013 (Office of the State Demographer, 2016, p. 3).

Since release of *GBP'95*, the five counties surrounding the lower portion of the Galveston Bay watershed added 1.8 million people, a 33 percent net increase (U.S. Census Bureau, Population Division, 2016), reinforcing Houston's position as the nation's fourth-largest city. As the population increases, so too does the demand for water for drinking, agriculture, landscaping, and industrial uses. That demand may limit the volume of freshwater reaching Galveston Bay, as well as alter the quality, timing and / or location in which the water arrives, thus impacting the productivity of the estuary (Texas Water Development Board, *Bays & Estuaries,* 2018). More information about freshwater inflows begins on page 91.

In addition, population growth requires supportive infrastructure such as wastewater systems. If a wastewater system is not well built and maintained, it can contribute to higher concentrations of fecal bacteria and reduced water quality. Runoff from residential and commercial housing and roadways contributes to nonpoint source pollution due to increased impervious surfaces. Runoff from lawns, construction sites, and streets can include bacteria, nutrients, sediments, petroleum products, and heavy metals, also contributing to reduced water quality. More information about nonpoint source pollution begins on page 45.

Changes in Land Use

Since 1995, the region has experienced a significant shift in land use due in part to population growth, which led to the loss of habitats. Loss of habitat affects surface water quality, reduces or threatens biodiversity, and disrupts the food chain.

In 2000, the five counties that surround Galveston Bay had 1.5 million housing units; by 2010, that total had reached 1.8 million, a 23 percent increase in the total housing units in the region (U.S. Census Bureau, Housing Division, 2016). The increase in development contributed to wetlands loss in Galveston Bay. Between 1996 and 2010, 365 acres of saltwater wetlands and 13,538 acres of freshwater wetlands were lost to development in the Galveston Bay system (Galveston Bay Foundation and Houston Advanced Research Center [GBF & HARC], 2016, p. 45). Changes to regional land use and their implications for Galveston Bay are explored further under Plan Priority Two: Protect and Sustain Living Resources.

Gordy marsh (photo credit: U.S. Fish and Wildlife Service).

Natural and Man-Made Disasters

Areas along the coast are inherently vulnerable to the forces of nature, particularly tropical storms, hurricanes, and stalled storm fronts, all of which are capable of reshaping the coastline. Unaltered estuaries and bay systems are resilient to natural disasters, while those same systems can become less resiliant following man-made alterations. These areas play a vital role in tempering the hazards and subsequent economic effects.

The warm water temperatures of the Gulf of Mexico provide favorable conditions that are conducive for tropical storms to persist or even strengthen into a hurricane. As is the entire Texas Coast, the lower Galveston Bay watershed is vulnerable to hurricanes and has experienced many named storms since the release of *GBP'95*. While the intensity of rainfall and overall impact have varied, each storm has brought the risk of flooding due to accumulation and / or storm surge; water quality pollution due to industrial and domestic infrastructure failures and contaminated runoff; and the potential to alter the salinity of the bay, necessary for the health of its aquatic life.

The region also experienced negative impacts to its living resources due to other disasters, including, but not limited to, chemical spills and other releases. These disasters have affected the bay and its river and bayou tributaries and, in turn, affected the economy and the quality of life of Galveston Bay region residents. These disasters have increased an awareness for resilience in the natural and built environments, particularly the need to consider coastal resilience in and around Galveston Bay. Resilience is the ability to prevent a short-term hazard event from turning into a long-term, community-wide disaster. Coastal resilience is defined as a community's ability to "bounce back" after hazardous events such as hurricanes, coastal storms, and flooding rather than simply reacting to impacts (National Oceanic and Atmospheric Administration, 2017).

Progress Through Partnerships

The GBEP works cooperatively with local governments, businesses, ports, commercial fisheries, recreational anglers, environmental and other nonprofit organizations, and state and federal natural resource agencies. The contributions of these partners shape the success of CCMP initiatives and a sustainable future for Galveston Bay**.**

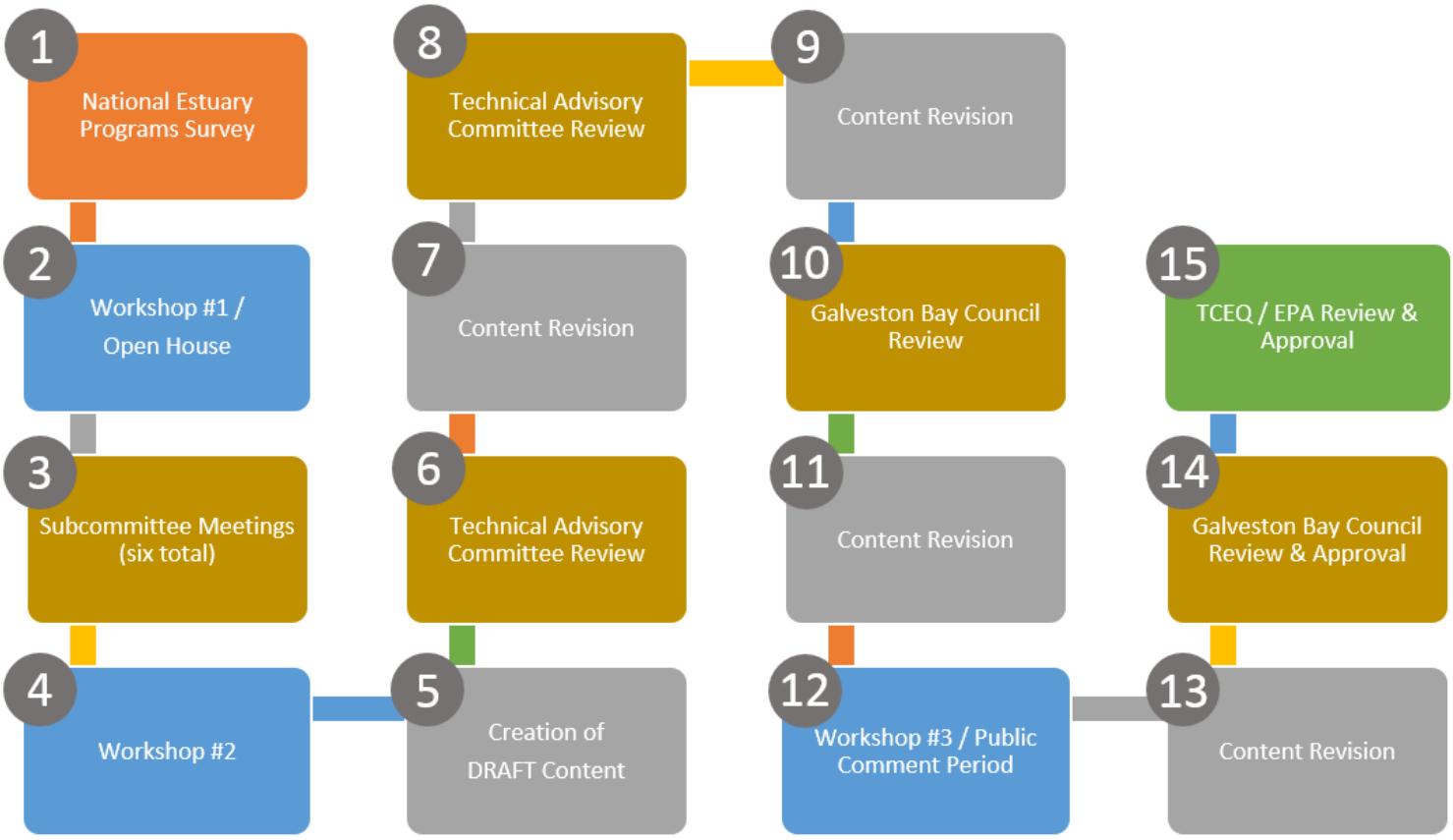
The GBEP, the Council and its subcommittees, and stakeholder groups, working to preserve Galveston Bay, have accomplished a great deal since the creation of *GBP'95*. The GBEP partners made notable achievements in improving water quality, restoring wetlands, protecting habitats, and educating the public. Since its inception, the GBEP has directly funded more than 200 implementation projects and dedicated $5 million to on-the-ground resource conservation and education projects. Additional efforts to improve Galveston Bay and its estuary were undertaken by area governments, agencies, and nonprofit organizations. Examples of these achievements can be found throughout this document.

The GBEP worked with an artist to create chalk art drawings depicting the connection between stormwater and bay health on storm drains, which were recorded as stop-art videos and distributed as public service announcements throughout the lower portion of the Galveston Bay watershed.

DEVELOPMENT OF THE GALVESTON BAY PLAN, 2ND EDITION

The GBEP consulted with directors and CCMP revision coordinators from other NEPs and listened to feedback from local stakeholders to develop an approach and craft *GBP'18*. Suggested techniques included coordination with the Council and its subcommittees with a focus on small-group meetings and using a Technical Advisory Committee to guide stakeholder engagement activities and the development of *GBP'18* content. The GBEP also incorporated feedback from multiple sources to create a comprehensive Public Engagement Plan (see Appendix B: List of Public Engagement Materials) and scheduled stakeholder and public engagement activities.

FIGURE 3
THE GALVESTON BAY PLAN, 2ND EDITION REVISION PROCESS

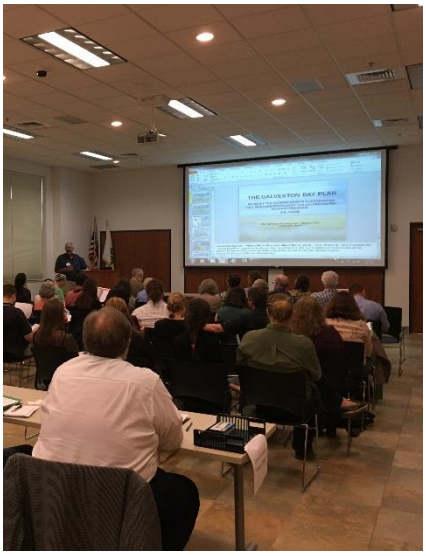


In October 2016, the GBEP hosted Workshop #1 and a public Open House to review existing priorities in *GBP'95* and the *SAP*, as well as identify any emerging priorities that should be incorporated into *GBP'18* (see page 163, Public Review Process). Meeting invitations were sent to all Council and subcommittee members, government affiliates, partnership organizations, and numerous regional agencies, organizations, and newsletter subscribers.

Using the input received during Workshop #1 and the public Open House, the GBEP developed technical frameworks for four focus areas that corresponded with the subcommittees of the Council: M&R, NRU, PPE, and WSQ. The Council and its subcommittees provided feedback on the frameworks through six meetings.

In March 2017, stakeholders and interested parties reviewed the revised frameworks and provided feedback at Workshop #2. Workshop attendees saw how comments were incorporated into Actions and gave additional guidance and feedback on the draft Actions that would become *GBP'18*.

A draft of *GBP'18* was released for public comment and review in early 2018. The GBEP held a public Open House (Workshop #3) on March 5, 2018, to present the draft. The GBEP received many comments following the meeting through an online forum. After addressing those comments, *GBP'18* was submitted to the Council for approval on October 17, 2018. *GBP'18* identifies specific milestones and projects to ensure the protection and preservation of Galveston Bay over the next 10 years and beyond.



Workshop #2 attendees listened to a presenter (far left). Participants reviewed a technical framework (center). Participants added content to a technical framework (top right). Participants prioritized Objectives for a workshop exercise (bottom right).

COMPARING THE TWO PLANS

The GBEP used *GBP'95* as a starting point for the development of *GBP'18*, but there are some key differences that will assist the reader with reconciling the two. When *GBP'95* was developed, stakeholders identified the 17 most pressing issues facing Galveston Bay and developed 82 corresponding Actions under 11 Action Plans to address those problems. For *GBP'18*, stakeholders sought to simplify its structure while still building on the hard work of *GBP'95*.

FIGURE 4
FOUR PLAN PRIORITIES

Plan Priority One:
Ensure Safe Human and Aquatic Life Use

Plan Priority Two:
Protect and Sustain Living Resources

Plan Priority Three:
Engage Communities

Plan Priority Four:
Inform Science-Based Decision Making

Both versions of the CCMP address 17 Priority Issues. *GBP'18* is organized under four Plan Priorities (see Figure 4) and 10 Action Plans. Many Actions under the Action Plans from *GBP'95* were combined or removed due to completion or changes in regulation, and the original 82 Actions became 38 (see Figure 5). More information on how *GBP'95* is integrated into *GBP'18* appears in Appendix E: Technical Crosswalk.

GBP'18 addresses many broad issues, focusing on proactive management versus reactive management. The Council and its subcommittees purposefully focused on Actions and topic areas that can be addressed by the GBEP and its partners.

By structuring *GBP'18* around Plan Priorities instead of issues, the GBEP and its partners draw focus to action-oriented outcomes that, when achieved, will solve problems and preserve Galveston Bay. For example, with the establishment of the legislative process for environmental flows (information on Senate Bills 1-3 begins on page 92), the *GBP'18* Freshwater Inflows Action Plan shifts from developing regulatory protections to actions that support continued research, outreach, and community engagement to ensure adequate flows of freshwater reach Galveston Bay to protect and sustain living resources.

FIGURE 5
COMPARING THE PLANS, AT A GLANCE

	GBP'95	***GBP'18***
Priority Issues	17	17
Plan Priorities	Not Applicable	4
Action Plans	11	10
Actions	82	38

Other changes include, but are not limited to, a focus on the creation and implementation of watershed-based plans (WBP), expanded coordination on water quality improvements, expanded stakeholder involvement, more significant focus on education/outreach initiatives, and more robust work to protect and sustain living resources through science-based decision making. *GBP'18* also seeks to identify Actions that support freshwater inflow to Galveston Bay to protect and sustain living resources.

GBP'18 builds upon previous plans and the significant body of scientific research, publications, and public input received for 30 years. However, this document does not revisit all data in its entirety, nor does it replace the multiple *State of the Bay Reports* or other research publications that provide the foundation of *GBP'18*. A complete list of publications cited appears in Appendix G: Bibliography.

What is The Galveston Bay Plan, 2nd Edition?

GBP'18 is a guidance document or central point of reference for improved coordination among stakeholders across the Galveston Bay watershed. It helps to avoid duplication and optimize efficiency through its four Plan Priorities, 10 Action Plans, and 38 Actions. The document is not intended to be regulatory or specifically binding on Actions or timeframes.

GBP'18 is designed to address the issues stakeholders have identified as the priorities for implementation over the next 10 years, modifying the region's collective efforts based on knowledge and expertise gained through experience. These priorities do not mean the efforts of *GBP'18* abandon previous priorities, instead they acknowledge a limitation of resources and focus on the most achievable and high-priority Actions for the coming decade.

LOOKING AHEAD

GBP'18 is a roadmap for the future. It reflects the work and input of many stakeholders and two decades of conservation work. It is a living document that will continue to be updated or revised as priorities or conditions change.

In the technical sections of *GBP'18*, some Actions are left intentionally flexible to account for emerging technologies, opportunities, and threats such as Hurricane Harvey, a Category 4 hurricane that hit the Texas gulf coast in August 2017. Harvey caused wide-spread flooding and property damage, with hundreds of thousands of structures affected by the storm and tens of thousands of people displaced. At the time of publication, the scale and scope of Harvey's impact on Galveston Bay was not fully apparent. However, recovery work will inform future efforts of the GBEP and its partners.

Additional topics to consider, which were identified by stakeholders during the creation of *GBP'18,* include coastal resilience in the face of changing weather patterns and sea levels; changes in land use; increased population; and emerging contaminants, such as endocrine disrupters, personal care products, and microplastics.

The Council, with technical support from its subcommittees, works as information becomes available to ensure *GBP'18* remains flexible enough to meet the changing needs of the Galveston Bay estuary and its stakeholders.

FIGURE 6
COMPOSITION OF THE GALVESTON BAY COUNCIL

Type of Organization	Interest Represented
Federal Agencies	U.S. Coast Guard
	U.S. Geological Survey
	National Marine Fisheries Service
	U.S. Department of Agriculture, Natural Resource Conservation Service
	U.S. Army Corps of Engineers
	U.S. Environmental Protection Agency
	U.S. Fish and Wildlife Service
State Agencies	Texas Department of Agriculture
	Texas General Land Office
	Texas Department of State Health Services
	Texas Commission on Environmental Quality
	Texas Parks & Wildlife Department
	Texas Railroad Commission
	Texas Department of Transportation
	Texas State Soil & Water Conservation Board
	Texas Water Development Board
Regional/Local Governments	Gulf Coast Authority
	Houston-Galveston Area Council
	City of Houston
	Medium Local Governments - pop 25K- 500K
	Small Local Governments - pop <25,000
	Trinity River Authority
	Port of Houston Authority
	Large Local Governments - pop >500K
	San Jacinto River Authority
Environmental/Citizens' Groups	Galveston Bay Foundation
	Citizens-at-Large
	Underrepresented Community Representative
	League of Women Voters
	Coastal Conservation Association
	Low-Income Community Representative
	Other Conservation Organizations
Private Sector	Nature Tourism
	Greater Houston Partnership
	Utilities
	Industry
	Marinas
	Commercial Fisheries
	East Harris County Manufacturer's Association
Research/Academia	Major Universities
	Texas Sea Grant Program

About the Estuary Program

GBEP MISSION
To preserve Galveston Bay for generations to come.

GBEP PURPOSE
To provide comprehensive ecosystem management through collaborative partnerships and ensure preservation of Galveston Bay's multiple uses.

GBEP GOALS
- Judiciously acquire, manage, and disburse funds to implement specific actions in the CCMP.
- Provide coordination and communication between state and federal resource agencies for cross-jurisdictional issues.
- Coordinate, monitor, and track implementation activities of CCMP partners.
- Identify and communicate Galveston Bay improvements to agencies, stakeholders, and the public.
- Conduct public outreach and education to increase awareness of Galveston Bay.
- Maintain stakeholder involvement in the decision-making process through the Galveston Bay Council.

THE GALVESTON BAY COUNCIL
Per *GBP'95*, the TCEQ appointed the Council, a 41-member advisory committee, in November 1995 as governing body for CCMP implementation.

Many stakeholder groups are represented on the Council, which:
- Provides an ongoing forum for technical and stakeholder review and involvement during implementation.
- Contributes to assessments of plan effectiveness and participates in periodic redirection of *GBP'95's* management initiatives.
- Ensures coordination and tracking implementation.
- Advises the TCEQ during the review of projects.
- Maintains agency commitments to implement *GBP'95*; ensures efficient cross-jurisdictional coordination; and, if necessary, facilitates the resolution of disputes.
- Sets annual priorities for the implementation of action plans.

SUBCOMMITTEES AND PARTNERS
Subcommittees of the Council meet quarterly, or more frequently if needed, to facilitate *GBP'95's* implementation activities and provide technical support to the Council. This includes developing projects and programs that fulfill implementation activities outlined in the CCMP, finding opportunities to collaborate and leverage funds with other organizations and stakeholders.

The subcommittees are:
- Natural Resource Uses Subcommittee
- Water and Sediment Quality Subcommittee
- Public Participation and Education Subcommittee
- Monitoring and Research Subcommittee
- Budget and Priorities Subcommittee

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Plan Organization

The Priority Issues and Actions from *GBP'95* and the *SAP* are still relevant and crucial to protecting and preserving Galveston Bay. *GBP'18* builds on the successful projects started from earlier plans and identifies new or modified Actions.

Wetlands adjacent to Jumbile Cove in West Galveston Bay (photo credit: Sarah Bernhardt).

STRUCTURE OF THE GALVESTON BAY PLAN, 2ND EDITION

The technical heart of *GBP'18* is its Action Plans, nested within four Plan Priorities (see Figure 7 on Page 33). The 10 Actions Plans were developed by the Council and its four subcommittees through a series of meetings and workshops, during which the activities necessary to preserve Galveston Bay were outlined and grouped. More information about the process by which the Action Plans were developed through stakeholder engagement begins on page 167, Public Review Process.

Many of the numbered Actions within the Action Plans continue to address issues previously identified in *GBP'95*. New Actions have been added to address revised Plan Priorities. Plan Priorities, Action Plans, and Actions are presented in this document with numerical and alphabetical labels for organization and communication purposes but are not placed in any specific order based on their relative importance or priority.

READING THE GALVESTON BAY PLAN, 2ND EDITION

The four technical components of this document, called Plan Priorities, follow a similar pattern to increase readability. Each Plan Priority is symbol- and color-coded and includes a short topical introduction, followed by an overview of the factors influencing each priority and a brief discussion of past successes. Action Plans are structured similarly, providing a brief topical overview and highlighting the status of current efforts in the region.

Each Action is assigned a number that references the Action Plan under which it is housed. Each of the 38 Actions includes a short discussion, followed by a list of Potential Implementers, Activities, Performance Measures, Implementation Cost Estimates, and References to previous plans. Figure 9: Anatomy of an Action on page 38 provides a detailed explanation of the various components, categories, and definitions common to all Actions.

Due to the dynamic nature of Galveston Bay, some Actions in *GBP'18* are relevant to multiple Plan Priorities and Action Plans. Text or symbols indicate where Actions are closely linked. Figure 8: Plan Priorities Matrix on pages 36 and 37 gives an overview of which Plan Priorities are addressed by Actions under the 10 Action Plans. Figure 7: Structure Overview is a comprehensive view of the four Plan Priorities and 10 Action Plans.

FIGURE 7
THE GALVESTON BAY PLAN, 2ND EDITION STRUCTURE OVERVIEW

PLAN PRIORITIES OVERVIEW

Plan Priority One:
Ensure Safe Human and Aquatic Life Use

Galveston Bay is an economic driver for the Houston-Galveston region with frequent and varied use by residents, tourists, and commercial and trade interests. For people who live, work, and play in and around Galveston Bay it is beneficial to take an active role in protecting it. *GBP'18* outlines the steps to be taken to ensure Galveston Bay is kept safe for human and aquatic life use.

To ensure safe human and aquatic life use of Galveston Bay, three Action Plans are identified.

Improve Water Quality Through Nonpoint Source Pollution Abatement

Improve Water Quality Through Point Source Pollution Abatement

Promote Public Health and Awareness

Plan Priority Two:
Protect and Sustain Living Resources

The lower Galveston Bay watershed is composed of habitats that range from open water areas and estuarine wetlands to freshwater wetlands and upland coastal prairie. These habitats support plant, fish, and wildlife species that ensure the health and biological diversity of the estuarine system. *GBP'18* continues the ecosystem approach to living resource protection identified in *GBP'95* to ensure the existence of an optimal variety and distribution of coastal habitats.

To protect and sustain the living resources of Galveston Bay, three Action Plans are identified.

Support Habitat Conservation

Support Species Conservation

Sustain Freshwater Inflows

Plan Priority Three:
Engage Communities

Nearly 5.4 million people call the five counties that surround Galveston Bay home (U.S. Census Bureau, Population Division, 2016), with millions more visiting the region each year. Residents and visitors affect the health of Galveston Bay through their daily actions, which makes engaging the people of Galveston Bay critical to its long-term successful management, and the sustainability of the bay and its resources.

GBP'18 continues and builds upon the comprehensive public participation and education work identified in *GBP'95*, with a renewed focus on connectivity, personal responsibility, and increasing environmental literacy.

To fully engage the people who live, work, and play in Galveston Bay, two Action Plans are identified.

Preserve Galveston Bay Through Stakeholder and Partner Outreach

Support Public Education and Awareness Initiatives

Plan Priority Four:
Inform Science-Based Decision Making

The health of the Galveston Bay estuary is dynamic, due to both human interactions and natural processes. These changes can affect the people, habitats, and species of Galveston Bay, making monitoring and research essential for the GBEP and its partners to manage, protect, and sustain Galveston Bay.

GBP'18 continues the coordinated approach identified in *GBP'95* with monitoring and research activities that focus on applied research and coordination to identify knowledge gaps and research needs and collection of data to address emerging issues, such as endocrine disrupters and personal care product contaminants.

To ensure data used by the GBEP and its partners are accurate, defensible, and accessible, two Action Plans are identified.

Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring

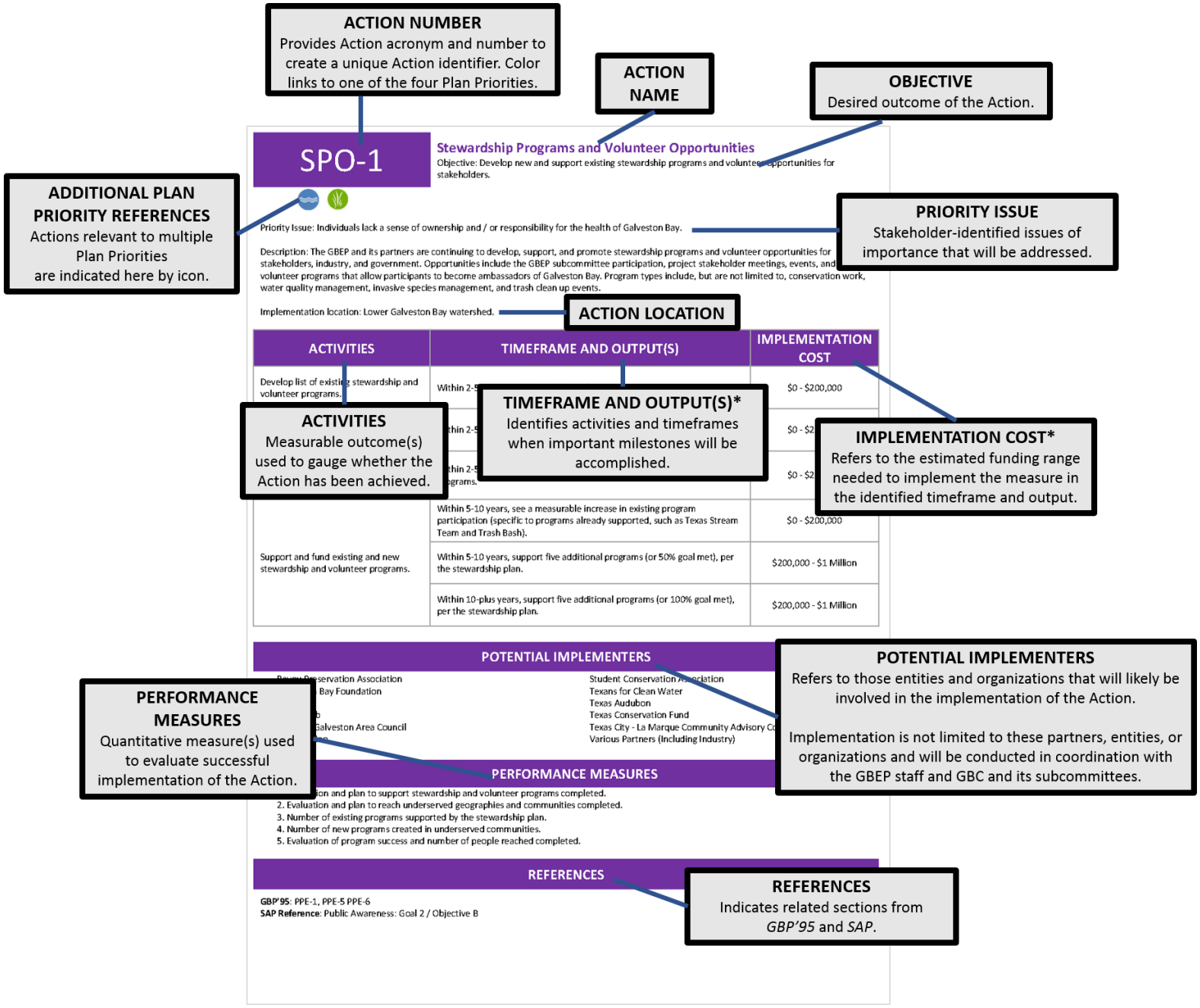
Increase Access to Galveston Bay Ecosystem Information

FIGURE 8
PLAN PRIORITIES MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS		PLAN PRIORITIES			
		Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Improve Water Quality Through Nonpoint Source Pollution Abatement (NPS)					
NPS-1	Support Watershed-Based Plan Development and Implementation	x	x	x	x
NPS-2	Support Nonpoint Source Education and Outreach Campaigns	x	x	x	
NPS-3	Implement NPS Best Management Practices	x	x		x
NPS-4	Host Nonpoint Source Workshops	x		x	x
Action Plan: Improve Water Quality Through Point Source Pollution Abatement (PS)					
PS-1	Support Stormwater Education Programs	x		x	
PS-2	Achieve Sanitary Sewer System Capacity and Integrity	x		x	
PS-3	Increase Wastewater Treatment Facility Compliance	x		x	
Action Plan: Promote Public Health and Awareness (PHA)					
PHA-1	Improve Seafood Advisory Awareness	x		x	x
PHA-2	Improve Regional Contact Recreation Risk Awareness	x		x	
PHA-3	Improve Contact Recreation Safety Through Watershed-Based Plans (WBPs)	x			x
PHA-4	Improve Shellfish Consumption Safety Through WBPs	x		x	x
PHA-5	Improve Finfish Consumption Safety Through WBPs	x		x	x
Action Plan: Support Habitat Conservation (HC)					
HC-1	Land Acquisition	x	x		
HC-2	Habitat Restoration	x	x		
HC-3	Habitat Enhancement	x	x		
Action Plan: Support Species Conservation (SC)					
SC-1	Native Species Management		x	x	x
SC-2	Invasive Species Control		x	x	x
Action Plan: Sustain Freshwater Inflows (FWI)					
FWI-1	Regional Planning for Freshwater Inflows	x	x	x	
FWI-2	Freshwater Inflows Research and Management	x	x		x
FWI-3	Water Conservation and Education	x	x	x	

ACTION PLANS AND CORRESPONDING ACTIONS		PLAN PRIORITIES			
		Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Preserve Galveston Bay Through Stakeholder and Partner Outreach (SPO)					
SPO-1	Stewardship Programs and Volunteer Opportunities	x	x	x	
SPO-2	Workshops and Events	x	x	x	
SPO-3	Support Regional Initiatives	x	x	x	x
SPO-4	Local Government Outreach	x	x	x	x
Action Plan: Support Public Education and Awareness Initiatives (PEA)					
PEA-1	Key Issue Engagement	x	x	x	x
PEA-2	Adult Education	x	x	x	
PEA-3	Kindergarten to 12th Grade (K-12) Education Efforts			x	
Action Plan: Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES)					
RES-1	Conduct Biological Stressor Monitoring and Research	x	x	x	x
RES-2	Conduct Geochemical Stressor Monitoring and Research	x	x	x	x
RES-3	Conduct Physical Stressor Monitoring and Research	x	x	x	x
RES-4	Conduct Monitoring and Research to Address Limits to Contact Recreation	x		x	x
RES-5	Conduct Monitoring and Research to Address Limits to Seafood Consumption	x		x	x
RES-6	Evaluate Best Management Practice (BMP) Projects	x		x	x
RES-7	Conduct Research on Ecosystem Service and Economic Valuation of Bay Resources				x
RES-8	Complete Coastal Resiliency and Acclimation Studies				x
Action Plan: Increase Access to Galveston Bay Ecosystem Information (ACS)					
ACS-1	Tracking Ecosystem Health Indicators	x	x	x	x
ACS-2	Access to Monitoring and Research Data	x	x	x	x
ACS-3	Track Galveston Bay Plan Implementation	x	x	x	x

FIGURE 9
ANATOMY OF AN ACTION



**Timeframe and Output(s) and Implementation Costs are set ranges collectively developed by subcommittee members, Council members, and attendees of the public workshops. Ranges are consistent throughout the document.*

Outputs that appear in multiple Actions are not intended to count toward total Implementation Costs multiple times but are instead a shared cost between multiple Actions. An example of this is the State of the Bay Symposium, which will be the final output for many research Activities under multiple Actions.

Plan Priority One:
Ensure Safe Human and Aquatic Life Use

To preserve Galveston Bay for future generations, the GBEP and its partners must take steps to ensure the safe human and aquatic life use of its waters.

Trash Bash volunteers take a break to fish off a dock on Dickinson Bayou (photo credit: Trash Bash).

The Galveston Bay estuary is one of the most productive in the country, contributing billions of dollars each year to the local economy through commercial fishing, tourism, and oyster harvesting (EPA, 2004, p. 251) and millions of dollars in local and state tax revenue (Galveston Island). Its 232 miles of shoreline are a destination for fishing, boating, bird watching, and recreation. In addition, Galveston Bay is a major transportation hub and economic driver for the region, used to ship goods into and out of the nation's number one port in foreign tonnage, the Houston Ship Channel (Port of Houston Authority, 2018).

However, steps are needed to ensure Galveston Bay is kept safe for human and aquatic life use. Those who live and recreate in the Galveston Bay watershed should actively participate in protecting the health of the bay by choosing behaviors that positively affect water quality, plants, and animals. To ensure safe human and aquatic life use of Galveston Bay, three Action Plans are identified.

ACTION PLANS

- **Improve Water Quality Through Nonpoint Source Pollution Abatement**
- **Improve Water Quality Through Point Source Pollution Abatement**
- **Promote Public Health and Awareness**

The three Action Plans identified under this Plan Priority were developed primarily through the WSQ subcommittee of the Council.

FACTORS THAT INFLUENCE PLAN PRIORITY

There are several crucial factors that determine safe human and aquatic life use of Galveston Bay. The foremost of these is the quality of the surface water in the lower Galveston Bay watershed. Water quality is a key indicator of the health of the bay and whether those waters pose a risk for human use. Water quality in Galveston Bay is generally good, especially in the open bay. The *2017 Galveston Bay Report Card*, developed by the Houston Advanced Research Center (HARC) and the Galveston Bay Foundation, graded water quality by evaluating nitrogen, phosphorus, and dissolved oxygen. Based on these three parameters, Galveston Bay received a grade of an A for two consecutive years (2015 and 2016 data) (GBF & HARC, 2016, p. 8; GBF & HARC, 2017, p. 8). Per the Report Card, this grade "is consistent with long-term trends of improving water quality as a result of Clean Water Act implementation and ongoing implementation of Watershed Protection Plans in our region (locally-driven, watershed-specific plans to voluntarily address complex water quality problems in the region). 2016 was also a good year for consistent rainfall, which helps keep the region's rivers and bayous flowing."

The Relationship Between Water Quality and Water Quantity

Water quantity, in the form of freshwater inflows, is intrinsically linked to water quality and the health of Galveston Bay. The tremendous productivity of its estuary relies on both good water quality and plentiful flows from its watershed. As populations grow, less water is available for environmental interests. At the same time, development can contribute pollutants and decrease natural land cover that filters and slows stormwater. As inflows become smaller, more irregular, and of lower quality, the bay ecosystems can be degraded.

While natural functions cannot be wholly re-created, best management practices can be integrated to mitigate the impacts of development. Water conservation efforts can increase water supplies. Green infrastructure techniques help filter and regulate stormwater and reduce water demand. Pursuing a strategy of low impact development and wise use of water resources helps address the need for clean and sufficient inflows to the bay.

Seafood consumption safety did not fare as well as water quality in the *2017 Galveston Bay Report Card*, receiving a grade of C for Galveston Bay and a grade of D for rivers and bayous. Contamination from polychlorinated biphenyls (PCBs) and dioxins (toxic pollutants that are driving factors in seafood consumption advisories) is different than other water quality parameters. Typically the result of industrial and chemical production processes and incomplete combustion, PCBs and dioxins affect the food chain and are most often found in the fatty tissue of fish and larger aquatic life. People who eat fish or shellfish contaminated by PCBs and dioxins can develop long-term, serious illnesses.

Detailed Water Quality Data

More information about the water quality parameters discussed in *GBP'18* can be found online. Key resources include the GBEP Regional Monitoring Database, the Galveston Bay Report Card, and the Houston-Galveston region Clean Rivers Program's annual regional water quality report, *How's The Water?*.

The Texas Department of State Health Services (TDSHS) issues seafood consumption advisories when tests on fish and shellfish indicate there is an increased risk to human health from the presence of toxic pollutants. In September 1990, TDSHS issued the first dioxin advisory for upper Galveston Bay (DSHS ADV-3). Additional advisories for the Galveston Bay estuary and the Houston Ship Channel (DSHS ADV-50 and ADV-55) were issued in 2013, rescinding portions of previous advisories. The TDSHS website includes current fishing advisories, bans, and more.

Feral hogs contribute to water quality degradation in many areas (photo credit: Texas A&M AgriLife Extension Service).

Contact recreation is a fundamental component of human use of the waters within the Galveston Bay watershed. This includes several activities, such as swimming, fishing, and boating, where there is risk of ingesting water. Forty-six percent of the assessed stream miles in Galveston Bay are impaired for high levels of bacteria (TCEQ, 2014, TCEQ_AU_Line_14). This impairment is determined by the TCEQ based on concentrations of indicator bacteria (*Escherichia Coli [E. coli],* Enterococcus [enterococci]), and fecal coliform, which come from mammal and bird excrement.

These bacteria indicate the presence of other dangerous pathogens in the water that can cause gastrointestinal illness and infections if ingested. Since release of *GBP'95*, the GBEP and its partners continue to implement programs to address bacteria, most notably the Bacteria Implementation Group (BIG). More information about the BIG begins on page 54.

BUILDING ON PAST SUCCESS

GBP'95 provided a roadmap for the GBEP to address the water quality challenges affecting safe human and aquatic life use of Galveston Bay. Since its publication, water quality improvement projects that address nonpoint source (NPS) and point source (PS) pollution, as well as aid public health and awareness, were supported by the GBEP.

WATERSHED-BASED PLANS

WBPs are strategies for mitigating impairments and / or concerns in water bodies. In Galveston Bay, bacteria, dissolved oxygen, nutrients, and PCBs and dioxins are the primary parameters resulting in impairments (Houston-Galveston Area Council [H-GAC], 2014). There are two types of WBPs in the Galveston Bay estuary.

TOTAL MAXIMUM DAILY LOAD / IMPLEMENTATION PLAN

A Total Maximum Daily Load (TMDL) is a regulatory process triggered when a water body is placed on the TCEQ's list of impaired water bodies, the 303(d) list. The TMDL calculates the maximum amount of a pollutant that a water body can receive and still meet water quality standards. An Implementation Plan (I-Plan) is a stakeholder-driven plan that describes how the pollutant reductions described in the TMDL will be achieved. Stakeholders propose voluntary, and sometimes regulatory, measures in the I-Plan to address the pollutant of concern. There are currently five TMDL / I-Plan projects in the lower portion of the Galveston Bay watershed. The EPA's website provides more information about TMDL / I-Plans, including funding and development.

WATERSHED PROTECTION PLAN

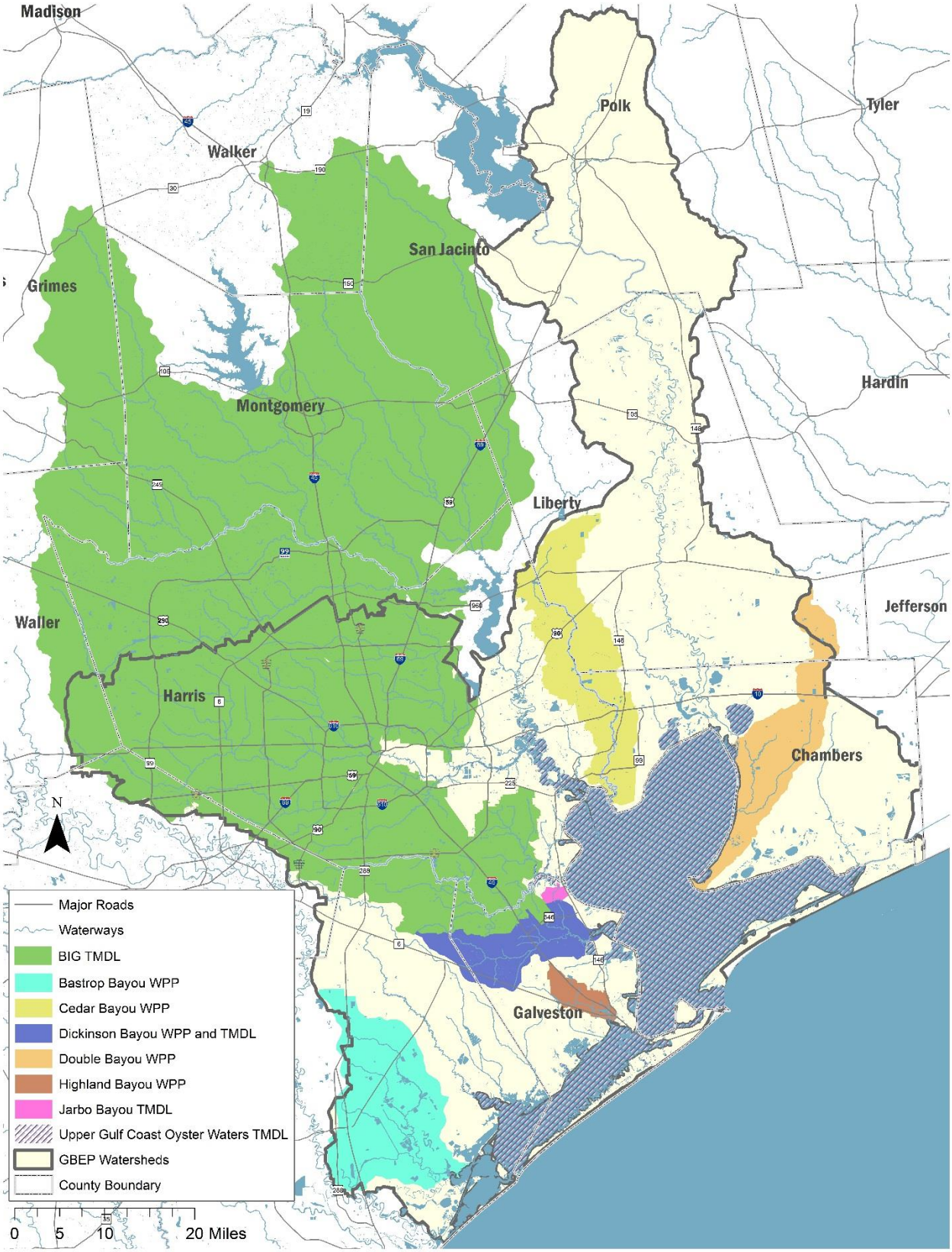
Watershed Protection Plans (WPP) are voluntary (non-regulatory) plans developed by watershed stakeholders. A WPP can be can be developed to preserve and / or restore water bodies. Local stakeholders work to improve or protect water quality by looking at issues beyond typical water quality parameters. A WPP can also be implemented by a concerned group of residents, even if the water body does not appear on the 303(d) list (H-GAC, 2014). Within the lower Galveston Bay watershed, there are five WPP projects at various stages of completion and implementation. The TCEQ's website has more information about WPPs.

Additional focused studies seek to improve water quality using primarily voluntary means and enhanced coordination among stakeholders. For example, the BIG's Top Five Most and Top Five Least Impaired Water Bodies project, funded by the GBEP, aimed to identify specific bacteria sources.

Water Resources Information Map

Learn more about regional water quality through the Houston-Galveston Area Council's Water Information Resources Map (WRIM). The WRIM displays concern and impairment data for five parameters in the Houston-Galveston region in an interactive format.

FIGURE 10
WATERSHED-BASED PLANS IN THE LOWER PORTION OF THE GALVESTON BAY WATERSHED*



**Houston Ship Channel and Galveston Bay TMDL and Implementation Plan not included on this map.*


The Ghirardi Family WaterSmart Park in League City incorporates numerous BMPs, including rain gardens, a green roof, and a cistern to collect rain water (photo credits: Sarah Bernhardt).

BEST MANAGEMENT PRACTICES

Best Management Practices (BMP) include any practice that could be implemented to protect water quality and ensure safe human and aquatic life use. The successful implementation of BMPs identified by WBPs is dependent on gaining early and sustained participation and involvement of stakeholders in the watershed, which can be a time-intensive process. Pet waste disposal stations, riparian buffers, pump-out stations for boater waste, and stormwater treatment wetlands are some of the many examples of BMPs that are included in WBPs in the Galveston Bay watershed.

Education efforts are key in targeting specific behaviors and pollutant sources, such as the Cease the Grease campaign managed by the Galveston Bay Foundation and the Back the Bay campaign administrated through the GBEP. More information about Back the Bay is included on page 103.

Direct structural implementation projects are a focus for regional BMPs. The Ghirardi Family WaterSmart Park was completed in the spring of 2014 as a collaborative effort between the Texas A&M AgriLife Extension Service, League City, and the GBEP. The park is a 3.75-acre neighborhood space that incorporates rain gardens, a cistern to collect rain water for irrigation, a green roof on the pavilion, and WaterSmart landscapes.

Texas A&M AgriLife Extension Service is monitoring the effectiveness of the local stormwater BMPs, which have the unique soils and climate conditions that have not been well studied here. These data will help quantify the benefits of features like rain gardens and swales for local decision makers as they consider incorporating the use of these practices into their codes and ordinances.

ACTION PLAN 1 OF 3

IMPROVE WATER QUALITY THROUGH NONPOINT SOURCE POLLUTION ABATEMENT (NPS)

One of the most difficult areas of environmental management is the control of NPS pollution, particularly in rapidly growing areas with varying land uses. Rainfall runoff or flood waters contain contaminants from many land-based sources, including agriculture, construction, on-site sewage facilities, pet waste, lawn care products, and auto maintenance. These contaminants can degrade the tributaries of Galveston Bay, and then eventually affect the bay. The contaminants most commonly associated with NPS pollution are bacteria, sediment, nitrogen, and phosphorus.

The Houston-Galveston region is projected to add 3.5 million people by 2040 (H-GAC, 2017). Increased land disturbance and impervious surfaces associated with ongoing development can generate NPS pollution from a wider geographic area, while a decrease in permeable surfaces and natural areas, including wetlands, can further reduce the opportunity for runoff to be filtered as it flows to the bay. As urban and suburban development increases, implementation of BMPs that reduce or eliminate runoff are of increasing importance to manage NPS pollution.

What is Nonpoint Source Pollution?

NPS pollution is any type of pollution affecting a waterway that originates from many diffuse sources and not from a single identifiable discharge point. This may include rainfall runoff flowing over land, seepage, or illegal dumping.

The Armand Bayou stormwater treatment wetland at the University of Houston-Clear Lake (more information on page 46) (photo credit: Environmental Institute of Houston, University of Houston at Clear Lake).

Example of Nonpoint Source Pollution Action Implementation

During development of *GBP'18*, the GBEP and its partners emphasized the need to implement BMP projects that include a monitoring and research component to reduce NPS pollution in and around Galveston Bay. Some existing BMPs in the region already included performance data.

The Armand Bayou stormwater treatment wetland at the University of Houston at Clear Lake is an example of a successful BMP that was installed and monitored, demonstrating a reduction in NPS pollution. The stormwater wetland was found to be effective for the removal of phosphorus and indicator bacteria depending on flow regime and bank stability (Guillen, Mokrech, Oakley & Moss, 2014, p. 12). With the decreased levels of phosphorus and indicator bacteria, the frequency of algal blooms in Armand Bayou was reduced as the overall level of dissolved oxygen increased (Guillen, Mokrech, Oakley & Moss, 2014, p. 12). As the plant community becomes more established, the filtration of the stormwater treatment wetland is expected to increase and attract more aquatic and wildlife species. Considering the broad range of land uses, looking at land-based pollutants on a watershed scale allows for simultaneous analysis of potential NPS pollution in the lower Galveston Bay watershed. Moving forward, the GBEP and its partners will work with organizations implementing new and existing BMPs to analyze data and produce a regional BMP white paper that reviews select BMPs.

Action Plan Overview

The NPS Action Plan includes four Actions that address this issue, including support for WBP development and implementation (**NPS-1**); support of NPS education campaigns (**NPS-2**); implementation of structural and nonstructural NPS projects (**NPS-3**); and presentation of workshops to enhance technical understanding and expand use of BMPs (**NPS-4**).

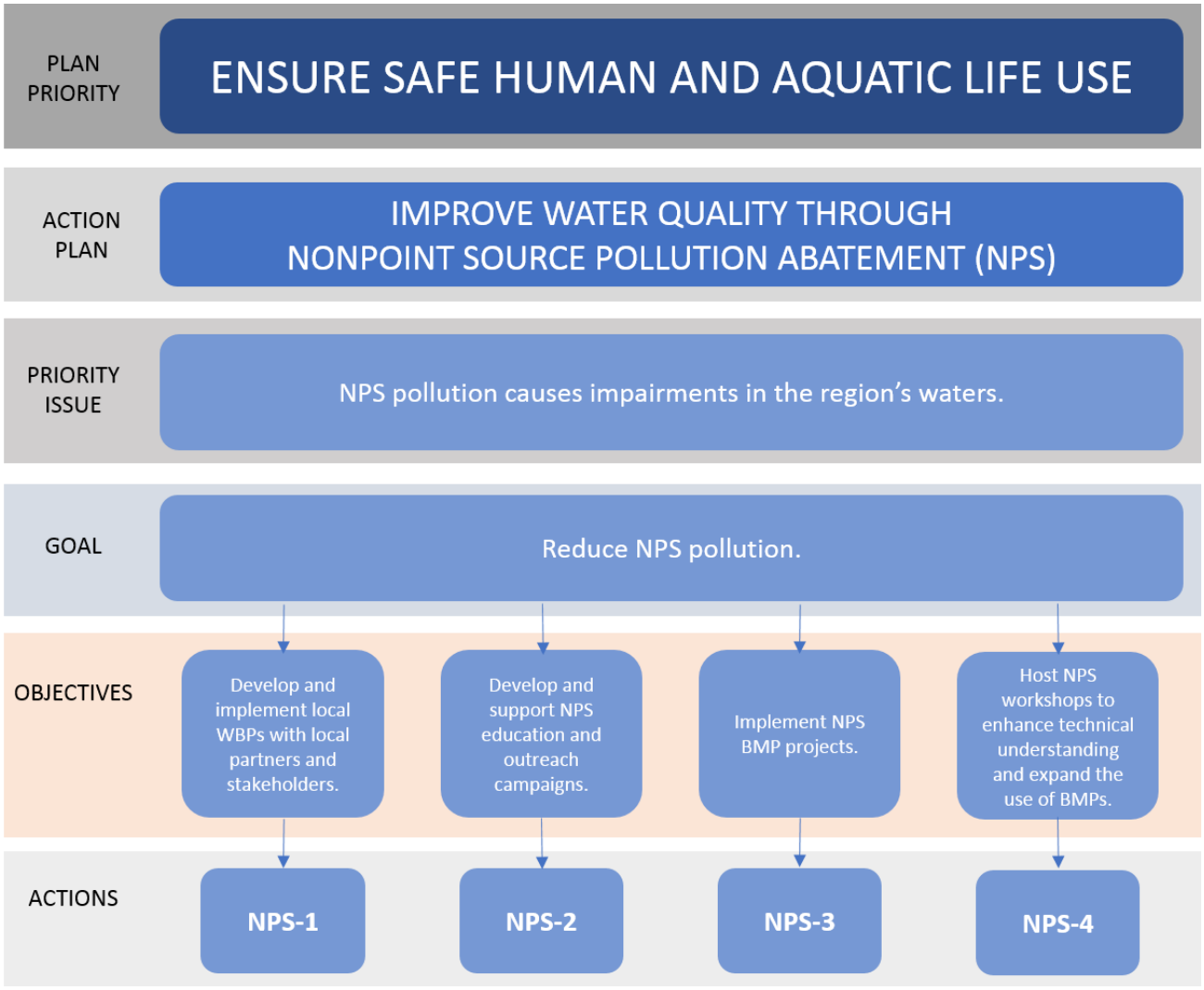
FIGURE 11
NPS ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Improve Water Quality Through Nonpoint Source Pollution Abatement (NPS)						
	NPS-1	Support Watershed-Based Plan Development and Implementation	x	x	x	x
	NPS-2	Support Nonpoint Source Education and Outreach Campaigns	x	x	x	
	NPS-3	Implement NPS Best Management Practices	x	x		x
	NPS-4	Host Nonpoint Source Workshops	x		x	x

Successful implementation of WBPs (**NPS-1**) and supporting BMPs (**NPS-3**) will broadly support Plan Priority Two: Protect and Sustain Living Resources. **NPS-1** requires coordination with the M&R subcommittee on Plan Priority Four: Inform Science-Based Decision Making. Similarly, NPS education (**NPS-2)** requires coordination with the NRU and PPE subcommittees of the Council, specifically on Action **SPO-3** included under Plan Priority Three: Engage Communities. Expanding understanding and use of BMPs in the region through workshops and speaking engagements (**NPS-4**) closely aligns with the Activities for Action **SPO-2** and will also be coordinated between the WSQ, PPE, and M&R subcommittees.

More information on **SPO-3** is presented on page 110. More information on **SPO-2** is provided on page 109.

FIGURE 12
NONPOINT SOURCE ACTION PLAN



NPS-1

Support Watershed-Based Plan Development and Implementation

Objective: Develop and implement local WBPs with local partners and stakeholders.

Priority Issue: NPS pollution causes impairments to the region's waters.

Description: The GBEP and its partners are identifying target area(s) to schedule implementation of WBPs by developing prioritization measures, such as relationship of water body to water quality standard impairment, local source of funding or match available, ongoing watershed planning effort, size of water body, access to monitoring data, etc.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Identify target project areas and support development and implementation of 10 WBPs.	Within 2-5 years, support development and / or implementation of two WBPs (20% of goals met).	$0 - $200,000
	Within 5-10 years, support development and / or implementation of three additional (five total) WBPs (50% of goals met).	$200,000 - $1 Million
	Within 10-plus years, support development and / or implementation of five additional (10 total) WBPs (100% of goals met).	$1 Million - $50 Million

POTENTIAL IMPLEMENTERS

City of Houston
Future Watershed Partners
Galveston Bay Foundation
Galveston County Health District
HARC
H-GAC
Texas A&M AgriLife Extension Service
Texas Parks and Wildlife Department
Texas Sea Grant Program
Texas State Soil and Water Conservation Board

PERFORMANCE MEASURES

1. Number of WBPs developed and / or implemented.

REFERENCES

GBP'95 Reference: NPS-1, NPS-2, NPS-5, NPS-10, NPS-11, NPS-14, NPS-15, NPS-16
SAP Reference: Ecosystem and Human Health – WSQ: Goal 1 / Objective A

NPS-2

Support Nonpoint Source Education and Outreach Campaigns

Objective: Develop and support NPS education and outreach campaigns.

Priority issue: NPS pollution causes impairments to the region's waters.

Description: The GBEP and its partners support NPS education and outreach campaigns that target area(s) using specific messaging to foster public awareness, improve education, and encourage action to improve water quality. (Education is defined for Plan Priority Three: Engaging Communities on page 100.)

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Work with PPE subcommittee and partners to coordinate and facilitate ongoing NPS education and outreach through existing campaigns, such as Back the Bay.	Within 2-5 years, conduct initial assessment of target population.	$0 - $200,000
Continue NPS education and outreach and engage target populations.	Within 2-5 years, initiate target area NPS education campaign.	$200,000 - $1 Million
	Within 5-10 years, track number of individuals involved, target populations, or groups engaged.	$0 - $200,000
Successfully engage target populations and track results.	Within 10-years, track changes in public perception through follow-up evaluation/questionnaire. In addition, track changes in behavior and in environmental parameters (i.e., water quality, SSO events, etc. based on program focus).	$0 - $200,000

POTENTIAL IMPLEMENTERS

Galveston Bay Foundation
H-GAC
Texans for Clean Water
Texas A&M AgriLife Extension Service
Texas Parks and Wildlife Department
Texas State Soil and Water Conservation Board

PERFORMANCE MEASURES

1. Number of individuals or groups engaged in NPS campaigns.
2. Number of public assessments completed.

REFERENCES

GBP'95: NPS-1, NPS-2, NPS-5, NPS-11, NPS-14, NPS-15, NPS-16, PPE-3
SAP Reference: Ecosystem and Human Health – WSQ: Goal 1 / Objective A; Ecosystem and Human Health – WSQ: Goal 1 /Objective B / Objective F; Public Participation and Education – Public Education: Goal 1 / Objective B

NPS-3

Implement Nonpoint Source Best Management Practices

Objective: Implement NPS BMP projects.

Priority Issue: NPS pollution causes impairments to the region's waters.

Description: The GBEP and its partners are identifying specific structural and nonstructural measures to implement to improve water quality. The GBEP and its partners are applying structural and nonstructural NPS BMPs to identified target area(s).

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Develop and install five BMP projects.	Within 2-5 years, initiate two BMP projects.	$0 - $200,000
	Within 5-10 years, initiate three additional BMP projects (five total).	$0 - $200,000
	Within 10-plus years, complete five BMP projects.	$200,000 - $1 Million
Complete effectiveness monitoring and share results with partners, including possible data evaluations, white papers, and project mapping.	Within 10-plus years, evaluate project results and develop white paper on findings.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Galveston Bay Foundation
H-GAC
Texans for Clean Water
Texas A&M AgriLife Extension Service
Texas Parks and Wildlife Department
Texas State Soil and Water Conservation Board

PERFORMANCE MEASURES

1. Number of BMPs implemented.
2. Estimated pollutant load reduction.

REFERENCES

GBP'95: NPS-2, NPS-5, NPS-11
SAP Reference: Ecosystem and Human Health – WSQ: Goal 1 / Objective C

NPS-4

Host Nonpoint Source Workshops

Objective: Host NPS workshops to enhance technical understanding and expand the use of BMPs.

Priority Issue: NPS pollution causes impairments to the region's waters.

Description: The GBEP and its partners are providing NPS technical workshops in target area(s) to enhance the reach of structural and nonstructural BMPs that address failing on-site sewage facilities, feral hogs, illicit discharges, illegal dumping, boater wastes, and agricultural sources. The GBEP and its partners are also tying in with regional campaigns, such as Back the Bay, where applicable.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Understand current awareness of BMPs by conducting pre-workshop assessments.	Within 2-5 years, conduct BMP awareness level assessments prior to hosting workshops.	$0 - $200,000
Conduct 10 BMP workshops to enhance technical understanding and awareness.	Within 2-5 years, conduct one BMP education workshop per year.	$0 - $200,000
	Within 5-10 years, conduct one BMP education workshop per year.	$0 - $200,000
	Within 10-plus years, conduct one BMP education workshop per year.	$0 - $200,000
Measure impact of workshops by conducting BMPs post-workshop assessments.	Within 10-plus years, conduct BMP awareness level assessments after hosting workshops.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Texas General Land Office
H-GAC
Texas A&M AgriLife Extension Service
Texas Parks and Wildlife Department
Texas State Soil and Water Conservation Board

PERFORMANCE MEASURES

1. Number of NPS workshops with pre- and post-assessments completed.

REFERENCES

GBP'95, NPS-1**,** NPS-2, NPS-5, NPS-11, NPS-14, NPS-15, NPS-16, PPE-3, PPE-7
SAP Reference: Ecosystem and Human Health – WSQ: Goal 1 / Objective D / Objective E

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ACTION PLAN 2 OF 3

IMPROVE WATER QUALITY THROUGH POINT SOURCE POLLUTION ABATEMENT (PS)

Traditionally, pollution abatement efforts in the region focused on regulating PS discharges, like effluent from industry and municipal wastewater treatment facilities (WWTFs). These types of discharges are highly scrutinized under the requirements and oversight of regulatory permits. In more recent years, flows from stormwater systems joined these traditional discharges as part of the focus on permit controls to improve degraded water quality. Although permit requirements help ensure the safety of stormwater discharges, these regulated systems remain a focus of water quality efforts.

Failing infrastructure overflows from sanitary sewer systems or improperly treated wastewater can affect a waterway by introducing high levels of fecal bacteria. Excessive bacteria can endanger human health.

Stormwater system flows are typically untreated and can carry contaminants and nutrients from developed areas directly to local waterways. Nutrients can lead to low levels of dissolved oxygen and endanger aquatic life. Contamination from point sources contributes to the overall effect of water pollution on the environment and on the local economies of Galveston Bay.

What is Point Source Pollution?

Point source pollution is any type of pollution affecting a waterway that originates from discrete sources or a single identifiable discharge point. Point sources of pollution can include regulated discharges from WWTFs and stormwater systems.

The watershed that flows to Galveston Bay has over 1,000 regulated wastewater discharges and a varied network of municipal stormwater systems (TCEQ, 2014, TCEQ_AU_Line_14). With regional growth projected to continue at a rapid pace in the coming decades, both wastewater and stormwater capacity and discharges will increase proportionally.

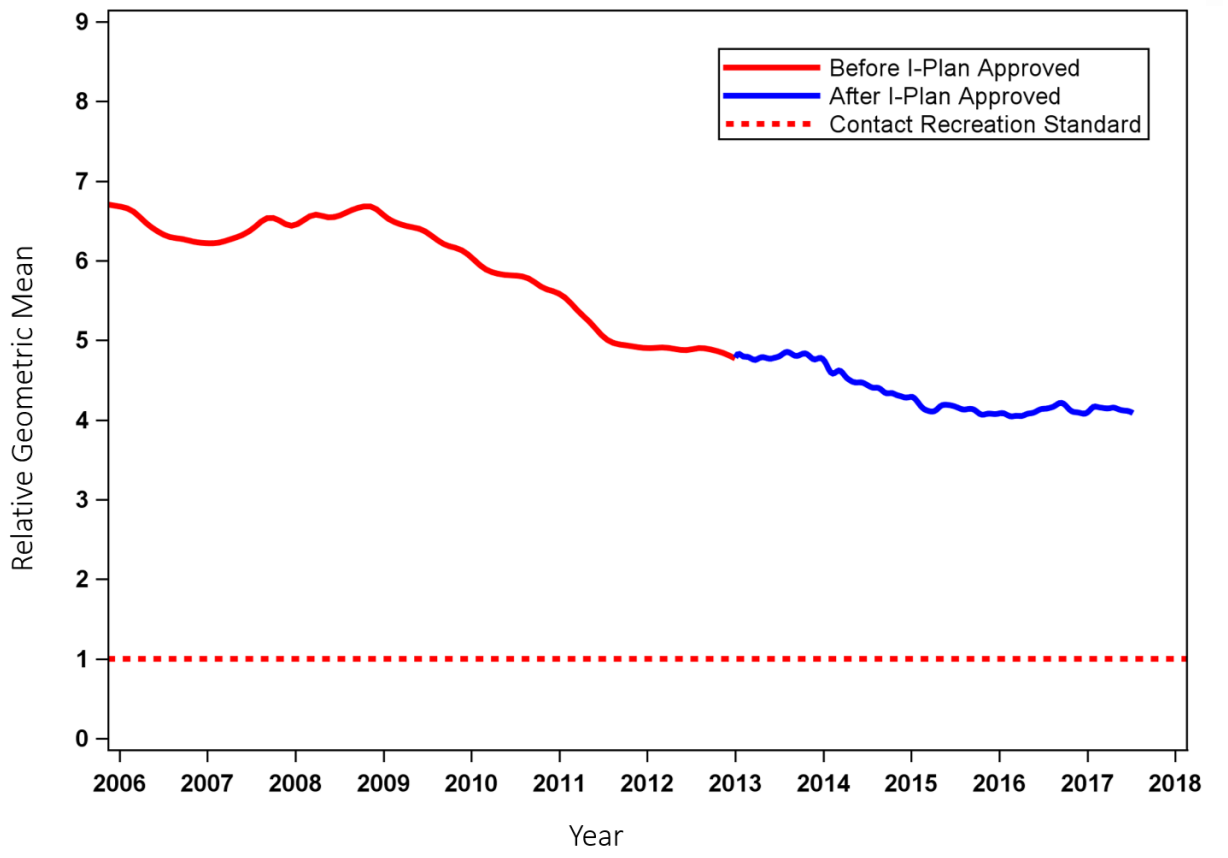
The combination of rapid growth, highly variable and rapid precipitation events over a short period of time, poorly draining soils, and large collection systems based on low-density development presents unique challenges to area wastewater and stormwater utilities. Although these sources are the focus of regulatory controls, the number of dischargers, elevated risk of human waste as a public health concern, insufficient enforcement capacity, and increasing volumes of discharges mean point sources will continue to be a source of concern for water quality in the Galveston Bay watershed.

Extreme weather events can cause flooding, storm surge, and windstorms that stress wastewater and stormwater systems with quantities of water far greater than their maximum designed capacity. When these hazards occur more frequently, they overburden the resiliency of the bay.

Example of Point Source Pollution Action Implementation

Bacteria impairments in the region continue to be the most pressing issue. The GBEP and its partners are addressing this issue and reducing PS pollution through projects such as the BIG. The BIG is a partnership between the H-GAC, local governments, businesses, and community leaders to develop and implement a plan to reduce bacteria. The project area is a combination of more than 100 TMDLs in adjacent watersheds with common stakeholders working to create a single plan.

FIGURE 13
BACTERIA IN THE BIG PROJECT AREA:
MOVING SEVEN-YEAR RATIO OF GEOMETRIC MEAN TO PCR STANDARD



The BIG offers a menu of water protection activities, most of which are voluntary; however, one regulatory area of success is an initiative to halve the standard bacteria permit limit to 63 most probable number (MPN) of fecal coliform per 100 mililiters (mL) for some wastewater permit holders in the BIG project area. This initiative, along with other non-regulatory actions, has contributed to continued water quality improvement (see Figure 13). *

**It is important to note that 96.5 percent of the reported grab / daily maximum bacteria samples meet required permit limits for bacteria.*

With the increase of centralized wastewater treatment, water quality for the lower Galveston Bay watershed is characterized as good for many water quality parameters. However, potential contaminants, such as personal care products and pharmaceuticals, have not been routinely tested. Wastewater treatment technology has not been thoroughly evaluated to determine if it will prevent these contaminants from passing through without being treated. In other parts of the country, one class of these compounds, endocrine disruptors, is linked to changes in the sex ratio of fish and deformities in aquatic life (Vajda et al., 2008). The GBEP and its partners continue to monitor new research on these contaminants and will incorporate findings into future efforts where appropriate.

FIGURE 14
PS ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Improve Water Quality Through Point Source Pollution Abatement (PS)						
	PS-1	Support Stormwater Education Programs	x		x	
	PS-2	Achieve Sanitary Sewer System Capacity and Integrity	x		x	
	PS-3	Increase Wastewater Treatment Facility Compliance	x		x	

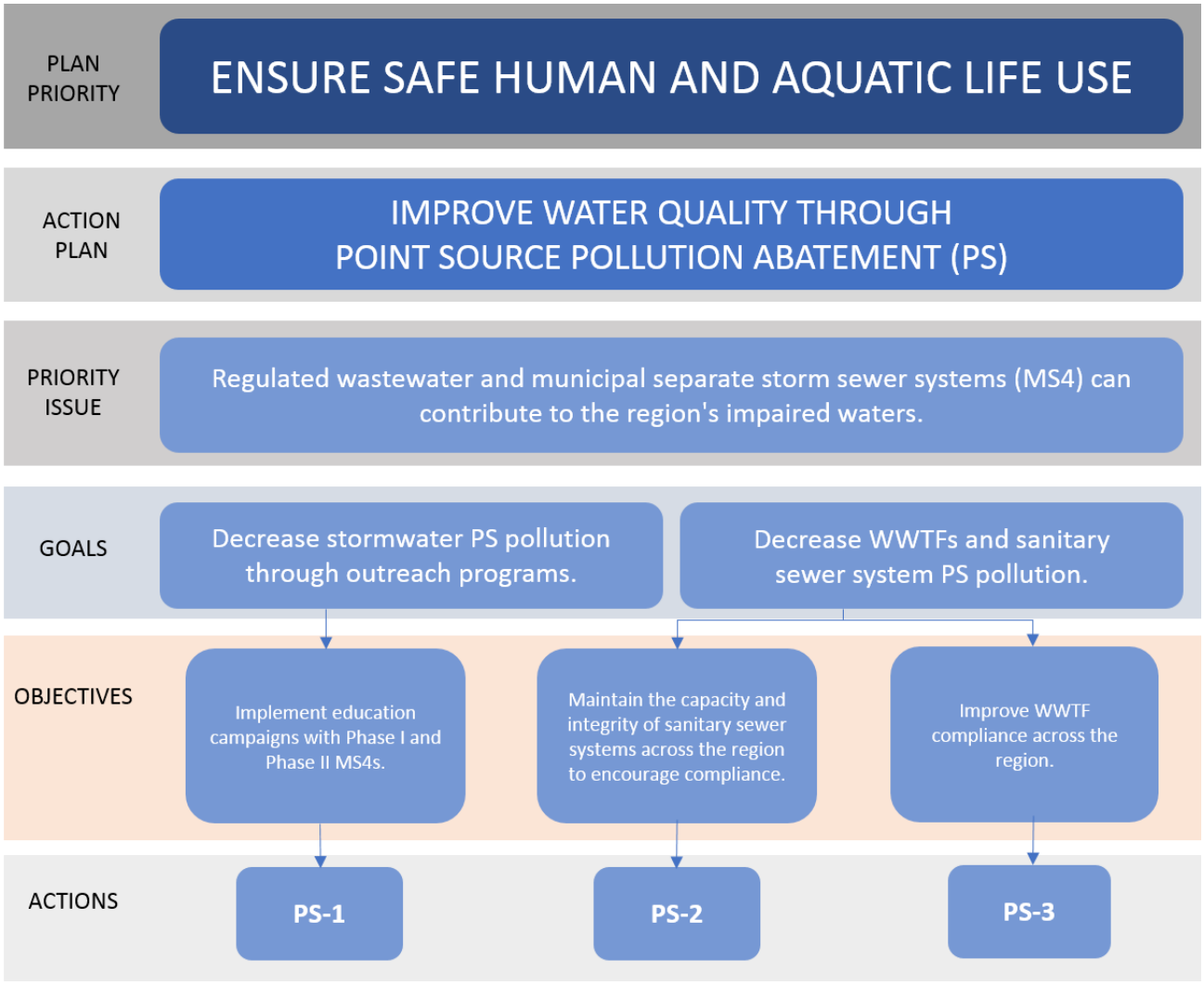
Action Plan Overview

GBP'18 identifies three Actions to improve water quality through PS pollution abatement. The first is to increase public awareness of stormwater issues and promote the use of green infrastructure to mitigate stormwater impacts (**PS-1**). Increasing public awareness of stormwater issues, precipitating a change in behaviors that negatively influence stormwater quality, is a key element in **PEA-1**, included under Plan Priority Three: Engage Communities. Coordination between the WSQ and PPE subcommittees on this issue is key to successful implementation.

Promoting TCEQ efforts and programs to reduce sanitary sewer overflows, such as regional education campaigns (**PS-2**) and seeking to increase compliance by WWTFs through coordination with the TCEQ and technical support for local utilities (**PS-3**) are crucial to reducing point source pollution. Successful implementation of **PS-2**, requires coordination with the PPE subcommittee on **SPO-3** and **PEA-1**. A similar coordination effort between the subcommittees will support the creation of a local utilities toolbox (**PS-3**), which is also supported by **SPO-3**.

More information on **PEA-1** is given on page 116. More information on **SPO-3** is provided on page 110.

FIGURE 15
POINT SOURCE ACTION PLAN



PS-1

Support Stormwater Education Programs

Objective: Implement education campaigns with Phase I and Phase II MS4s.

Priority Issue: Regulated wastewater and MS4s can contribute to the region's impaired waters.

Description: The GBEP and its partners are collaborating on existing education campaigns with owners and operators of Phase I and II MS4 permits on the development and implementation of stormwater management programs to address sediment, litter, pet waste, and illicit discharges from the MS4s.

The GBEP and its partners will also promote BMPs, including low impact development / green infrastructure, construction BMPs and illicit discharge detection programs, and other water quality improvement techniques across the region.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Increase collaboration between MS4 programs across the region.	Within 2-5 years, develop database to track existing MS4 programs and identify opportunities for collaboration.	$0 - $200,000
Work with PPE subcommittee and partners to coordinate and facilitate stormwater outreach efforts.	Within 2-5 years, coordinate with PPE to promote or host workshops and regional messaging campaigns to support point source education efforts.	$0 - $200,000
Finalize stormwater outreach plan and begin implementation activities, such as hosting or promoting workshops and promoting regional messaging.	Within 5-10 years, continue to coordinate with PPE on stormwater outreach efforts.	$200,000 - $1 Million
Complete stormwater outreach plan implementation activities.	Within 10-plus years, continue to coordinate with PPE on stormwater outreach efforts and host identified workshops.	$200,000 - $1 Million
Complete effectiveness monitoring and share results with partners, including possible data evaluations, white papers, and project mapping.	Within 10-plus years, track success of workshops by identifying the number of MS4s implementing BMPs.	$0 - $200,000

POTENTIAL IMPLEMENTERS

H-GAC
Local MS4 Permit Holders
Texans for Clean Water
TCEQ

PERFORMANCE MEASURES

1. Database of MS4s completed.
2. Number of stormwater workshops and educational programs completed.
3. Number of MS4s implementing BMPs post-workshops.

REFERENCES

GBP'95: NPS-1, NPS-2, NPS-6, NPS-7, NPS-12, NPS-13, PS-5, SD-5, SD-6, SD-7
SAP Reference: Ecosystem and Human Health – WSQ: Goal 1 / Objective D; Ecosystem and Human Health – WSQ: Goal 2 / Objective B; Public Participation and Education - Public Education: Goal 1 / Objective B

PS-2

Achieve Sanitary Sewer System Capacity and Ensure Integrity

Objective: Maintain the capacity and integrity of sanitary sewer systems across the region to encourage compliance.

Priority Issue: Regulated sanitary systems can contribute to the region's impaired waters.

Description: The GBEP and its partners are promoting TCEQ programs to encourage repairs, improvements, and replacement of chronically failing sanitary sewer systems.

The GBEP and its partners are promoting TCEQ's Sanitary Sewer Overflow Initiative that develops compliance agreements with municipalities with sanitary sewer overflows and use of existing initiatives that address fats, oils, grease, and sanitary wipes--common causes of sanitary sewer overflows.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Work with partners to improve or replace failing sanitary sewer systems in project area.	Within 2-5 years, identify and prioritize list of geographies with chronically failing sanitary sewer systems in need of repair, improvement, or replacement.	$0 - $200,000
	Within 5-10 years, support or host technical workshops (number to be determined) for targeted geographies.	$0 - $200,000
Host or support regular sanitary sewer systems workshops.	Within 5-10 years, track number of workshops supported or hosted and number of attendees.	$0 - $200,000
Track the number of TMDL / I-Plans in the project area.	Within 10-plus years, track number of TMDL / I-Plans initiated or completed in targeted geography.	$0 - $200,000
Demonstrate the effectiveness of sanitary sewer systems and efforts to repair, improve, or replace failing sanitary sewer systems.	Within 10-plus years, pull sanitary sewer overflow data for targeted geographies to determine whether a reduction occurred.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Bayou Preservation Association
City of Houston Public Works Department
Galveston Bay Foundation
Galveston County Health District
Harris County Pollution Control Department
H-GAC
Sanitary Sewer System Owners / Operators
TCEQ
Watershed-Based Plan Participants / Stakeholders

PERFORMANCE MEASURES

1. List of geographies with failing sanitary sewer systems.
2. Number of workshops and educational programs completed.
3. Number of TMDL/I-Plans initiated.
4. Number of geographies that show a reduction in sanitary sewer overflows.

REFERENCES

GBP'95: PS-1, PS-2
SAP Reference: Ecosystem and Human Health – WSQ: Goal 2 / Objective A

PS-3

Increase Wastewater Treatment Facility Compliance

Objective: Improve WWTF compliance across the region.

Priority Issue: Regulated wastewater systems can contribute to the region's impaired waters.

Description: The GBEP and its partners are coordinating with the TCEQ's Environmental Assistance Division on opportunities to improve WWTF compliance.

The GBEP and its partners are creating a compliance tool box that includes measures like technical workshops, increased regulatory compliance inspections and no-notice inspections, development of a non-regulatory inspection program, identification of funding sources, and potential for regionalization of chronically noncompliant WWTFs. The tool box may be promoted through the GBEP's Back the Bay.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Create a toolbox to provide support to chronically failing WWTFs.	Within 2-5 years, identify chronically failing WWTFs and evaluate factors leading to noncompliance; create compliance toolbox.	$0 - $200,000
Promote toolbox to provide support to chronically failing WWTFs.	Within 5-10 years, use compliance tool box to work with chronically failing facilities, communicating through technical workshops and non-regulatory and regulatory visits (number to be determined {TBD}).	$200,000 - $1 Million
Track the success of support provided to chronically failing WWTFs.	Within 10-plus years, pull failure data for identified WWTFs to determine compliance tool box success.	$0 - $200,000

POTENTIAL IMPLEMENTERS

City of Houston Public Works Department
EPA
Galveston County Health District
Harris County Pollution Control Department
H-GAC
Local Governments
Local Health Districts
Local Industry
TCEQ
Texas Parks and Wildlife Department

PERFORMANCE MEASURES

1. Assessment of needs/gaps of failing WWTFs, to understand why they are failing, completed.
2. Compliance toolbox completed.
3. Number of WWTFs that received toolbox in compliance.

REFERENCES

GBP'95: PS-3, PS -4
SAP Reference: Ecosystem and Human Health – WSQ: Goal 3 / Objective A / Objective B

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ACTION PLAN 3 OF 3

PROMOTE PUBLIC HEALTH AND AWARENESS (PHA)

Good water, sediment, and air quality are important to the ecological health of Galveston Bay. In turn, a healthy bay is important to the health of bay users. Bay users who consume fish or shellfish that contain toxins can become seriously ill. People who use surface water for contact recreation, such as swimming, wading, and windsurfing, risk exposure to waterborne pathogens that can cause gastrointestinal distress, infections, and other illnesses.

Elevated bacteria levels in open bay waters and the shoreline periodically close portions of the bay to recreational and commercial oyster harvesting, and many tributaries in the lower Galveston Bay watershed exceed state standards for safe contact recreation. Sediment is contaminated with toxic agents in localized areas, and portions of the Houston Ship Channel and upper Galveston Bay exceed fish-tissue quality criteria for select contaminants, increasing health risks associated with consuming contaminated seafood from those areas. Continued water quality monitoring, fish-tissue monitoring, and public education initiatives are essential to promoting public health and increasing the public's awareness of associated risks.

Example of Public Health and Awareness Action Implementation

Bay waters are generally considered a low public health risk for contact recreation uses as they meet state water quality standards for contact recreation. Inland tributaries designated for contact recreation can have elevated levels of bacteria. Forty-six percent of assessed stream miles in the lower Galveston Bay watershed have a bacteria impairment for contact recreation (TCEQ, 2014, TCEQ_AU_Line_14). Several of these impaired water bodies are covered under individual WBPs that recommend measures for their improvement.

Consumption of some fish and shellfish can pose a significant public health risk, particularly if harvested from certain areas of Galveston Bay. TDSHS issues *Health Consultations* reports that advise on the risk of consuming fish and shellfish. A characterization study for PCBs and dioxins that the GBEP began in the late 1990s continues to address the main toxins found in fish tissue.

TDSHS also classifies oyster-producing waters in the state as approved, conditionally approved, restricted, or prohibited for shellfish harvest. Consuming oysters, notably raw oysters, can pose a health risk as oysters concentrate bacterial and viral pathogens in their tissue. The Upper Texas Coast Oyster Waters TMDL / I-Plan was completed in January 2014 to address elevated concentrations of bacteria found in tributaries and runoff from shorelines entering the bay.

Since 1989, state and local agencies, such as the Texas General Land Office (GLO) and Galveston County Health District, perform bacteria testing to inform beach-goers about recreational water safety. Additional information is accessible electronically through the Texas Beach Watch website. The Galveston Bay Foundation's Water Monitoring Team collects enterococci bacteria data using "citizen scientists," volunteers specially certified to collect a small amount of water to be tested. This program is a Texas Stream Team partner (learn more about Texas Stream Team under Plan Priority Three: Engage Communities). The annual *Galveston Bay Report Card* also provides residents with answers to questions about whether it is safe to swim in area surface water or to consume fish and shellfish harvested locally. Other initiatives, such as coordination between the EPA and Galveston Bay Foundation at the San Jacinto Waste Pits, make it easier for the public to be informed about complex issues. Signage in multiple languages at sites around Galveston Bay provides warnings to the public where fish consumption advisories are in place. Future efforts to provide subsistence fisherman with targeted information on fish consumption advisories will be explored under this Action Plan.

Action Plan Overview

Increased public awareness (**PHA-1**) of current fish advisories and shellfish sanitation will help with decisions about when to eat fish that are caught, when or if to eat raw oysters, and when to allow children to play in local water bodies. Participation in existing watershed-based planning (**PHA-2**) is key to the improvement of Bay waters. Each WBP has measures for stakeholder involvement. The GBEP helps support WBP implementation and provides a technical forum for regional coordination.

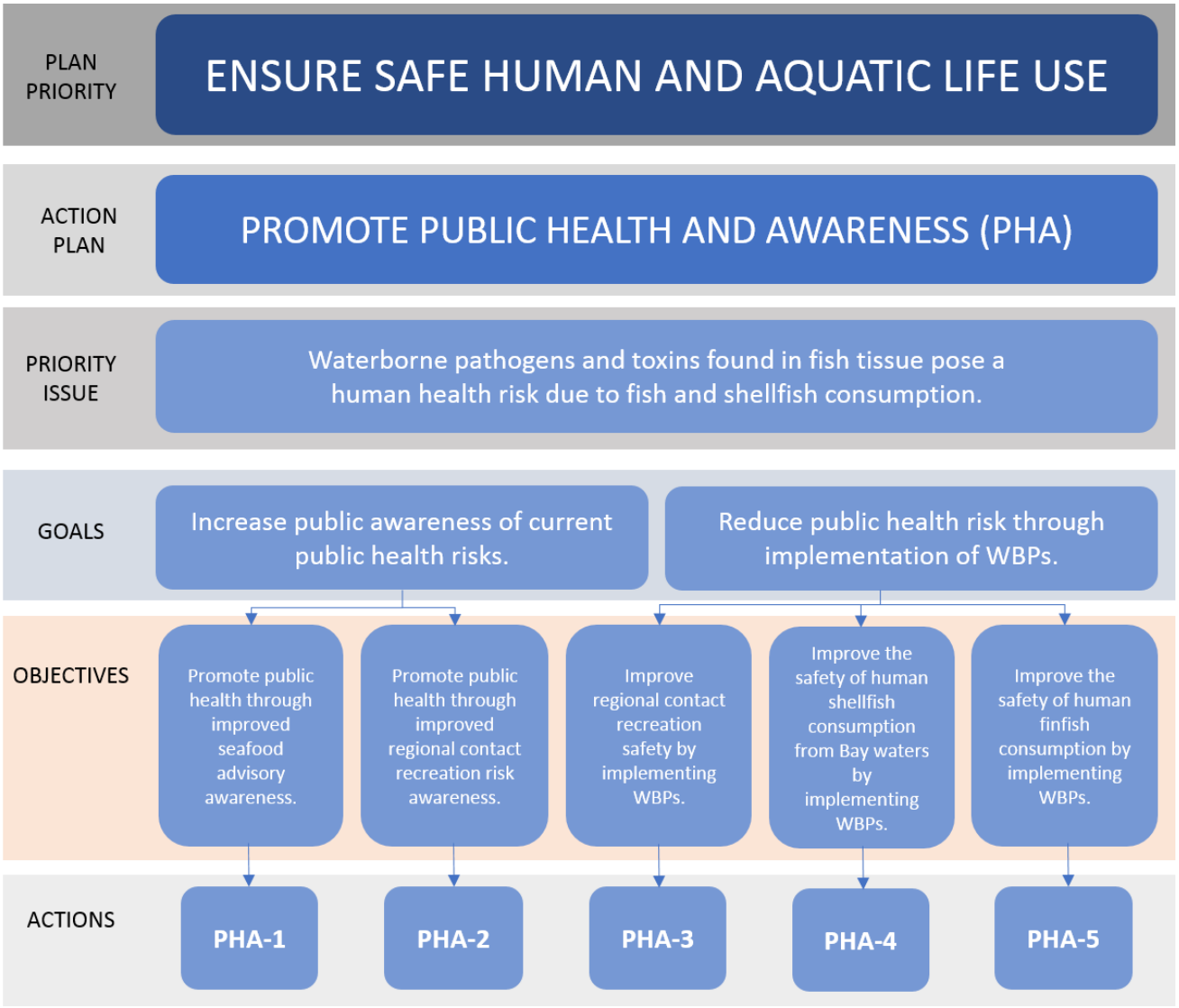
FIGURE 16
PHA ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Promote Public Health and Awareness						
	PHA-1	Improve Seafood Advisory Awareness	x		x	x
	PHA-2	Improve Regional Contact Recreation Risk Awareness	x		x	
	PHA-3	Improve Contact Recreation Safety Through Watershed-Based Plans (WBPs)	x			x
	PHA-4	Improve Shellfish Consumption Safety Through WBPs	x		x	x
	PHA-5	Improve Finfish Consumption Safety Through WBPs	x		x	x

Successful implementation of **PHA-1** and **PHA-2** requires coordination with the PPE subcommittee of the Galveston Bay Council on Action **PEA-1**, included under Plan Priority Three: Engage Communities. Education of the public about health risks from legacy pollutants, waterborne pathogens, air pollution, and fish-tissue contamination will drive **PHA-3**, **PHA-4**, and **PHA-5**. Successful implementation of all Actions requires coordination with the PPE and M&R subcommittees of the Council.

More information on **PEA-1** is provided on page 116.

FIGURE 17
PUBLIC HEALTH AWARENESS ACTION PLAN



PHA-1

Improve Seafood Advisory Awareness

Objective: Promote public health through improved seafood advisory awareness.

Priority Issue: Waterborne pathogens and toxins found in fish tissue pose a human health risk due to fish and shellfish consumption.

Description: The GBEP and its partners are supporting effective seafood advisory outreach.

The GBEP and its partners are working with the PPE subcommittee and stakeholders on outreach, education, and awareness efforts to assist the public in evaluating risks from consuming Galveston Bay fish and / or shellfish. These efforts will leverage and build upon existing outreach and awareness initiatives.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Work with PPE subcommittee to develop a Seafood Advisory Awareness Outreach Plan.	Within 2-5 years, develop Seafood Advisory Awareness Outreach Plan. Identify specific goals for increasing awareness (goals TBD).	$0 - $200,000
Finalize Seafood Advisory Awareness Outreach Plan and begin implementation.	Within 5-10 years, see significant progress on Outreach Plan goals (50% of goals met).	$0 - $200,000
	Within 10-plus years, see significant progress on Outreach Plan goals (100% of goals met).	$200,000 - $1 Million
Successfully implement Seafood Advisory Awareness Outreach Plan and track results.	Within 10-plus years, assess effectiveness of Outreach Plan by tracking number of groups and individuals reached.	$0 - $200,000

POTENTIAL IMPLEMENTERS

County Health Departments
Galveston Bay Foundation
Galveston County Health District
Harris County Pollution Control
Local / City Governments
Texas Department of State Health Services
Texas Parks and Wildlife Department
Texas Sea Grant

PERFORMANCE MEASURES

1. Seafood Advisory Awareness Outreach Plan completed.
2. Number of groups and individuals reached through outreach and education.

REFERENCES

GBP'95: PH-1
SAP Reference: Ecosystem and Human Health - Public-Health Protection: Goal 3 / Objective B

PHA-2

Improve Regional Contact Recreation Risk Awareness

Objective: Promote public health through improved regional contact recreation risk awareness.

Priority Issue: Waterborne pathogens pose a human health risk due to contact recreation exposure.

Description: The GBEP and its partners are working with the PPE subcommittee to develop a public contact recreation risk advisory program. These efforts will leverage and build upon existing outreach and awareness initiatives.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Work with PPE subcommittee to develop a Contact Recreation Outreach Plan.	Within 2-5 years, develop Contact Recreation Outreach Plan. Identify specific goals for increasing awareness (goals TBD).	$0 - $200,000
Finalize Contact Recreation Outreach Plan and begin implementation.	Within 5-10 years, significant progress on Outreach Plan goals (50% of goals met).	$0 - $200,000
	Within 10-plus years, significant progress on Outreach Plan goals (100% of goals met).	$200,000 - $1 Million
Successfully implement Contact Recreation Outreach Plan and track results.	Within 10-plus years, assess effectiveness of Outreach Plan by tracking number of groups and individuals reached.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Bayou Preservation Association
County Health Departments
Galveston Bay Foundation
Harris County Pollution Control
H-GAC
Local Governments
Texas Sea Grant

PERFORMANCE MEASURES

1. Contact Recreation Outreach Plan completed.
2. Number of groups and individuals reached through outreach and education.

REFERENCES

GBP'95: PH-3
SAP Reference: Ecosystem and Human Health - Public-Health Protection: Goal 3 / Objective A

PHA-3

Improve Contact Recreation Safety Through Watershed-Based Plans

Objective: Improve regional contact recreation safety by implementing WBPs.

Priority Issue: Waterborne pathogens pose a human health risk due to contact recreation exposure.

Description: The GBEP and its partners are supporting and facilitating the development and implementation of WBPs, including TMDLs and WPPs, to address bacteria impaired contact recreation waters.

Support may also include continuing the stakeholder process or funding specific BMPs from WBPs.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Support the implementation of ongoing WBPs and development of 3-4 new WBPs.	Within 2-5 years, support and facilitate the implementation of current and development of one to two new WBPs.	$0 - $200,000
	Within 5-10 years, support and facilitate the implementation of current and development of an additional two WBPs.	$200,000 - $1 Million
Successfully develop 3-4 WBPs and track results.	Within 10-plus years, assess impact of supported WBPs by tracking the number of BMPs implemented and number of improved assessment units.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Bayou Preservation Association
City of Houston
County Health Departments
Galveston Bay Foundation
Harris County Pollution Control Department
H-GAC
HARC
TCEQ
Texas A&M AgriLife Extension Service
Texas Sea Grant
Texas State Soil and Water Conservation Board
Watershed-Based Plan Owners / Stakeholders

PERFORMANCE MEASURES

1. Number of WBPs developed and implemented.
2. Number of BMPs implemented.
3. Number of improved assessment units.

REFERENCES

GBP'95: PH-3
SAP Reference: Ecosystem and Human Health - Public-Health Protection: Goal 3 / Objective B

PHA-4

Improve Shellfish Consumption Safety Through Watershed-Based Plans

Objective: Improve the safety of human shellfish consumption from Bay waters by implementing WBPs.

Priority Issue: Waterborne pathogens and toxins found in edible tissue pose a human health risk due to shellfish consumption.

Description: The GBEP and its partners are supporting implementation of WBPs, such as the Upper Texas Coast Oyster Waters TMDL / I-Plan to address bacteria-impaired oyster waters.

Support also includes continuing the stakeholder process or funding specific measures of WBPs.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Demonstrate a change in shoreline bacteria concentrations.	Within 2-5 years, support implementation of the Upper Texas Coast Oyster Waters TMDL / I-Plan and report on status.	$0 - $200,000
	Within 5-10 years, continue to support implementation of the Upper Texas Coast Oyster Waters TMDL / I-Plan and report on status.	$0 - $200,000
	Within 10-plus years, review water quality data to determine whether a decrease in bacteria concentrations occurred.	$0 - $200,000

POTENTIAL IMPLEMENTERS

City of Houston
Galveston Bay Foundation
Galveston County Health District
Harris County Pollution Control Department
Texas A&M AgriLife Extension Service
TCEQ
Texas Department of State Health Services
Texas Sea Grant

PERFORMANCE MEASURES

1. Upper Texas Coast Oyster Waters TMDL/I-Plan implemented.
2. Number of improved assessment units for bacteria concentrations.

REFERENCES

GBP'95: PH-2
SAP Reference: Ecosystem and Human Health - Public-Health Protection: Goal 1 / Objective B; Ecosystem and Human Health - Public-Health Protection: Goal 2 / Objective A

PHA-5

Improve Finfish Consumption Safety Through Watershed-Based Plans

Objective: Improve the safety of human finfish consumption by implementing WBPs.

Priority issue: Waterborne pathogens and toxins found in fish tissue pose a human health risk due to fish consumption.

Description: The GBEP and its partners are supporting and facilitating the development and implementation of legacy and toxin WBPs, as the need arises.

The GBEP and its partners are also providing support, as needed, for existing PCB and dioxins TMDL studies.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Support the implementation of current and / or development of 3-4 new WBPs.	Within 2-5 years, support and facilitate the development of one to two WBPs.	$0 - $200,000
	Within 5-10 years, support and facilitate the development of an additional two WBPs.	$200,000 - $1 Million
Complete impact assessment and results tracking of the 3-4 developed WBPs.	Within 10-plus years, assess impact of supported WBPs by tracking the number of BMPs implemented and number of improved assessment units.	$0 - $200,000

POTENTIAL IMPLEMENTERS

City of Houston
Galveston Bay Foundation
Galveston County Health District
Harris County Pollution Control Department
TCEQ
Texas A&M AgriLife Extension Service
Texas Department of State Health Services
Texas Sea Grant

PERFORMANCE MEASURES

1. Number of WBPs completed.
2. Number of BMPs implemented.
3. Number of improved assessment units.

REFERENCES

GBP'95: WSQ-1, WSQ-2, WSQ-3, WSQ-4
SAP Reference: Ecosystem and Human Health - Public-Health Protection: Goal 1 / Objective B; Ecosystem and Human Health - Public-Health Protection: Goal 2 / Objective A

Plan Priority Two:
Protect and Sustain Living Resources

To preserve Galveston Bay for future generations, the GBEP and its partners must take steps to protect and sustain its living resources.

Student volunteers plant wetland species at a wetland restoration project at Sheldon Lake State Park (photo credit: Galveston Bay Foundation).

The Texas coast features a wealth of coastal habitats that support an abundance and diversity of fish and wildlife. Preservation of wetlands and natural areas is critical for the maintenance of water quality and the protection of valuable fish and wildlife habitat in the region.

The Galveston Bay estuary was considered one of the most biologically productive estuaries in Texas in 2005 (EPA, 2004, p. 250). A system of freshwater inflows from rivers, bayous, and streams that mix with warm saltwater from the Gulf of Mexico provides a nutrient-rich environment for Galveston Bay's indigenous coastal plants, fish, and wildlife. However, changing land use and development, as well as increased water demands and other factors, threaten living resources in the estuary. To adequately protect and sustain the bay's living resources, three Action Plans are identified.

ACTION PLANS

- **Support Habitat Conservation**
- **Support Species Conservation**
- **Sustain Freshwater Inflows**

The three Action Plans identified under this Plan Priority were developed primarily through the NRU subcommittee of the Council.

FACTORS THAT INFLUENCE PLAN PRIORITY

Galveston Bay hosts a variety of habitats, including regularly flooded estuarine intertidal emergent wetlands, tidal inlets, creeks, and ponds. Some sub-bays are vegetated with SAV in the open water adjacent to intertidal emergent wetlands. Vegetated and unvegetated salt flats occur just inland and at slightly higher elevations than the intertidal marshes. At higher elevations, these habitats grade into coastal prairie interspersed with brackish to freshwater marshes. The tributaries, bayous, and rivers are lined with varying riparian habitats, such as emergent marsh and forests.

These habitats support fish, wildlife, and plant species that ensure the health and biological diversity of the estuarine system, from primary producers, like phytoplankton, to large mammals, such as dolphins. These organisms occupy different feeding, or trophic, levels but all are integral to ecosystem function.

Just as Galveston Bay's habitat types and species are indicators of the health of the estuary, its salinity is also an indication of its health. Freshwater inflows perform a crucial role and are an important factor driving the health of Galveston Bay. The volume, timing, and quality of freshwater inflows to the estuary directly influence the biodiversity of the bay and its health.

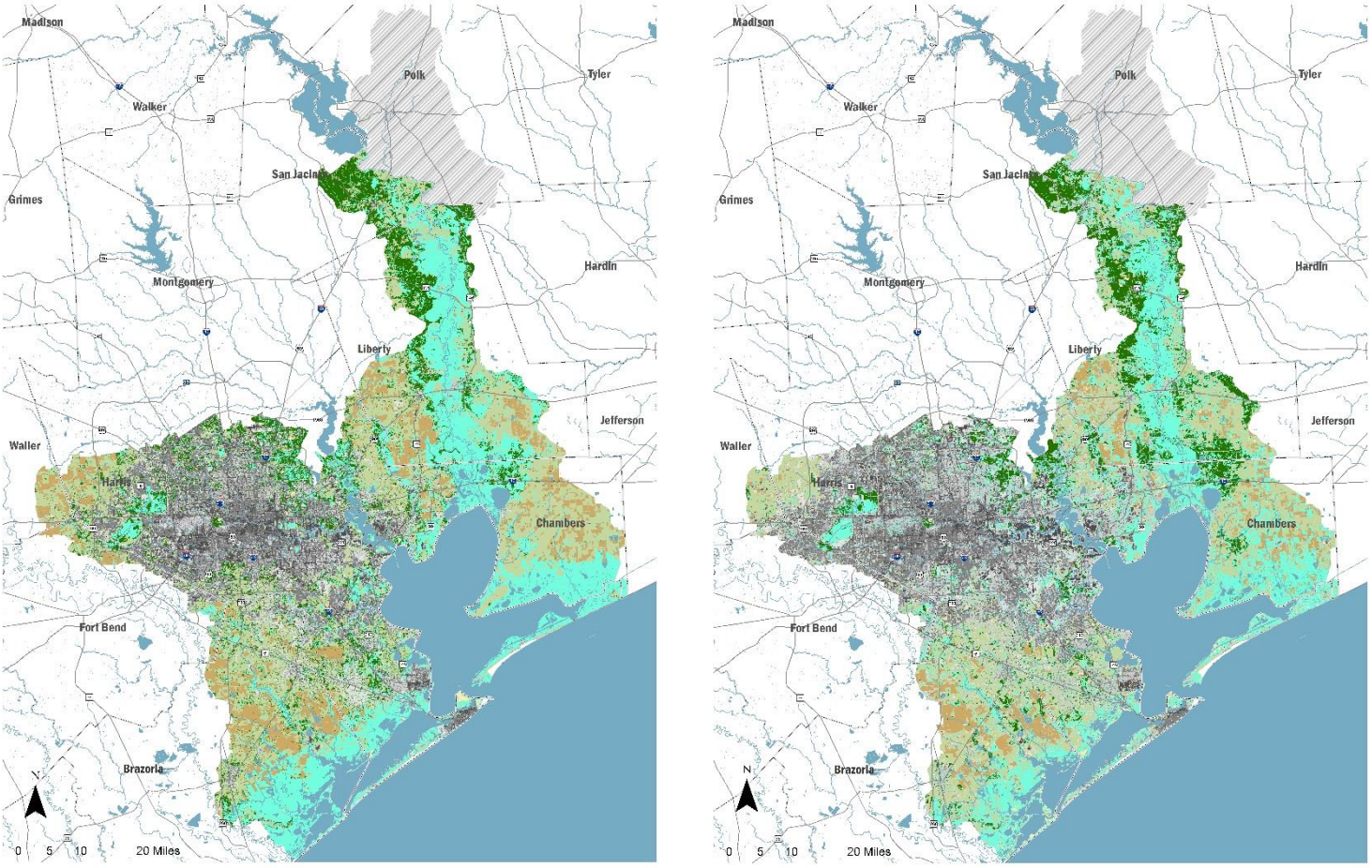
The *2017 Galveston Bay Report Card* indicates the living resources in Galveston Bay are under stress from a variety of sources, including hurricanes, development and population growth, subsidence and erosion, and increasing water use and climate variability, such as flooding and drought. Habitat loss, and its subsequent impact on native species and water quality, poses a significant threat to ecosystem health in Galveston Bay. Passage of the Clean Water Act in 1972 provided federal protection for wetlands in the Galveston Bay ecosystem, but development continues to contribute to the loss of wetlands in Galveston Bay (GBF & HARC, 2017, p. 45).

LAND USE CHANGE IN GALVESTON BAY

Now, more than 5.4 million people live in the five counties surrounding Galveston Bay. This marks a 33 percent population increase since the release of the *GBP'95* in April 1995 (U.S. Census Bureau, Population Division, 2016).

This population growth resulted in increased development and changes in land use. As stated in the *2016 Galveston Bay Report Card*, an estimated 13 percent of wetlands were lost to development between 1996 and 2010 (GBF & HARC, 2016, p. 45). Figure 18 demonstrates changes in land use between 1996 and 2015.

FIGURE 18
LAND COVER CHANGE



Changes in land use between 1996 (left) and 2015 (right). Source: H-GAC Community and Environmental GIS (CE GIS). Appendix G begins with a more detailed explanation of how these data were developed.

BUILDING ON PAST SUCCESS

The GBEP is successful in leveraging program funding to benefit Galveston Bay's living resources. Since 2000, the GBEP and its partners protected (conserved), restored, and enhanced 29,050 acres of coastal habitats, leveraging approximately $95.8 million in local, industry, state, and federal contributions. Each dollar the GBEP contributed to habitat and species conservation projects leveraged $17.

NORTH DEER ISLAND PROTECTION PROJECT

In 2006, the GBEP collaborated with state and local organizations on the North Deer Island Protection Project, led by the TPWD. Partners worked for eight years to stabilize approximately 1.7 miles of North Deer Island's rapidly eroding shoreline. Erosion rates up to 10 feet per year threaten the island's critical nesting and foraging habitat for waterbirds.

The project resulted in the protection of critical nesting and foraging habitat for 30,000 nesting pairs of 19 species of waterbirds, including endangered and threatened species, as well as nursery areas for commercially and recreationally important finfish and shellfish. Partners placed 24,100 tons of limestone to create 6,450 feet of nearshore breakwater and armored shoreline, which protects upland nesting areas, wetlands, tidal flats, and lagoons. North Deer Island now features some of the most spectacular bird watching in Galveston Bay.

In addition to the successful restoration of critical habitat, North Deer Island highlights the importance of collaboration in the Galveston Bay watershed. The diverse partnership that led to implementation of this project included Audubon Texas, NRG Energy/Reliant Energy, EPA, Houston Audubon Society, Harris and Eliza Kempner Fund, Galveston Bay Foundation, Meadows Foundation, Shell Marine – National Fish and Wildlife Foundation, the GLO, the U.S. Fish and Wildlife Service, and TPWD. The North Deer Island Protection Team received the Gulf of Mexico Program's Gulf Guardian Partnership Award in 2008 and the White House Coastal America Partnership Award in 2009.

Aerial image of North Deer Island protection project site (photo credit: Woody Woodrow, U.S. Fish and Wildlife Service).

CONSERVATION ASSISTANCE PROGRAM

Through a collaboration between the GBEP, Galveston Bay Foundation, and Texas Coastal Partners, the Conservation Assistance Program (CAP) supports regional efforts to preserve wetlands and coastal habitats that protect the long-term health and productivity of Galveston Bay. With the help and consensus of conservation partners, the collaborative identifies conservation projects, develops funding strategies, works with landowners to negotiate conservation easements, carries out due diligence, and finalizes the purchase and transfer of title to the appropriate land conservation entity.

Artist Boat Eco-Art Kayak Adventures at the Artist Boat Coastal Heritage Preserve in West Galveston Bay (photo credit: Artist Boat).

From 2011 to 2017, nine projects closed under this partnership, including the Lone Pine Farm and Anahuac National Wildlife Refuge Coastal Prairie, permanently protecting 5,137 acres and leveraging $9,000,000. Approximately 10,000 acres of habitat have ongoing efforts, including Gordy Marsh Phase II Conservation and the Anchor Bay acquisition of the Coastal Heritage Preserve.

WEST BAY CONSERVATION INITIATIVE

The West Bay Conservation Initiative is a concentrated effort made up of habitat conservation, restoration, and enhancement projects supported by nonprofit organizations, state and federal agencies, and private partners. The objective of the initiative is to conserve and restore habitat and associated biological communities critical to the Galveston Bay ecosystem. This initiative includes protection of fringing intertidal and high marsh, tidal flats, freshwater wetlands, working (agricultural) lands, and coastal prairie.

In 2013, the GBEP secured $2 million from the GLO's Coastal Impact Assistance Program (CIAP) to conserve properties in the West Bay Watershed. This was implemented by placing coastal wetlands and habitats critical to water quality, wildlife, and habitat continuity under long-term conservation.

Through this grant, the GBEP and its partners permanently protected 850 acres of coastal habitat. These properties included the Savannah Oaks rice farm (700-acre conservation easement), Chocolate Bayou (103-acre fee simple acquisition), and the Coastal Heritage Preserve middle tract (47-acre fee simple acquisition).

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ACTION PLAN 1 OF 3

SUPPORT HABITAT CONSERVATION (HC)

The Galveston Bay watershed provides significant recreational opportunities and economic benefits to the region (EPA, 2004, p. 248). Local economies benefit from the bounty of the bay's fisheries and oyster reefs. Wetlands improve water quality and augment resilience during storms. Coastal prairies absorb floodwaters and sequester carbon. These and other component ecosystems work to support the biodiversity of the bay. The binding element that serves as the framework for the productivity of the Galveston Bay estuary is habitat.

Habitat is generally defined as the natural environment of an organism. The bay's health is dependent on the balance of physical, biological, and chemical conditions necessary to maintain the habitats that support its robust ecosystems. The overall health of the bay and the services it provides depend on the health of the habitats that create them.

> All of Galveston Bay's principal commercial and recreational fishery species rely on estuarine wetlands during at least some part of their life cycle (Lester, 2011b, p. 3).

Crucial habitats in the estuarine environment of Galveston Bay and the terrestrial environment of its upland watershed include those most significantly affected over the past decades. Wetland loss, changes to oyster reefs, declines of SAV, loss of tidal flats, conversion of coastal prairies to developed areas, and loss of riparian forests along bay tributaries threaten the strength of Galveston Bay. The *2017 Galveston Bay Report Card* indicates many of the bay's crucial habitats (freshwater wetlands, SAV, and oyster beds) remain threatened and in need of intervention (p. 44). The ability of the bay to support its abundant bird life, native plant communities, and other living systems depends on high-functioning habitat.

Armand Bayou Nature Center (photo credit: Lyman Brown).

Acquisition of high-value habitat is a focus of *GBP'18*. Regional conservation efforts, as evidenced by the Texas Farm and Ranch Land Program, the CAP, and community-driven Greenprints by the Trust for Public Land, focus on acquisition of land or acquisition of development rights through conservation easements. Restoration of existing degraded habitat provides another important avenue to increasing habitat function and capacity. A final tool is enhancement and protection of native habitats. Establishing breakwaters to prevent wetland shoreline erosion and fragmentation, which often leads to the wetlands conversion to open water, and managing lands (fencing, mowing, prescribed burns, etc.) in conservation to preserve habitat values, is an effective tool for protecting habitats.

Status of Habitat Conservation Implementation

Per *GBP'95*, the Galveston Bay system lost a net of nearly 35,000 acres of wetlands and 1,800 acres of SAV between the 1950s and 1989 primarily due to human-induced subsidence, the conversion of wetlands to agricultural land, regional dredge-and-fill activities, and habitat fragmentation.

The loss of estuarine wetlands slowed since 1996, while loss of freshwater wetlands remains a concern. Much of this loss is attributed to the development of freshwater isolated wetlands and agricultural land from the expansion of the Houston metropolitan area. Two U.S. Supreme Court decisions (*Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers* in 2001 and *Rapanos v. United States* in 2006) and subsequent federal guidance coincide with the continued loss of freshwater wetlands to residential and commercial development in the watershed in the 2000s.

Other plant communities, like emergent intertidal wetlands and SAV, are affected by subsidence, increased water turbidity, and development encroachment. Encroaching development disturbs riparian areas along tributaries and converts prairie wetland complexes.

FIGURE 19
HABITAT TRENDS

Wetland Classification	1996	2005	Total Change 1996 to 2005	Annual Change 1996 to 2005	Percent Change 1996 to 2005
Estuarine Emergent	163,029	163,228	+199	+20	0%
Freshwater Emergent	169,746	168,068	-1,678	-168	-1%
Freshwater Forested	564,715	546,541	-18,264	-1,826	-3%
Freshwater Scrub/Shrub	75,061	69,016	-6,045	-605	-3%
Total	**972,551**	**946,764**	**-25,787**	**-2,579**	**-3%**

Acreage of estuarine and freshwater wetland in the five counties of the lower portion of the Galveston Bay watershed from 1996 to 2005 (Lester, 2011b, p. 11).

Since 2015, the *Galveston Bay Report Card* assessed trends in saltwater wetlands, oyster reefs, freshwater wetlands, and SAV. Habitats in Galveston Bay received an overall letter grade of D on the *2017 Galveston Bay Report Card*, indicating many of the habitats in Galveston Bay and its watershed are under stress. Freshwater wetlands, oyster reefs, and SAV have seen significant declines over the years, though some habitats, like fringing saltwater wetlands, are beginning to benefit from the successes of regulatory protection and restoration efforts (GBF & HARC, 2017, p. 44). In 2017, saltwater wetlands, freshwater wetlands, and oyster reefs received an incomplete grade, pending updated data. The remaining habitat assessed, SAV, was found to be "adequate for now."

The continued health and biodiversity of the Galveston Bay estuary depends on the conservation of varied and abundant high-quality habitat. Since the development of *GBP'95*, habitat conservation continues to be identified as the most critical need in protecting the Galveston Bay watershed.

Action Plan Overview

The HC Action Plan includes three Actions to conserve, restore, and enhance habitats. To support habitat conservation in Galveston Bay, land acquisition will be a primary focus (**HC-1**), as high-value habitat can rarely be acquired retroactively after conversion to other uses.

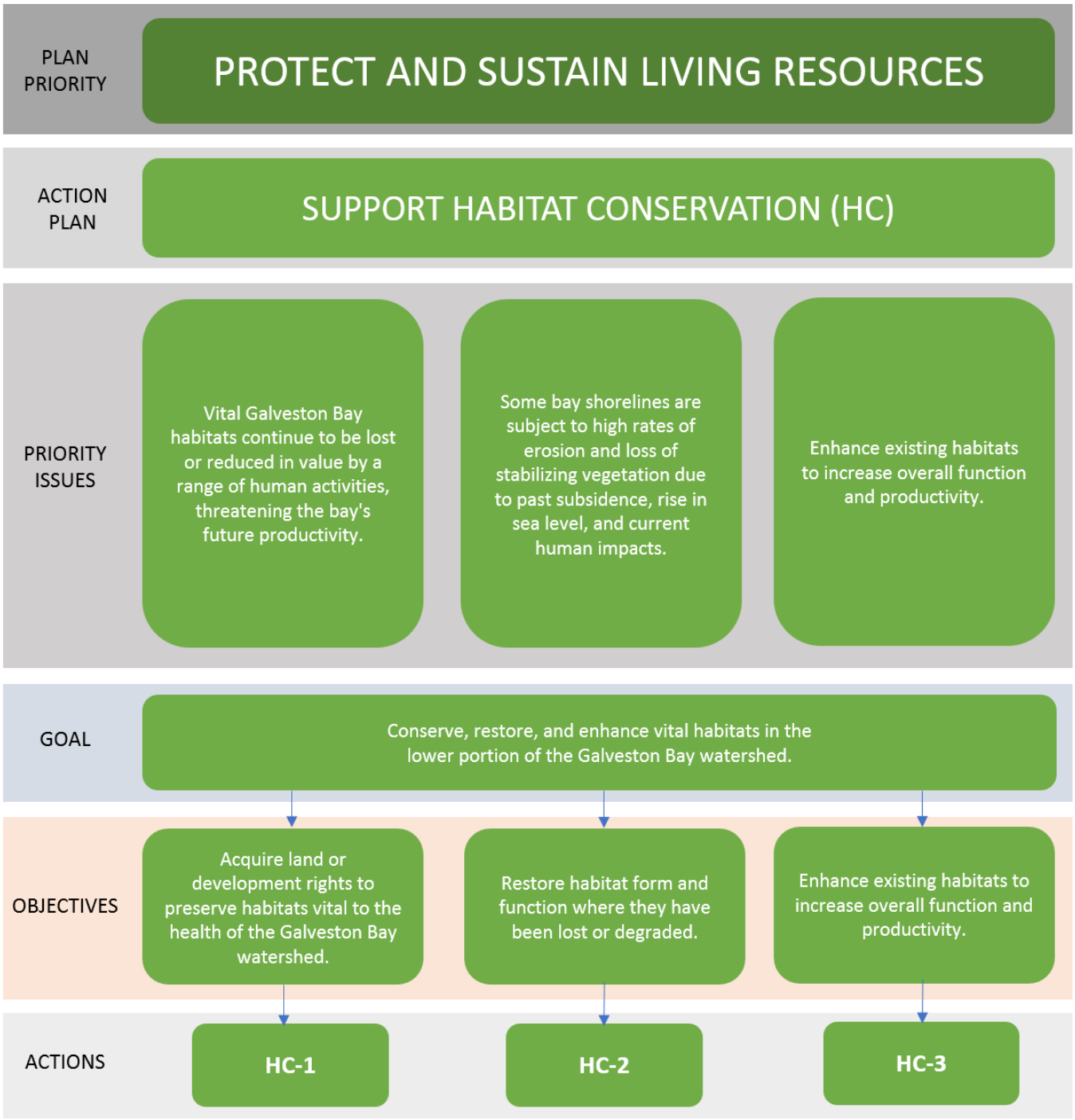
FIGURE 20
HC ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Support Habitat Conservation (HC)						
	HC-1	Land Acquisition	x	x		
	HC-2	Habitat Restoration	x	x		
	HC-3	Habitat Enhancement	x	x		

Restoring habitat is another means to improve the overall function of Galveston Bay (**HC-2**). While restoration may require more effort than acquisition and the full function of natural habitat may not be fully acheivable, it allows for the flexibility to address coastal habitat in areas where acquisition is not feasible. Enhancing habitat provides a third approach to promoting the bay's ecosystems, by increasing the function of existing habitat (**HC-3**). Because habitat can be thought of in size and quality, increasing quality allows for flexibility when increasing the size of habitat is not feasible. In addition, land acquired for conservation may be maintained and enhanced to protect the quality of habitat and conservation value.

Successful implementation of all three Actions requires coordination with the WSQ subcommittee of the Council.

FIGURE 21
HABITAT CONSERVATION ACTION PLAN



HC-1

Land Acquisition

Objective: Acquire land or development rights to preserve habitats vital to the health of the Galveston Bay watershed.

Priority Issue: Vital Galveston Bay habitats continue to be lost or reduced in value by a range of human activities, threatening the bay's future productivity.

Description: To address this, the GBEP and its partners have developed the CAP to define regional conservation priorities and facilitate land acquisition efforts in the lower Galveston Bay watershed. The GBEP and its partners are funding acquisition projects that leverage the GBEP's monies for additional funds, where possible, to conserve, restore, and enhance coastal habitats in the lower Galveston Bay watershed.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Active CAP initiatives in each sub-bay watershed of Galveston Bay	Within 2-5 years, create and maintain list of acquisition projects to submit for funding.	$0 - $200,000
Adapt acquisition projects for submission to multiple funding opportunities.	Within 5-10 years, develop conservation initiative white papers for targeted sub-bay watersheds.	$200,000 - $1 Million
	Within 5-10 years, continue the GBEP programmatic support for the CAP in the watershed.	$200,000 - $1 Million
	Within 5-10 years, develop grant proposals and funding strategies for acquisition projects.	$200,000 - $1 Million
	Within 10-plus years, place 5,000 acres of important coastal habitat under long-term conservation through fee-simple acquisition, conservation easements, and other mechanisms.	$5 Million - $50 Million

POTENTIAL IMPLEMENTERS

Ducks Unlimited
Galveston Bay Foundation
Houston Audubon
Houston Wilderness
National Fish and Wildlife Foundation
Scenic Galveston
Texas General Land Office Texas Parks and Wildlife Department
The Artist Boat
The Conservation Fund
The Nature Conservancy
Trust for Public Land
U.S. Department of Agriculture Natural Resource Conservation Service
U.S. Fish and Wildlife Service

PERFORMANCE MEASURES

1. List of acquisition projects.
2. Number of conservation initiative white papers completed.
3. Number of acres of habitat under permanent conservation.

REFERENCES

GBP'95: HP-1, HP-2
SAP Reference: Ecosystem and Human Health - Habitat and Landscape Level Conservation: Goal 1 / Objective A / Objective B

HC-2

Habitat Restoration

Objective: Restore habitat form and function where they have been lost or degraded.

Priority Issue: Vital Galveston Bay habitats continue to be lost or reduced in value by a range of human activities, threatening the bay's future productivity. Some bay shorelines are subject to high rates of erosion and loss of stabilizing vegetation due to past subsidence, rise in sea level, and current human impacts.

Description: To address this, the GBEP and its partners are funding projects that restore lost or degraded coastal habitat(s) and conserve adjacent coastal habitat(s), leveraging the GBEP's monies for additional funds, when applicable.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Active restoration plan in each sub-bay watershed of Galveston Bay.	Within 2-5 years, identify coastal areas to target for restoration of lost or degraded coastal habitats, using 1950s aerial imagery as a benchmark.	$200,000 - $1 Million
Adapt restoration projects for submission to multiple funding opportunities.	Within 5-10 years, develop funding strategies for restoration projects that can be adapted to multiple funding sources.	$0 - $200,000
	Within 10-plus years, restore 2,500 acres of lost or degraded coastal habitats.	$5Million – $50 Million

POTENTIAL IMPLEMENTERS

Ducks Unlimited
Galveston Bay Foundation
Houston Wilderness
National Oceanic and Atmospheric Administration Restoration
NRG Energy
Port Houston
Texas A&M AgriLife Extension Service
Texas Community Watershed Partners
Texas General Land Office
Texas Parks and Wildlife Department
Texas Sea Grant
The Nature Conservancy
U.S. Department of Agriculture Natural Resource Conservation Service
U.S. Fish and Wildlife Service

PERFORMANCE MEASURES

1. Habitat Conservation Blueprint (HC-2 and HC-3) updated.
2. Number of acres of restored land.

REFERENCES

GBP'95: HP-1, HP-2
SAP Reference: Ecosystem and Human Health - Habitat and Landscape Level Conservation: Goal 2 / Objective A / Objective B

HC-3

Habitat Enhancement

Objective: Enhance existing habitats to increase overall function and productivity.

Priority Issue: Vital Galveston Bay habitats continue to be lost or reduced in value by a range of human activities, threatening the bay's future productivity. Shoreline management practices do not address negative environmental consequences to the bay or the need for environmentally compatible public access to its resources. Invasive species threaten native species, habitats, and ecological relationships.

Description: To address this, the GBEP and its partners are supporting and funding projects that enhance coastal habitat(s), leveraging the GBEP's monies for additional funds, when applicable.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Active enhancement plan in each sub-bay watershed of Galveston Bay.	Within 2-5 years, identify important coastal areas to target for enhancement of degraded coastal habitats.	$200,000 - $1 Million
Adapt enhancement projects for submission to multiple funding opportunities.	Within 5-10 years, develop funding strategies for enhancement projects that can be adapted to multiple funding sources.	$0 - $200,000
	Within 10-plus years, enhance 5,000 acres of lost or degraded coastal habitats.	$1 Million - $10 Million

POTENTIAL IMPLEMENTERS

Armand Bayou Nature Center
Galveston Bay Foundation
Houston Audubon
Houston Wilderness
Houston Parks and Recreation Department
NOAA Restoration
NRG Energy
Port Houston
Scenic Galveston
Texas Parks and Wildlife Department
Texas Sea Grant
The Artist Boat
The Nature Conservancy
U.S. Department of Agriculture Natural Resource Conservation Service
U.S. Fish and Wildlife Service

PERFORMANCE MEASURES

1. Habitat Conservation Blueprint (HC-2 and HC-3) updated.
2. Number of acres of enhanced land.

REFERENCES

GBP'95: HP-1
SAP Reference: Ecosystem and Human Health - Habitat and Landscape Level Conservation: Goal 2 / Objective A / Objective B

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ACTION PLAN 2 OF 3

SUPPORT SPECIES CONSERVATION (SC)

Fish and wildlife resources are an important gage of the health of Galveston Bay. These resources are a significant driver of human interactions via economic, recreation, and aesthetic pursuits. The conservation of the bay's native species in the watershed is dependent on adequate habitat, freshwater inflows, and water quality. Resource managers seek to protect certain species and, in some cases, return them to sustainable levels. Species management in the Galveston Bay watershed is primarily implemented by supporting habitat conservation projects that sustain or restore native species populations and reduce invasive species.

Invasive species are defined as plants, animals, and other organisms that are "non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (USDA National Agricultural Library, Executive Order 13112). Invasive species compete with native species for resources such as food, light, water, and shelter. They often reproduce faster than native species and are difficult to eradicate. In addition to resource competition, invasive species can be destructive to infrastructure affecting boating, fishing, and hunting and can be devastating to crops, fisheries, forests, and other natural resources. Prevention is crucial to stopping the spread of invasive species (GBF & HARC, 2017, p. 40). Resource managers typically manage invasive species on small scales and work through regulations to prevent future infestations (Gonzalez, 2011, p. 34).

> There are many factors that determine population size of a given species; important among them are habitat quality and quantity, fishing pressure, and numerous natural processes such as reproductive rates, predation, competition and disease (Gonzalez, 2011, p.1).

Status of Species Conservation Implementation

Long-term data suggest most species that reside permanently or periodically in Galveston Bay are doing well, though there are some exceptions. Since 2015, the *Galveston Bay Report Card* assessed trends in shellfish, finfish, colonial waterbirds, and invasive species.

Wildlife in Galveston Bay received an overall letter grade of C on the *2017 Galveston Bay Report Card* which stated that finfish and bird populations are considered adequate and maintaining, while some shellfish populations are deteriorating and require action.

SAV in West Galveston Bay (photo credit: Sarah Bernhardt).




Salicornia mosaic (far left) (photo credit: U.S. Fish and Wildlife Service). Roseate spoonbill (center) (photo credit: Jason Leifester). Blooming cacti at the TAMUG Wetlands Center (top right) (photo credit: Sarah Bernhardt). Oyster reef restoration project (bottom right) (photo credit: Port Houston).

SHELLFISH

Using data collected by the TPWD Coastal Fisheries Division since 2002, the *2017 Galveston Bay Report Card* analyzed blue crabs and two species of shrimp to develop a shellfish grade. While the white shrimp appear to be maintaining their population levels and brown shrimp appear to be recovering, the blue crab population saw a significant decline since 2002. Increased recreational and commercial use of the bay stemming from regional population increases, decreased habitat, and more stress placed system-wide on Galveston Bay influence shellfish populations.

Oysters received an incomplete grade and are addressed separately from other shellfish. Oysters are not only an important fishery, but they also improve water quality and serve as habitat for a variety of other animals. The bay's oyster reefs have significantly declined over time due to the historical overharvesting of oyster shells, the damaging storm surge of Hurricane Ike in 2008, drought, fishing pressure, and disease. Map data describing the distribution of oyster reefs in Galveston Bay were created by the Texas A&M University in 1994 and are out of date. TPWD is in the process of finalizing new oyster reef mapping information.

FINFISH

The *2017 Galveston Bay Report Card* analyzed 12 species of finfish using the same TPWD data. Finfish populations in Galveston Bay maintained levels since 2002, except for gafftopsail catfish and Atlantic croaker, whose populations increased.

COLONIAL WATERBIRDS

Separate from other bird populations in the Galveston Bay watershed, colonial waterbirds appear stable. The *2016 Galveston Bay Report Card* analyzed 16 species of waterbirds, including herons, egrets, gulls, terns, and ibises using Texas Colonial Waterbird Surveys collected over the past 15 years. Per the report, most species analyzed "have not shown either increases or decreases since 2002. Notable exceptions include a moderate increase in royal tern populations and significant increases in populations of tri-colored heron, brown pelican, and laughing gull."

INVASIVE SPECIES

The rivers and bayous flowing into the Galveston Bay watershed are home to established invasive species, causing problems in waterways. Documented invasive species in the watershed include water hyacinth, Chinese tallow, grass carp, armored catfish, fire ants, and zebra mussel (GBF & HARC, 2017, p. 40). There is no designated monitoring program for invasive species in Texas; however, many resource managers and citizen scientists around the state report and track the spread of invasive plants and animals. Per the *2017 Galveston Bay Report Card*, aquatic invasive species are reported to a national database maintained by the U.S. Geological Survey.

The Ladybird Johnson Wildflower Center's Texas Invasives Program also maintains a database of invasive plants and pests reported in Texas. The TPWD and the Texas Department of Agriculture oversee invasive species regulation in Texas, with both agencies maintaining lists of prohibited species. Within the watershed, the NRU subcommittee established a work group to directly address the issue of invasive and non-native species. More information about the Invasive Species Work Group and its efforts is given on page 138.

Species conservation is directly linked to habitat conservation, as all species are dependent on the maintenance of their essential habitats. However, even if habitats are maintained, pressure can be applied to populations from a variety of sources, including climate variability such as extreme flooding and drought, overfishing, or the introduction of invasive species that outcompete native species for their essential habitat.

Other Species Trends

Trends in colonial waterbirds suggest stable populations (GBF & HARC, 2016, p. 33), including some shorebirds that are rare or endangered. Houston Audubon and other bay managers created a system of bird sanctuaries in and around the bay to protect important foraging and nesting areas.

Other wildlife, including reptiles and marine mammals, can be found in the bay. Bottlenose dolphins and three species of sea turtles are increasingly reported. Research intensified to track the habits of these large predators and to collect biological samples to evaluate biomagnification of toxins in the food chain. Sea turtles found in the bay and nesting on the beach appear to respond to conservation efforts (Gonzalez, 2011, p. 48).

Action Plan Overview

The SC Action Plan includes two Actions to restore and sustain native species: **SC-1** will sustain native populations by conserving, protecting, and restoring key terrestrial and aquatic habitats, and directly correlates with **HC-1**, **HC-2**, and **HC-3**. **SC-2** targets habitats affected by invasive species for restoration and application of best land management practices, and directly correlates with **HC-3**.

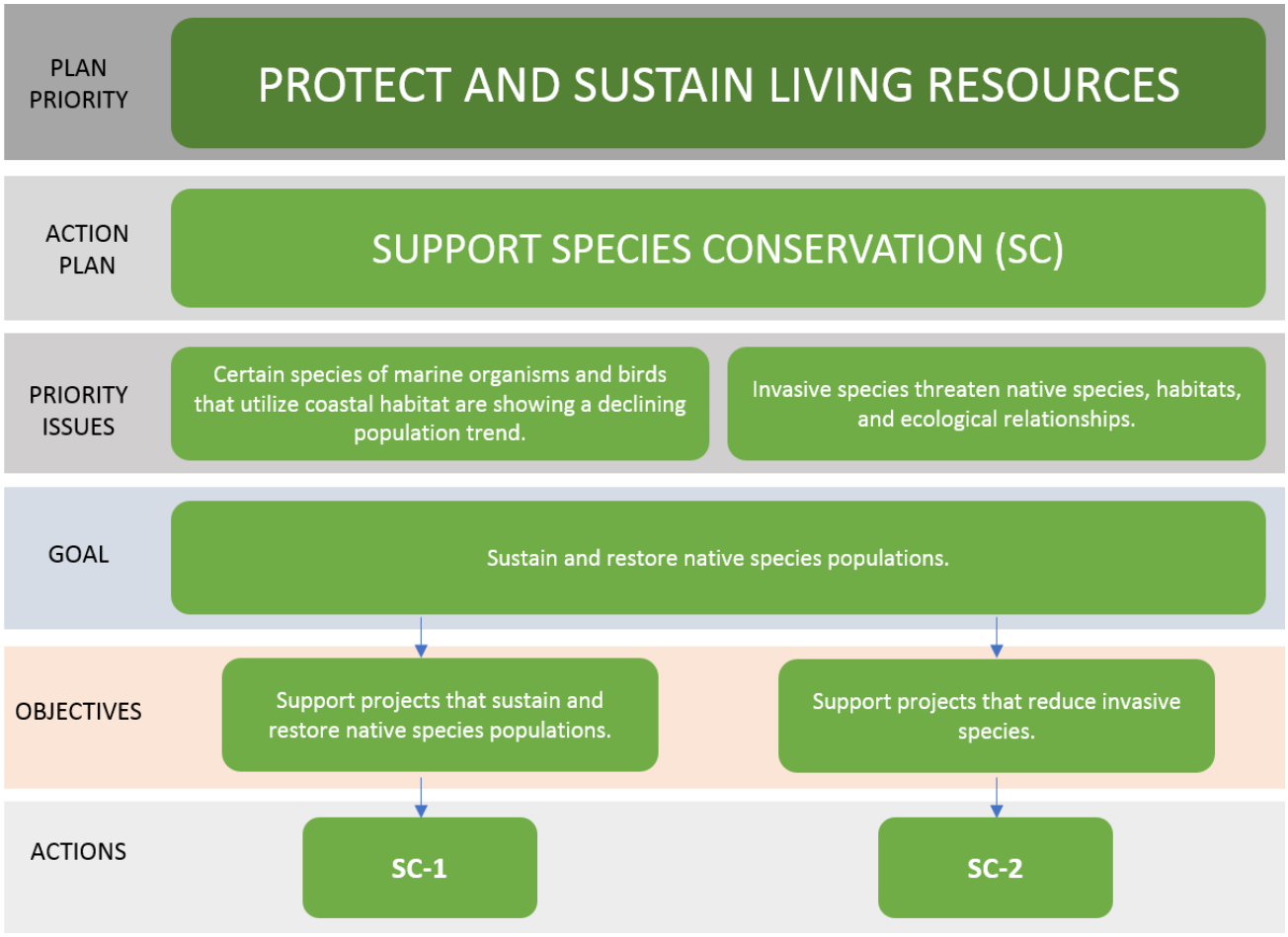
FIGURE 22
SC ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Support Species Conservation (SC)						
	SC-1	Native Species Management		x	x	x
	SC-2	Invasive Species Control		x	x	x

Successful implementation of **SC-1** and **SC-2** requires coordination with the M&R subcommittee of the Council on multiple Actions outlined under Plan Priority Four: Inform Science-Based Decision Making. Those Actions address research on biological, chemical, and physical stressors on aquatic and terrestrial species. Information learned from future research will be applied in decisions made to protect native species and address invasive species control.

Successful implementation of both Actions requires coordination with the M&R and PPE subcommittees of the Council.

FIGURE 23
SPECIES CONSERVATION ACTION PLAN



SC-1

Native Species Management*

Objective: Support projects that sustain and restore native species populations.

Priority Issue: Certain species of marine organisms and birds that utilize coastal habitat are showing a declining population trend.

Description: To address this, the GBEP and its partners are seeking to support and fund projects that enhance coastal habitat(s), leveraging the GBEP's monies for additional funds, when applicable, to sustain and restore native species populations.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Support native species conservation projects on public and private lands.	Within 2-5 years, develop habitat conservation projects based on species needs.	$200,000 - $1 Million
	Within 5-10 years, continue to develop habitat conservation projects based on species needs.	$200,000 - $1 Million
	Within 10-plus years, continue to develop habitat conservation projects based on species needs.	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

American Bird Conservancy
Armand Bayou Nature Center
Audubon Texas
Bayou Preservation Association
Ducks Unlimited
Galveston Bay Foundation
Gulf Coast Bird Observatory
Houston Audubon
Houston Wilderness
National Oceanic and Atmospheric Administration Restoration
NRG Energy
Texas A&M AgriLife Extension Service
Texas Community Watershed Partners
Texas General Land Office
Texas Parks and Wildlife Department
The Nature Conservancy
U.S. Department of Agriculture Natural Resource Conservation Service
U.S. Fish and Wildlife Service

PERFORMANCE MEASURES

1. Habitat Conservation Blueprint (HC-2 and HC-3) updated.
2. Number of projects with native species managed and enhanced.

REFERENCES

GBP'95: SP-1
SAP Reference: Ecosystem and Human Health - Sustaining Species Populations: Goal 1 / Objective D

**This Action and its corresponding Activities, represent a holistic approach to habitat conservation and are a are a part of a larger effort.*

SC-2

Invasive Species Management*

Objective: Support projects that reduce invasive species.

Priority Issue: Invasive species threaten native species, habitats, and ecological relationships.

Description: To address this, the GBEP and its partners are seeking to support and fund projects that enhance coastal habitat(s) by reducing invasive species, leveraging the GBEP's monies for additional funds, when applicable.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Support invasive species management on public and private lands.	Within 2-5 years, identify important coastal areas to target for enhancement of degraded coastal habitats.	$0 - $200,000
	Within 5-10 years, develop funding strategies for enhancement projects that can be adapted to multiple funding sources.	$0 - $200,000
	Within 10-plus years, enhance 5,000 acres of lost or degraded coastal habitats (please see **HC-3**).	$1 Million - $500 Million

POTENTIAL IMPLEMENTERS

Armand Bayou Nature Center
Ducks Unlimited
Galveston Bay Foundation
Houston Audubon
HARC
Houston Parks and Recreation Department
Houston Wilderness
NOAA Restoration
NRG Energy
Texas A&M AgriLife Extension Service
Texas Community Watershed Partners
Texas General Land Office
Texas Parks and Wildlife Department
The Nature Conservancy
U.S. Department of Agriculture Natural Resource Conservation Service
U.S. Fish and Wildlife Service

PERFORMANCE MEASURES

1. Habitat Conservation Blueprint (HC-2 and HC-3) updated.
2. Number of projects with invasive species managed, including the type and amount of invasives completed.

REFERENCES

GBP'95: SP-10
SAP Reference: Ecosystem and Human Health - Sustaining Species Populations: Goal 2 / Objective A / Objective B

**This Action and its corresponding Activities, represent a holistic approach to habitat conservation and are a are a part of a larger effort.*

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ACTION PLAN 3 OF 3

SUSTAIN FRESHWATER INFLOWS (FWI)

Environmental flows describe the quantity, quality, and timing of water flows needed to maintain ecologically healthy streams and rivers, as well as the bays and estuaries that they feed (Texas Water Development Board, *Texas Instream Flow Program*). Environmental flows are broken down into instream flow (the amount of water running in a river or stream) and freshwater inflow.

Freshwater inflow is the freshwater that flows into an estuary from rivers, streams, and creeks. This includes the contribution of wastewater effluent discharges, return flows (water that returns to surface or ground water after human use), and stormwater runoff into the bay and its tributaries. Galveston Bay's productivity is a result of the mixing of freshwater from the Trinity River, San Jacinto River, and area bayous and creeks with saltwater from the Gulf of Mexico.

Freshwater inflows carry nutrients and sediment to bay systems while reducing salinity ranges and maintaining a salinity gradient (change in salinity with depth). Tidal influences can move coastal saltwater miles up tributaries while the mass of freshwater inflows can extend miles into the Gulf. Bays and estuaries rely on a specific range of salinity and nutrient levels and sediment deposition to maintain optimal productivity and ecosystem services.

Adequate nutrient concentrations, along with a range of natural salinity levels, offer ideal conditions for phytoplankton and other organisms at the bottom of the food chain to thrive, while an adequate rate of sedimentation allows for the stabilization of wetland areas and salt marshes.

Estuarine species can generally survive a wide range of salinities, and can tolerate salinity extremes for brief periods. However, each species has an optimum range of salinity and temperature, and prolonged exposure outside of this range can be detrimental.The optimum salinity range for oysters is between 15-30 parts per thousand (ppt) (Hofstetter 1990). Changes to the natural volume, timing, and quality of freshwater inflow may impact the productivity of economically important and ecologically characteristic species. For example, a 2010 Texas A&M University-Galveston (TAMUG) study found oyster production increases in bay areas with lower salinity levels and suitable substrate (Quigg, A. et al, 2010). Ensuring adequate freshwater inflows to Galveston Bay will result in positive economic benefits to the region.

A Note About the Salinity of Galveston Bay

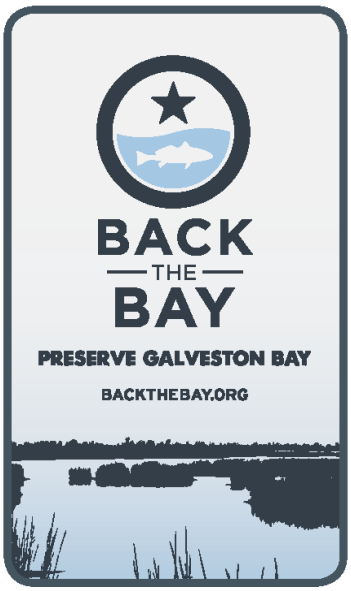
"During times of drought in the lower Galveston Bay watershed, the salinity of the bay system may range from 20 practical salinity units (psu) at the Trinity River delta to 35 psu at Bolivar Roads. When the Trinity River or all tributaries are under flood conditions, the salinity will be 0 psu well into Trinity Bay and less than 15 psu at Bolivar Roads.

In times of normal flow, salinity ranges from less than 10 psu in upper Trinity Bay to around 30 psu at Bolivar Roads, but there is typically a tidal wedge of high salinity water, greater than 30 psu, in the bottom of the Houston Ship Channel. A salinity wedge also reaches up the Trinity River; its existence is the cause of the U.S. Army Corps of Engineers Wallisville Lake Project on the Trinity River just west of Lake Anahuac (Lester, 2011a, p. 9)."

Status of Freshwater Inflows Implementation

Management of water supplies and the consideration of environmental flows have evolved since development of *GBP'95*. The GBEP and its partners created the Galveston Bay Freshwater Inflow Group (GBFIG) in 1996 to develop strategies to maintain adequate freshwater inflows to Galveston Bay. Texas Senate Bill 1, passed in 1997, established 16 Regional Water planning groups for the state to determine how to meet future water needs over a fifty-year planning horizon. Region H is the planning body for much of the lower portion of the Galveston Bay watershed. The GBFIG developed environmental flow recommendations and encouraged Region H to consider those flows when modeling available freshwater and developing regional freshwater management plans (HARC, 2017). Texas Senate Bill 2, passed in 2001, focuses on an instream flow data collection and study process for Texas' rivers.

In 2007, the 80th Texas Legislature passed Senate Bill 3, which tasked TCEQ to develop environmental flow standards for Texas' rivers and bays using a stakeholder approach. The legislation established the Environmental Flows Advisory Group and the Science Advisory Committee. The Environmental Flows Advisory Group formed the Basin and Bay Area Stakeholder Committee (BBASC) for each basin and bay system and the stakeholder committee appointed a Basin and Bay Expert Science Team (BBEST) for their basin. The Trinity and San Jacinto Rivers and Galveston Bay BBEST was appointed on December 1, 2008, and was tasked with recommending an environmental flow regime for the Trinity and San Jacinto Rivers and Galveston Bay based solely on scientific information (TCEQ, 2017).





Back the Bay campaign material (far left). A view from the Coastal Heritage Preserve in Galveston (center). A U.S. Fish and Wildlife Service aerial image (top right). Wetland in the Galveston Bay estuary (bottom right) (photo credits: Sarah Bernhardt).

The BBEST recommendations were submitted to the the BBASC in November 2009 and to the Environmental Flows Advisory Group and TCEQ in May 2010. The TCEQ adopted environmental flow standards for the Trinity and San Jacinto Rivers and Galveston Bay in April 2011. Following adoption, BBASC, assisted by the BBEST, prepared and submitted a work plan in 2012 that:

- establishes a periodic review of the environmental flow recommendations and a schedule for continuing validation or refinement of them, and
- prescribes monitoring and studies.

As stated by the Trinity and San Jacinto Rivers and Galveston Bay BBEST, the status of the systems "…are healthy and sound ecological environments" (Trinity and San Jacinto and Galveston Bay Basin and Bay Expert Science Team, 2009, p. 4). However, climate variability, such as increasing frequency of extreme drought and flood events, and population growth present emerging challenges that may affect the availability of freshwater inflows in the future and the bay's productivity. The 83rd, 84th, and 85th Texas Legislatures appropriated funds to the Texas Water Development Board for the continued study of environmental flows and to support the work plans for adaptive management.

FIGURE 24
FWI ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Sustain Freshwater Inflows (FWI)						
	FWI-1	Regional Planning for Freshwater Inflows	x	x	x	
	FWI-2	Freshwater Inflows Research and Management	x	x		x
	FWI-3	Water Conservation and Education	x	x	x	

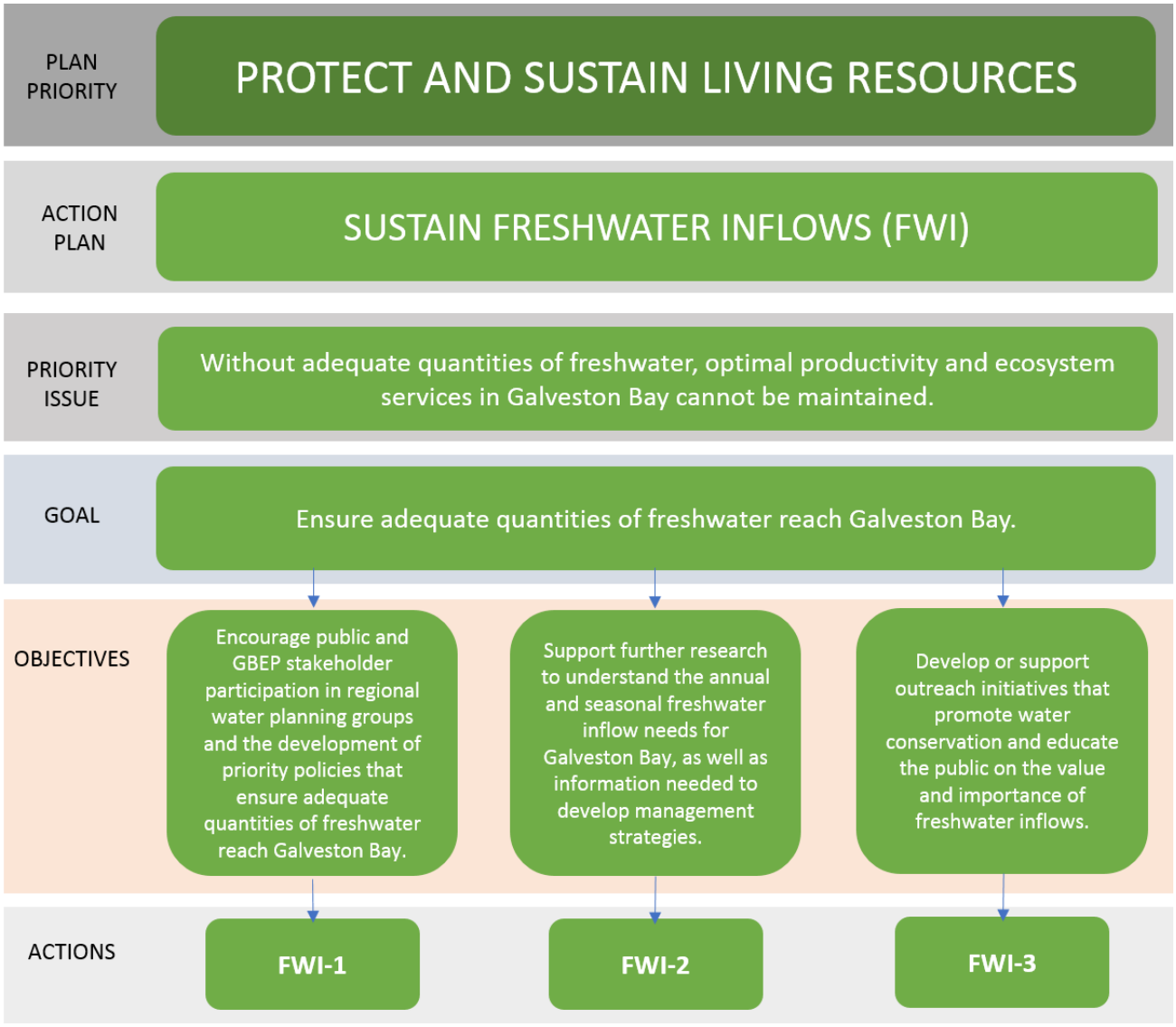
Action Plan Overview

The FWI Action Plan includes three Actions to ensure there are adequate levels of freshwater inflows. The GBEP and its partners will encourage public and stakeholder participation in regional water planning groups and development of priority policies that ensure adequate quantities of freshwater inflows to Galveston Bay (**FWI-1**). It is also essential to support research that aids in understanding the annual and seasonal freshwater inflow needs for Galveston Bay, as well as information needed to develop management strategies (**FWI-2**). Developing and / or supporting outreach initiatives that promote water conservation and educate the public on the value and importance of freshwater inflows is the third crucial component to ensuring there are adequate levels of freshwater inflows in Galveston Bay (**FWI-3**).

Successful implementation of regional planning efforts (**FWI-1**) and water conservation and education programs (**FWI-3**) require coordination with the PPE subcommittee of the Galveston Bay Council on Actions **SPO-1** and **PEA-2**, included under Plan Priority Three: Engage Communities. Similarly, supporting research that aids in understanding of freshwater inflows (**FWI-2**) closely aligns with Action **ACS-2**, and will also be coordinated between the NRU and M&R subcommittees.

More information about **SPO-1** is on page 108. More information about **PEA-1** is on page 116. More information about **ACS-2** is on page 142.

FIGURE 25
FRESHWATER INFLOWS ACTION PLAN



FWI-1

Regional Planning for Freshwater Inflows

Objective: Encourage public and GBEP stakeholder participation in regional water planning groups and the development of priority policies that ensure adequate quantities of freshwater reach Galveston Bay.

Priority Issue: Without adequate quantities of freshwater, optimal productivity and ecosystem services in Galveston Bay cannot be maintained.

Description: The GBEP and its partners are encouraging public participation in regional water planning efforts and the development of priority policies that ensure adequate quantities of freshwater reach Galveston Bay.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Develop partnerships to inform public of opportunities to comment on regional water planning.	Within 2-5 years, identify opportunities to participate in the regional water planning processes to ensure the rules that govern the regional water plans better protect water for wildlife (specific goals to be determined, could include increasing the number of partners each year).	$0 - $200,000
	Within 5-10 years, work with partners to create a plan and materials to address key issues.	$0 - $200,000
	Within 10-plus years, see completion of plan items to address key issues.	$0 - $200,000

POTENTIAL IMPLEMENTERS

City of Fort Worth
City of Houston
City of Dallas
Galveston Bay Foundation
National Wildlife Federation
Sierra Club
Texas Living Waters Project
Texas Parks and Wildlife Department
Texas Water Development Board
U.S. Department of Agriculture - Natural Resource Conservation Service
Other water authorities, including Trinity River Authority, North Fort Bend Water Authority, Gulf Coast Water Authority, Gulf Coast Authority, San Jacinto River Authority, and others

PERFORMANCE MEASURES

1. Plan to address key issues of fresh water inflows completed.
2. Number of resource materials developed to address key issues of fresh water inflows.
3. Number of people reached with fresh water inflow resource materials and outreach.

REFERENCES

GBP'95: None
SAP Reference: Freshwater Inflow and Bay Circulation: Goal 1 / Objective A / Objective B / Objective C

FWI-2

Freshwater Inflows Research and Management

Objective: Support further research to understand the annual and seasonal freshwater inflow needs for Galveston Bay, as well as information needed to develop management strategies.

Priority Issue: Without adequate quantities of freshwater, optimal productivity and ecosystem services in Galveston Bay cannot be maintained.

Description: To ensure adequate quantities of freshwater reach Galveston Bay, the GBEP and its partners are supporting further research to understand the annual and seasonal freshwater inflow needs for Galveston Bay, as well as information needed to develop management strategies.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Support research to understand the annual and seasonal freshwater inflow needs for Galveston Bay, as well as information needed to develop management strategies.	Within 2-5 years, present at the State of the Bay Symposia.	$0 - $200,000
	Within 2-5 years, collect data and share results and partner publications on the GBEP website.	$200,000 - $ 1 million
	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
	On a cycle of every 5-10 years, use research data to contribute to the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Houston Wilderness
Local Municipalities
National Wildlife Federation
NOAA
NOAA Fisheries
Texas A&M University - Galveston
Texas Living Waters Project
Texas Parks and Wildlife Department
Texas Water Development Board
U.S. Fish and Wildlife Service
U.S. Geological Survey
University of Houston - Clear Lake

PERFORMANCE MEASURES

1. Number of research studies addressing the annual and seasonal freshwater inflow and freshwater management needs of Galveston Bay completed.
2. Number of freshwater inflow white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: None
SAP Reference: Freshwater Inflow and Bay Circulation: Goal 1 / Objective A / Objective B / Objective C

FWI-3

Water Conservation and Education

Objective: Develop or support outreach initiatives that promote water conservation and educate the public on the value and importance of freshwater inflows.

Priority Issue: Without adequate quantities of freshwater, optimal productivity and ecosystem services in Galveston Bay cannot be maintained.

Description: To ensure adequate quantities of freshwater reach Galveston Bay, the GBEP and its partners are developing or supporting outreach initiatives that promote water conservation and educate the public on the value and importance of freshwater inflows. These efforts will leverage and build upon existing outreach and awareness initiatives.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Develop or support outreach initiatives that promote water conservation and educate the public on the value and importance of freshwater inflows.	Within 2-5 years, create regional initiatives plan that supports water conservation and the value of freshwater inflows (specific goals to be determined, could include increasing the number of partners each year).	$0 - $200,000
	Within 5-10 years, see significant progress on regional initiatives plan items (50% of goals met).	$200,000 - $1 million
	Within 10-plus years, see completion of all regional initiatives plan items (100% of goals met).	$200,000 - $ 1 million

POTENTIAL IMPLEMENTERS

Galveston Bay Foundation
Local Municipalities
National Wildlife Federation
Texas Living Waters Project
Texas Water Development Board
Other water authorities, including Trinity River Authority, North Fort Bend Water Authority, Gulf Coast Water Authority, Gulf Coast Authority, San Jacinto River Authority, and others

PERFORMANCE MEASURES

1. Regional plan for water conservation completed.
2. Number of partners supporting the water conservation plan.
3. Number of regional plan initiatives completed.

REFERENCES

GBP'95: None
SAP Reference: Freshwater Inflow and Bay Circulation: Goal 1 / Objective A / Objective B / Objective C

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Plan Priority Three:
Engage Communities

To protect and sustain Galveston Bay for future generations, the GBEP and its partners must effectively engage the communities in and around the lower portion of the Galveston Bay watershed.

An outreach professional explains the importance of using native plants in landscaping to prevent runoff pollution (photo credit: Houston-Galveston Area Council.

The Galveston Bay watershed is home to a significant portion of Texas' total population. Nearly 5.4 million people live in the five counties that surround Galveston Bay (U.S. Census Bureau, Population Division, 2016), and millions more visit the region each year to take advantage of its fishing and ecotourism opportunities.

Protecting and promoting the health of Galveston Bay are important. But communicating *why* to residents and visitors is a challenge. Long-term success in environmental awareness and stewardship takes time and is not simple. It is the result of repeated interactions with the public and engagement on a topic, such as the Texas Department of Transportation's "Don't mess with Texas" campaign, which has used the same slogan for more than 30 years with great success.

Long-term success requires people to go one step beyond their usual actions to understand what stewardship means by being conscious of what protects and promotes the health of Galveston Bay. Consciousness can lead to action, such as deciding to pour fats, oils, and grease (FOG) into a separate container and into the trash instead of pouring them down the drain, or tossing an empty soda can in the recycling bin instead of on the ground. To adequately engage communities, two Action Plans are identified.

ACTION PLANS

Preserve Galveston Bay Through Stakeholder and Partner Outreach

Support Public Education and Awareness Initiatives

The two Action Plans identified under this Plan Priority were developed primarily through the PPE subcommittee of the Council.

Common Engagement Terms
Frequently, terms associated with community engagement are used interchangeably. However, there are many variations. Below are some definitions to avoid ambiguity.

The "**public**" refers to all people in the Galveston Bay watershed. This is the broadest and most inclusive audience category.

A "**stakeholder"** could be an elected official, government employee, nonprofit organization employee, local business owner, land owner, volunteer, recreational bay user, or industry representative.

A "**partner**" is any person, group, or entity actively working in the Galveston Bay Watershed to implement *GBP'18*. More information about the GBEP partners is available at www.gbep.texas.gov/partners.

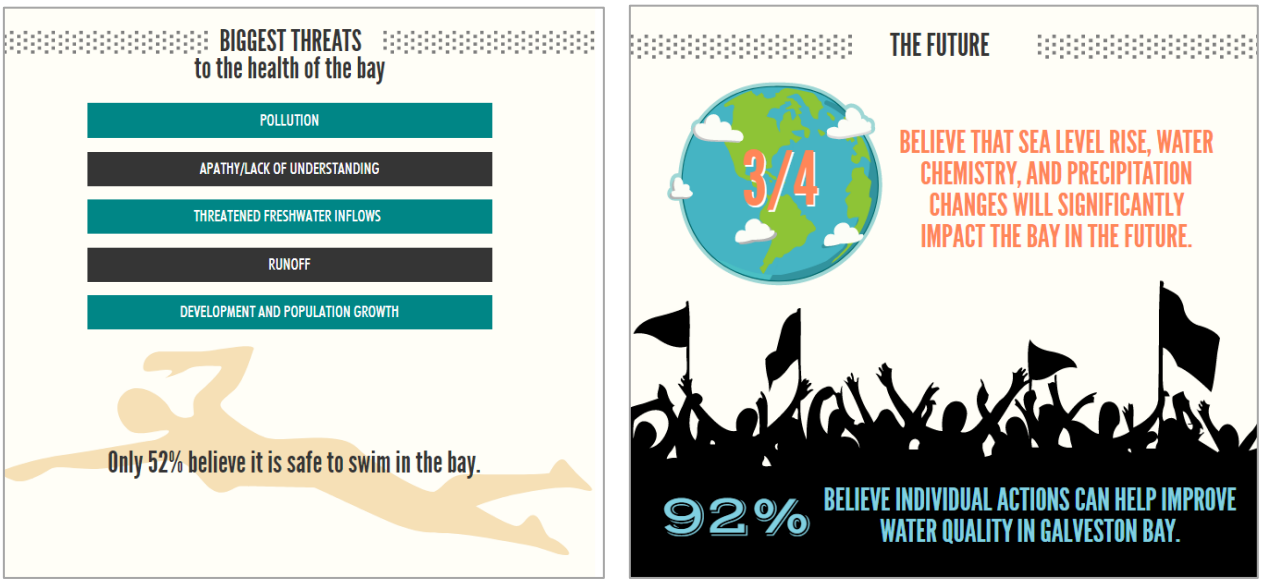
"**Education**" refers to efforts to increase the knowledge of specific audiences through intentional, structured communications or trainings. Specific audiences might include K-12 students, college students, teachers and instructors at all academic levels, or adult members of the public.

"**Outreach**" refers to any attempt to engage the public, stakeholders, or partners in activities or discussions that enhance connection to Galveston Bay. Typically, outreach activities apply to a broad audience with a less specific structure.

FACTORS THAT INFLUENCE PLAN PRIORITY

Population growth and shifts in land use contribute to how people relate to the natural environment and drive this Plan Priority. As the population in and around Galveston Bay continues to grow, the built environment increases and natural areas shrink, limiting opportunities for regular interactions with the natural environment.

Sixty-four percent of the households in the five counties surrounding the lower Galveston Bay watershed are one mile or less from a body of water, with 95 percent of households within five miles of a major water body (H-GAC Socioeconomic Modeling Group, 2016). A resilient Galveston Bay depends on an informed and supportive public that feels personally invested in its health.



A portion of the results from the Galveston Bay Foundation and HARC's online community surveys in 2014. (graphic credit: Galveston Bay Foundation and HARC).

From 2010 to 2014, to help inform the direction of the Back the Bay campaign and develop key messages to be used, surveys were conducted in the five-county region to gauge the public awareness level of Galveston Bay. Sixty percent of the public said their daily activities had little impact on the overall health of Galveston Bay. The results also showed that those who understood that their neighborhood storm drains connect to Galveston Bay were more likely to feel their daily activities impact the bay.

The survey also demonstrated that those who spend time outdoors have a higher awareness level of their personal connection to the bay. A 2014 survey revealed more than 60 percent of respondents consider Galveston Bay to be valuable to their community; however, 55 percent said their daily lives have little impact on the bay. A disconnect in the area between personal impact and the value of the region's natural resources continues to create a challenge to the environmental stewardship community to educate and inform.

Beginning in 2014, the Galveston Bay Foundation conducted a series of community surveys to improve understanding of the public's knowledge about Galveston Bay issues. Seventy-six percent of survey respondents were supportive of increased legal protection of habitats around Galveston Bay. Ninety-two percent of respondents stated that individual actions can help improve water quality in Galveston Bay (*The Galveston Bay Report Card*, 2015). These numbers indicate people realize the bay is an important regional ecosystem and have an interest in protecting and maintaining its productivity. But the need to bridge the gap between understanding and action persists.

Turning awareness into action to preserve the region's most valuable natural resource is a persistent challenge. Continuing to measure public awareness levels and opinions will help guide education and outreach efforts for the benefit of Galveston Bay.

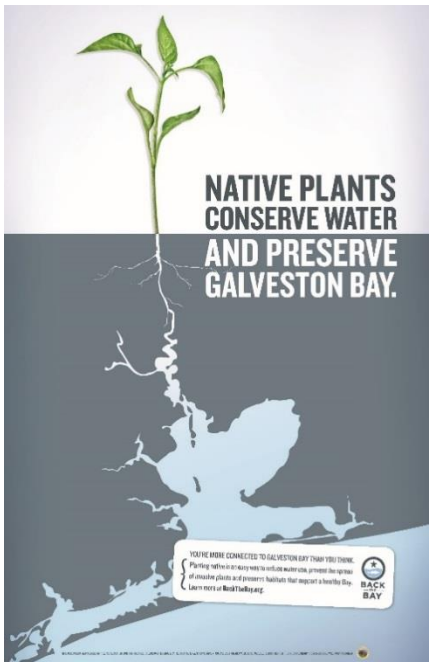
BUILDING ON PAST SUCCESS

The GBEP and its partners have developed and supported many successful PPE programs since 1989 to foster a sense of connectedness to the bay, including Bay Day, Marsh Mania, Galveston Bay Watershed Academic Partnership, the Galveston Bay Drive and Discover Guide, multiple State of the Bay symposia, and public outreach efforts surrounding the creation of the *SAP*. A few key programs are highlighted in the text that follows.

Back the Bay supports the development of campaign materials aimed at educating homeowners about nonpoint source pollution.

BACK THE BAY

Back the Bay, the most notable of the GBEP's PPE campaigns, began with a pilot concept in 2010 as an outcome of the *SAP* stakeholder engagement process. It aims to improve the environmental quality of Galveston Bay by increasing public awareness about the bay's value. Back the Bay is a programmatic vehicle for smaller, more targeted campaigns and environmental attitude and behavior assessments. To deliver the message, the campaign takes a watershed approach, originating from the bayous of metropolitan Houston, flowing to wetlands used by waterfowl hunters, and ending with the users of Galveston Bay.



Back the Bay campaign targeting water conservation and the use of native plants in Galveston Bay.

While working in the metroplex of the fourth-largest city in the United States is challenging, the campaign aims to bring together a diverse group of stakeholders. Its success serves as a case study for working in a large, diverse, urban watershed in an economically driven region under the administration of a state regulatory agency.

In 2012, Back the Bay was awarded a $1 million grant from the CIAP, making it the first public awareness campaign to receive a CIAP grant. The campaign successfully leveraged those funds and in-kind services from television and radio stations and newspapers in the 10th-largest media market in the U.S. to reach over five million people. The campaign garnered success by using a consistent message throughout the region and by leveraging partnerships. Organizations incorporated the campaign's messaging and creative materials into their outreach and education efforts.

Advertisement for the GBAN pollution reporting and monitoring tool.

GALVESTON BAY ACTION NETWORK

The Galveston Bay Action Network (GBAN) is an online pollution reporting and monitoring tool created by the Galveston Bay Foundation. By reporting pollution seen in the Houston-Galveston region, people can help protect both human health and natural resources. Oil and chemical spills, trash, dumping of waste, and illegal discharge of boat sewage have the potential to harm the environment and threaten the health of people, plants, and animals. Waterways that are abnormally colored or have an unusual odor, submerged vessels, and bird and fish kills should also be reported through the GBAN online tool. The public can report any type of pollution they see in the four counties surrounding Galveston Bay (Harris, Galveston, Brazoria, and Chambers) using their desktop or mobile device. Reports are automatically sent to the proper authority who can respond to the report.

This tool provides people with one location to report all pollution, resulting in the quickest response to get the pollution cleaned up. Reporting activities that negatively impact water quality, whether intentional or unintentional, can help protect Galveston Bay. The tool includes an interactive map of the reports that have been submitted.

At the GBAN website (http://www.galvbay.org/GBAN), people can report pollution or view past reports, as well as download the app from the app store.

STATE OF THE BAY SYMPOSIA

The GBEP serves as a clearinghouse for Galveston Bay-related activities and information through events such as the State of the Bay Symposia. The GBEP hosted 10 symposia from 1989 to 2017, spanning a broad range of topics relevant to Galveston Bay.

More than 300 people attended the 2016 Symposium representing business, government agencies, universities, nonprofit organizations, and the public. Program staff collaborated with regional partners on assembling a diverse group of expert speakers to explore means of sustaining Galveston Bay amid the Houston-Galveston region's rapidly growing population.

GALVESTON BAY DRIVE AND DISCOVER GUIDE

In 2013, the GBEP partnered with the Galveston Bay Foundation to update the 2004 *Galveston Bay Drive and Discover* guide with a new print document and free mobile app. This was one of the most successful outreach publications for the GBEP, with 40,000 copies distributed to visitor centers, libraries, and events. The publication blends both the human and natural history of Galveston Bay into an easy-to-understand guide for visiting points of historic, geologic, and environmental interest.

A GBEP partner hosts a Community Health And Resource Management (CHARM) workshop and live demonstration (photo credit: Houston-Galveston Area Council).

ACTION PLAN 1 OF 2

PRESERVE GALVESTON BAY THROUGH STAKEHOLDER AND PARTNER OUTREACH (SPO)

As a crucial regional resource, the bay must be managed to ensure its productivity and ecological diversity on a long-term, sustainable basis. The GBEP and its partners are involved in efforts to create a resilient Galveston Bay and estuary. However, comprehensive monitoring and cutting-edge research will not bring about change unless outcomes are communicated adequately to inspire the public toward action and behavioral change. The GBEP supports ongoing stewardship opportunities which ensure greater interest in the bay. People are more likely to protect and preserve Galveston Bay when they understand and feel connected to it.

As a non-regulatory program, stewardship is encouraged through voluntary regional efforts. Working with local governments, offering workshops and trainings, and supporting volunteer programs, such as Texas Stream Team, fosters engagement and connection. The GBEP can use existing stakeholder and partner relationships for strategic outreach to let people know they have an interest in protecting and preserving this resource. It is also crucial to identify barriers and benefits to needed behavioral changes so strategies can be developed to reach targeted communities. This starts with research to discover what inhibits individuals from engaging in behaviors that positively influence the health of Galveston Bay and then understanding what would encourage them to adapt sustainable practices. Once this baseline information is gathered, these data will be used to create and support stakeholder and partner outreach programs.

Example of Stakeholder and Partner Outreach Action Implementation

Since release of *GBP'95*, the GBEP has established, supported, and implemented successful programs and campaigns with its stakeholders and partners to engage communities in a resilient Galveston Bay. One notable effort, Cease the Grease, seeks to reduce sanitary sewer overflows from FOG through targeted outreach. Established by the City of Dallas, this effort was adapted for Galveston Bay through a partnership of 21 public and private partner entities, led by the Galveston Bay Foundation. All partners use common branding and consistent messaging to inform homeowners, apartment residents, schools, public works departments, restaurants, and hotels about the importance of properly disposing of FOG.

Youth education is a crucial component of Trash Bash. At the 2017 event, 56 percent of volunteers were under 18 years of age (photo credit: Trash Bash).

The River, Lakes, Bays 'N Bayous Trash Bash® (Trash Bash) is an example of a coordinated stakeholder and partner campaign with which the GBEP has an extensive network of partners and

volunteers. Trash Bash is the largest single-day waterway cleanup effort in the state of Texas. This award-winning cleanup event takes a two-pronged approach to engage with volunteers. First, it provides volunteers with tools and guidance to participate in the removal of trash from along waterways. Second, educational games and displays are incorporated, covering topics about common trash items, the timeline of trash breaking down, demonstrations for water conservation, and how trash affects the bay and coastal habitats. Between 1994 and 2017, 105,800 volunteers helped collect 2,189 tons of trash, recycle 16.33 tons of trash, recover 10,709 tires, and clean up 1,447 miles of shoreline. The Trash Bash website provides more about this annual event.

Building relationships with communities and community leaders is vital to foster sustainable behavior change. This means centering outreach and education within the community and taking the community's interests, issues, and capacities into consideration when developing programs and campaigns. The GBEP and partners support developing and strengthening stakeholder connections through community-based social marketing and community engagement efforts such as those identified in the "Guidelines for Excellence: Community Engagement" provided by the North American Association for Environmental Education.

Action Plan Overview

The SPO Action Plan includes four Actions to engage stakeholders and partners through outreach. **SPO-1** will increase stakeholders' and partners' sense of responsibility in the health of Galveston Bay by promoting new and existing stewardship and volunteer opportunities in the watershed. By increasing the number of events and workshops (**SPO-2**), stakeholders will have more opportunities to engage with partners in the region. Engaging local governments in conversations about key estuary issues and decision making (**SPO-4**) and expanding and supporting existing regional programs, such as the GBEP's Back the Bay campaign (**SPO-3**), can reinforce the relevance of Galveston Bay in the lives of stakeholders.

FIGURE 26
SPO ACTION PLAN MATRIX

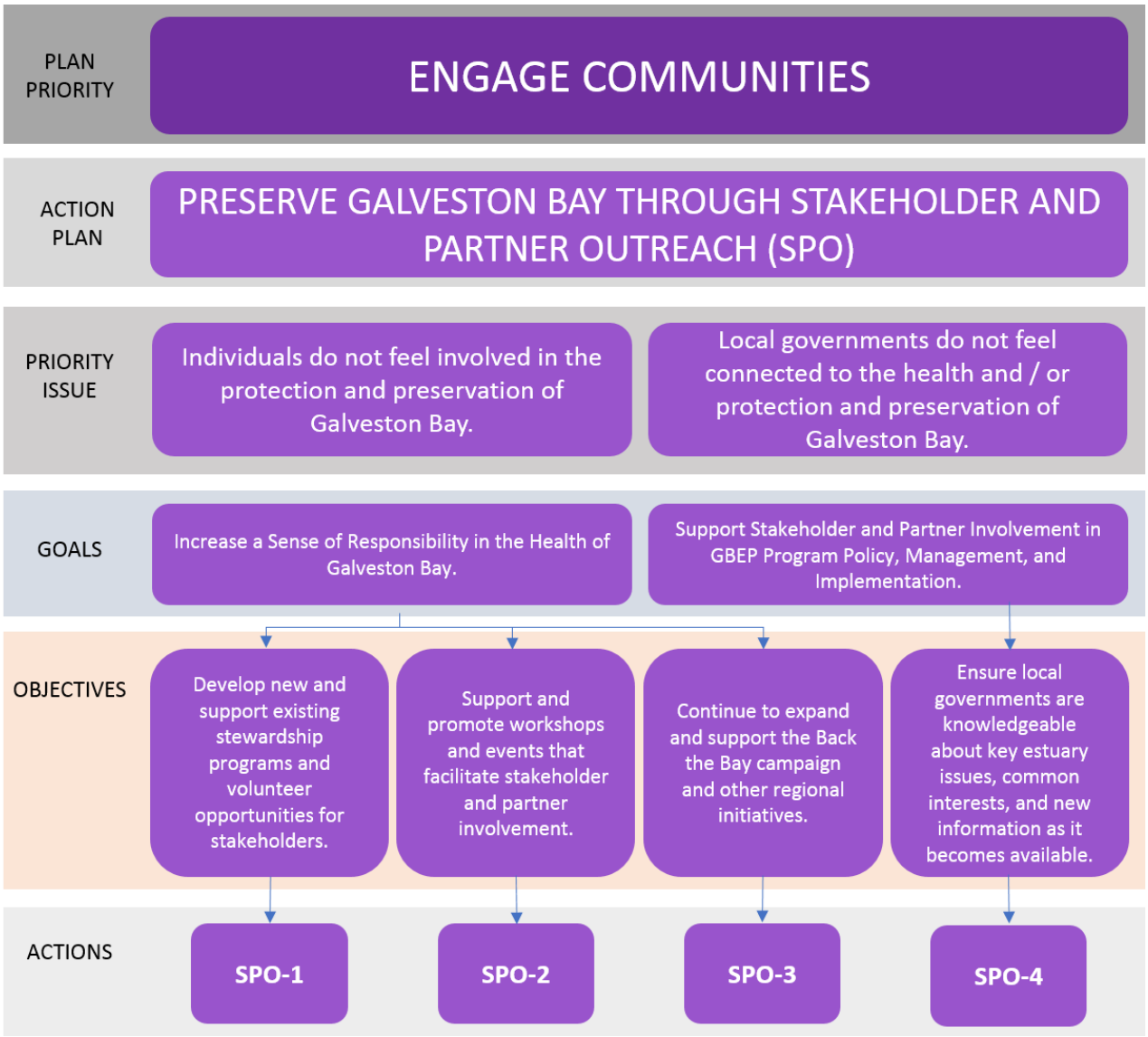
ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Preserve Galveston Bay Through Stakeholder and Partner Outreach (SPO)						
	SPO-1	Stewardship Programs and Volunteer Opportunities	x	x	x	
	SPO-2	Workshops and Events	x	x	x	
	SPO-3	Support Regional Initiatives	x	x	x	x
	SPO-4	Local Government Outreach	x	x	x	x

Successfully instilling a sense of responsibility for the health of Galveston Bay (**SPO-1)** supports Plan Priority One: Ensure Safe Human and Aquatic Life Use, specifically **NPS-2**, **PS-1**, **PHA-1**, and **PHA-2**. These efforts should be coordinated between the PPE and WSQ subcommittees. Successful implementation of Actions **SPO-3** and **SPO-4**

supports all four Plan Priorities of *GBP'18* and are necessary for the protection and preservation of Galveston Bay. Programming for these efforts should be coordinated between the PPE, WSQ, NRU, and M&R subcommittees.

Information about **NPS-2** is on page 49. Information about **PS-1** is on page 57. Information about **PHA-1** is on page 64. Information about **PHA-2** is on page 65.

FIGURE 27
STAKEHOLDER AND PARTNER OUTREACH ACTION PLAN



SPO-1

Stewardship Programs and Volunteer Opportunities

Objective: Develop new and support existing stewardship programs and volunteer opportunities for stakeholders.

Priority Issue: Individuals lack a sense of ownership and / or responsibility for the health of Galveston Bay.

Description: The GBEP and its partners are continuing to develop, support, and promote stewardship programs and volunteer opportunities for stakeholders, industry, and government. Opportunities include the GBEP subcommittee participation, project stakeholder meetings, events, and volunteer programs that allow participants to become ambassadors of Galveston Bay. Program types include, but are not limited to, conservation work, water quality management, invasive species management, and trash clean up events.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Develop list of existing stewardship and volunteer programs.	Within 2-5 years, develop database of existing programs.	$0 - $200,000
Identify new or underserved geographies and communities in need of stewardship or volunteer programs.	Within 2-5 years, identify new geographies and communities.	$0 - $200,000
Create stewardship plan to provide stewardship and volunteer activities to underserved geographies and communities.	Within 2-5 years, create stewardship plan to support existing (or create) 10 programs.	$0 - $200,000
Support and fund existing and new stewardship and volunteer programs.	Within 5-10 years, see a measurable increase in existing program participation (specific to programs already supported, such as Texas Stream Team and Trash Bash).	$0 - $200,000
	Within 5-10 years, support five additional programs (or 50% goal met), per the stewardship plan.	$200,000 - $1 Million
	Within 10-plus years, support five additional programs (or 100% goal met), per the stewardship plan.	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

Bayou Preservation Association
Galveston Bay Foundation
HARC
Sierra Club
H-GAC
Houston Zoo
Student Conservation Association
Texans for Clean Water
Texas Audubon
Texas Conservation Fund
Texas City - La Marque Community Advisory Council
Various Partners (Including Industry)

PERFORMANCE MEASURES

1. Evaluation and plan to support stewardship and volunteer programs completed.
2. Evaluation and plan to reach underserved geographies and communities completed.
3. Number of existing programs supported by the stewardship plan.
4. Number of new programs created in underserved communities.
5. Evaluation of program success and number of people reached completed.

REFERENCES

GBP'95: PPE-1, PPE-5 PPE-6
SAP Reference: Public Awareness: Goal 2 / Objective B

SPO-2

Workshops and Events

Objective: Support and promote workshops and events that facilitate stakeholder and partner involvement.

Priority Issue: Individuals do not feel involved in the protection and preservation of Galveston Bay.

Description: To facilitate broad stakeholder and partner involvement in estuary program policy, management, and implementation, the GBEP and its partners are continuing to host and expand the State of the Bay Symposia on a three-year schedule. The GBEP and its partners are supporting existing workshops and events hosted by stakeholders and partners in “off years” and exploring opportunities for new workshops or events.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Continue the regular State of the Bay Symposia to ensure key target audiences are reached.	Within 3 years, host symposia. Complete events database.	$0 - $200,000
	Within 5-10 years, continue to host symposia.	$0 - $200,000
	Within 10-plus years, continue to host symposia.	$0 - $200,000
Identify new opportunities for GBEP and partners to host workshops and events for stakeholders.	Within 2-5 years, identify underserved geographies and culturally diverse communities.	$0 - $200,000
	Within 2-5 years, create a workshop and events action plan (specific number of events to be determined).	$0 - $200,000
	Within 2-5 years, develop and promote a list of topical speakers, spanning all subject areas.	$0 - $200,000
	Within 5-10 years, see significant progress on workshop and events plan items (50% of goals met).	$0 - $200,000
	Within 10-plus years, complete all workshop and events plan items (100% of goals met).	$0 - $200,000
Support existing stakeholder activities and events in "off years."	Within 2-5 years, sponsor or assist in planning three stakeholder activities or events in years between symposia.	$0 - $200,000
	Within 5-10 years, continue to sponsor or assist in planning two stakeholder activities or events in years between symposia.	$0 - $200,000
	Within 10-plus years, continue to sponsor or assist in planning two stakeholder activities or events in years between symposia.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Galveston Bay Foundation
Houston Zoo
H-GAC
Bayou Preservation Association
HARC
Texas Community Watershed Partners
Texas Soil and Water Conservation Board
Texas A&M AgriLife Extension Service
Texas Commission on Environmental Quality

PERFORMANCE MEASURES

1. State of the Bay Symposia hosted every three to five years.
2. Number of workshops and events completed in the symposia off years.

REFERENCES

GBP’95: PPE-2
SAP Reference: Public Awareness: Goal 2 / Objective A

SPO-3

Support Regional Initiatives

Objective: Continue to expand and support the Back the Bay campaign and other regional initiatives.

Priority Issue: Individuals do not feel connected to the health and / or protection and preservation of Galveston Bay.

Description: To increase connectivity, the GBEP and its partners are building on previous Back the Bay campaign success and exploring new opportunities to refine and expand the campaign through stakeholder and partner feedback / participation.

The GBEP and its partners are supporting other regional initiatives, such as the Cease the Grease campaign and the GBAN.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Initial discussion of goals for Back the Bay, including expanded geographies and culturally diverse and underserved communities. Identify and support other regional campaigns, such as Cease the Grease and GBAN. Create new material resources and language translations, where needed.	Within 2-5 years, create regional initiatives plan (specific goals to be determined, could include increasing the number of partners each year).	$0 - $200,000
Annual discussion of goals for Back the Bay.	Within 5-10 years, see significant progress on regional initiatives plan items (50% of goals met).	$200,000 - $1 Million
	Within 10-plus years, see completion of all regional initiatives plan items (100% of goals met).	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

Bayou Preservation Association
Galveston Bay Foundation
Houston Zoo
Texas Living Waters Project

PERFORMANCE MEASURES

1. Communication plan for outreach and education initiatives completed.
2. Number of resource materials created to support the campaign plan and other regional initiatives.
3. Number of materials and resources translated.

REFERENCES

GBP'95: PPE-2
SAP Reference: Public Stewardship: Goal 1 / Objective A

SPO-4

Local Government Outreach

Objective: Ensure local governments are knowledgeable about key estuary issues, common interests, and new information as it becomes available.

Priority issue: Local governments do not feel connected to the health and / or protection and preservation of Galveston Bay.

Description: To ensure local governments feel connected, the GBEP and its partners are developing, distributing, and promoting resource materials for local government use and reference. The resource materials developed are a vehicle to build new and support existing relationships with local governments. Additionally, the GBEP and its partners are providing specific support to MS4 permit holders to assist in meeting permit requirements. Specialized materials geared toward communities without MS4 permits to supplement public engagement activities may also be developed.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Develop list of existing resource materials for local governments.	Within 2-5 years, develop a database of existing resources.	$0 - $200,000
Update existing resource materials list.	Within 5-10 years, update the database with new or updated resources.	$0 - $200,000
	Within 10-plus years, continue to update database with new or updated resources.	$0 - $200,000
Identify and address resource gaps / needs and target geographies and municipalities in need of resource materials.	Within 2-5 years, create plan to address key issues (specific resources to be determined based on gap analysis).	$0 - $200,000
Create new materials where needed.	Within 2-5 years, work with partners to create new materials identified in plan to address key issues.	$0 - $200,000
Distribute existing and new materials to targeted geographies and municipalities.	Within 5-10 years, see significant progress on action plan items to address key issues (50% of goals met).	$200,000 - $1 Million
	Within 10-plus years, see completion of all action plan items to address key issues (100% of goals met).	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

H-GAC
Galveston Bay Foundation
Texas General Land Office
HARC
Sierra Club
Houston Wilderness (Gulf-Houston Regional Conservation Plan)
National Wildlife Federation
Texans for Clean Water
Texas Living Waters Project

PERFORMANCE MEASURES

1. Database of local government resource outreach and education materials of key issues for Galveston Bay completed.
2. Communication plan to address local government outreach and education efforts on key issues about Galveston Bay completed.
3. Number of local governments implementing the outreach and education action plan on key issues about Galveston Bay.
4. Assessment evaluating the success of local governments implementing the outreach and education communications plan completed.

REFERENCES

GBP'95: PPE-2
SAP Reference: Public Awareness: Goal 2 / Objective A

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ACTION PLAN 2 OF 2

SUPPORT PUBLIC EDUCATION AND AWARENESS INITIATIVES (PEA)

In the Galveston Bay watershed, both the social and ecological components of the ecosystem influence each other. This dynamic informs the GBEP and its partners' focus on public education and awareness initiatives in Galveston Bay. Fostering environmental literacy in the region will help provide skills to understand, analyze, and think critically about current and future needs for Galveston Bay. Environmental literacy is achieved through awareness of the critical issues influencing Galveston Bay, including the importance of freshwater inflows, habitat and water conservation, protecting native bay species, preventing NPS pollution, potential risks from contact recreation, and seafood consumption safety.

Environmental literacy in kindergarten – 12th grade (K-12) and college students is a key focus area for *GBP'18*. Students who are engaged in bay-related research and stewardship efforts can serve as ambassadors to the larger community, affecting long-term, positive change as they become decision makers for the region. Environmental education curriculum and programs aligned with a focus on science, technology, engineering, art, and math are essential components for protecting and sustaining Galveston Bay. While there are several groups engaged in providing environmental education and awareness programs, there is a need for a more cohesive regional system to track these efforts and identify gaps in regional services and resources. In addition to implementing these programs, the GBEP and partners can play a role in bringing various groups together by helping catalog, profile, and publicize the region's environmental education and awareness programs.

Example of Public Education and Awareness Implementation Action

In 1996, Rice University's Kinder Institute for Urban Research conducted a survey for the GBEP to track public awareness and perceptions of a wide range of issues relating to environmental concerns, ecotourism, and protecting and preserving the region's natural resources. In 2005, the HARC issued a *Galveston Bay Indicators* report that included data on socioeconomic indicators for the region, including population data and changes in land use patterns. Additional public perception and awareness data were captured through surveys conducted before and during the Back the Bay campaign, and the Galveston Bay Foundation continues to track public opinions and attitudes with the annual *Galveston Bay Report Card*.

However, empirical data on environmental literacy in and around Galveston Bay is incomplete. Stakeholders developing *GBP'18* identified environmental literacy as a crucial element to successfully engaging communities to preserve Galveston Bay. To improve environmental literacy for students in the region, the GBEP and partners created the Galveston Bay Watershed Academic Partnership in 2007. This led to two youth symposia that highlighted student-led projects on local environmentally based issues and the development of a resource guide, *The Galveston Bay Estuary System: An Educator's Resource for Developing Bay-Related Curricula*. The guide provides science educators curricular resources for grades six through eight that focus on bay issues.

New partnership initiatives aim to make it easier to find educational resources in the region, such as the HERE in Houston website, which provides a one-stop shop for classroom and informal educators, Texas Master Naturalists, scout leaders, and others looking to teach about the environment of the Houston-Galveston region. In addition, the GBEP's partners hosted an education workshop at the 2009 State of the Bay Symposium. Many partners continue to collaborate on educational programs for teachers, students, homeowners, and the public, providing watershed education for curriculum, rain barrel workshops for homeowners, education for septic systems and well owners, and more. A continued effort to track social indicators will help guide the GBEP and its partners' efforts. There is an additional need to conduct research to identify underrepresented and underserved communities in the region to understand language and cultural barriers. This information will help guide translating outreach and education materials.

FIGURE 28
PEA ACTION PLAN MATRIX

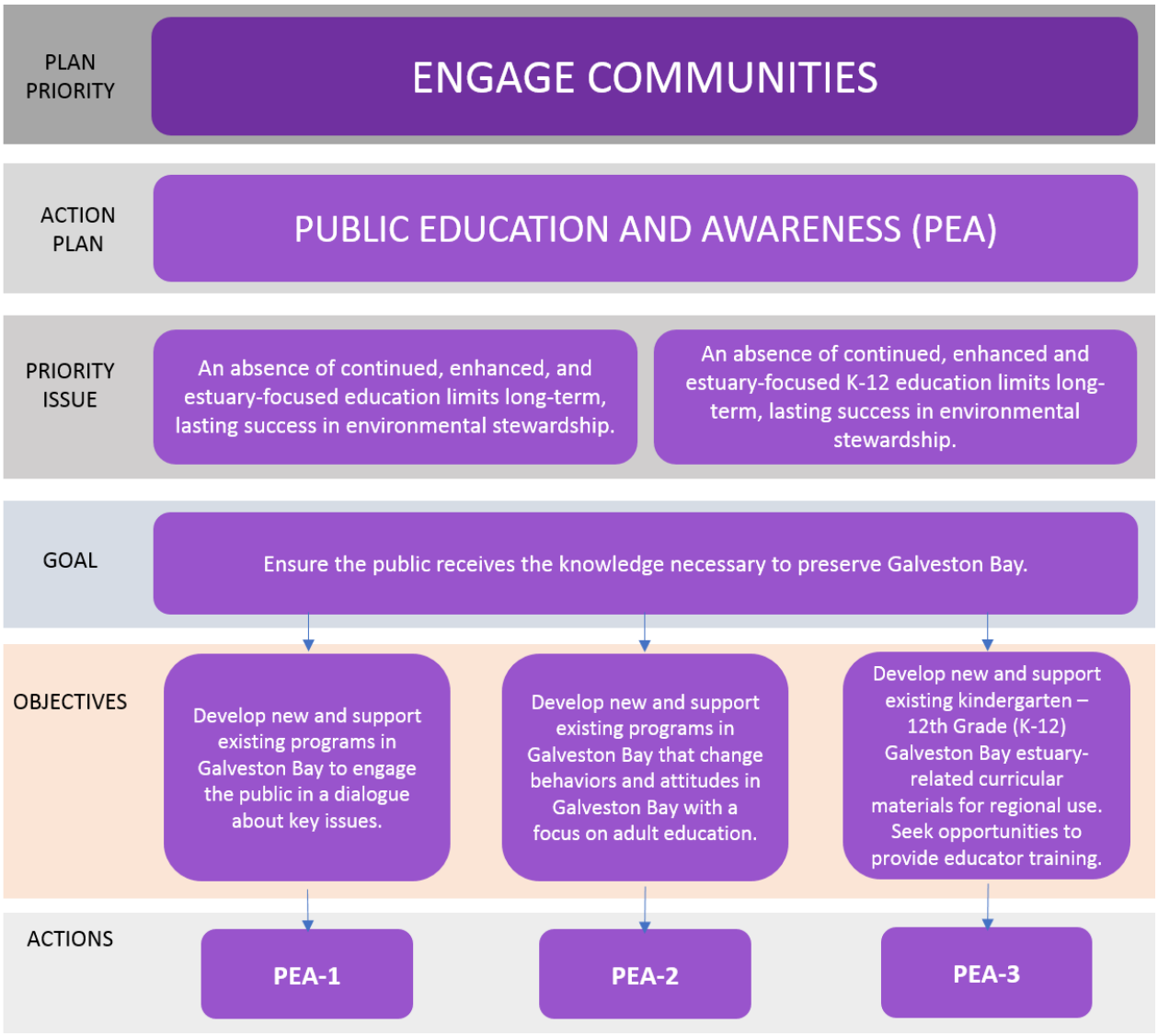
ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Support Public Education and Awareness Initiatives (PEA)						
	PEA-1	Key Issue Engagement	x	x	x	x
	PEA-2	Adult Education	x	x	x	
	PEA-3	Kindergarten to 12th Grade (K-12) Education Efforts			x	

Action Plan Overview

The PEA Action Plan includes three Actions that ensure information on protecting and preserving Galveston Bay is available to anyone who wants it. This is accomplished by engaging the public about key issues affecting Galveston Bay (**PEA-1**) and developing and promoting adult-focused awareness initiatives (**PEA-2**) in the lower Galveston Bay watershed. Engaging area students (K-12), as well as educators and trainers, on bay-related curriculum and materials will teach them how their behaviors and attitudes can positively affect Galveston Bay (**PEA-3**).

PEA-1 supports all Plan Priorities identified within *GBP'18*. Successful implementation of this Action requires coordination between the PPE, WSQ, NRU, and M&R subcommittees.

FIGURE 29
PUBLIC EDUCATION AND AWARENESS ACTION PLAN



PEA-1

Key Issue Engagement

Objective: Develop new and support existing programs in Galveston Bay to engage the public in a dialogue about key issues.

Priority Issue: An absence of continued, enhanced, and estuary-focused education limits long-term, lasting success in environmental stewardship.

Description: To establish more meaningful public engagement, the GBEP and its partners are continuing to develop, support, and promote public awareness along with education/outreach and starting a dialogue with the public about key issues affecting Galveston Bay and what can be done to mitigate those issues.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Capture list of existing awareness and education programs in the region.	Within 2-5 years, develop database of existing programs.	$0 - $200,000
Conduct gap analysis, to include public awareness and perception assessments to identify audiences and geographies needing additional education and awareness programs.	Within 2-5 years, conduct awareness level assessments prior to program expansion.	$0 - $200,000
	Within 2-5 years, identify new geographies and communities from assessments.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Bayou Preservation Association
Galveston Bay Foundation
HARC
Houston Zoo
Sierra Club
Student Conservation Association
Texans for Clean Water
Texas A&M AgriLife Extension Service
Texas Community Watershed Partners

PERFORMANCE MEASURES

1. Database of existing education and awareness programs in the region completed.
2. Number of completed public awareness assessments to identify audiences and geographies for education and outreach programs.

REFERENCES

GBP'95: PPE-3
SAP Reference: Public Education: Goal 1 / Objective B

PEA-2

Adult Education

Objective: Develop new and support existing programs in Galveston Bay that change behaviors and attitudes in Galveston Bay with a focus on adult education.

Priority Issue: An absence of continued, enhanced, and estuary-focused education limits long-term, lasting success in environmental stewardship.

Description: To better engage the public in long-term environmental stewardship, the GBEP and its partners are continuing to develop, support, and promote public education activities that change behaviors and attitudes in Galveston Bay with a focus on adult education and are conducting and / or supporting public awareness and public perception assessments to measure awareness levels and impact of the message.

Implementation location: Action for the Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Create plan of action to provide education and awareness programs to underserved geographies and communities. Explore additional topic needs, such as emerging pollutants.	Within 2-5 years, create plan to engage the public (specific goals to be determined based on gap analysis). Coordinate with other groups conducting similar research / assessment.	$0 - $200,000
	Within 5-10 years, see significant progress on items outlined in plan to engage the public (50% of goals met).	$0 - $200,000
	Within 10-plus years, see completion of all items outlined in plan to engage the public (100% of goals met).	$200,000 - $1 Million
Support and fund existing and new education and awareness programs.	Within 10-plus years, conduct awareness level assessment after program expansion.	$0 - $200,000
Create new material resources and language translations, where needed.	Within 5-10 years, create new materials identified in plan to engage the public.	$0 - $200,000
	Within 10-plus years, create any additional new materials, as needed.	$0 - $200,000

POTENTIAL IMPLEMENTERS

Galveston Bay Foundation
Bayou Preservation Association
HARC
Houston Zoo
Sierra Club
Student Conservation Association
Texans for Clean Water
Texas A&M AgriLife Extension Service
Texas Community Watershed Partners

PERFORMANCE MEASURES

1. Plan of action to deliver education and outreach programs in underserved geographies and communities completed.
2. Number of plan of action education and outreach programs implemented.
3. Number of materials and resources created to support outreach and education.
4. Number of pre- and post-assessments conducted with each education and outreach program.

REFERENCES

GBP'95: PPE-3
SAP Reference: Public Education: Goal 1 / Objective B

PEA-3

K-12 Education Efforts

Objective: Develop new and support existing K-12 Galveston Bay estuary-related curricular materials for regional use. Seek opportunities to provide educator training.

Priority Issue: An absence of continued, enhanced, and estuary-focused K-12 education limits long-term, lasting success in environmental stewardship.

Description: To ensure students and educators receive the knowledge necessary to protect and preserve Galveston Bay, the GBEP and its partners are continuing to develop, support, and promote programs that seek to educate K-12 audiences on how changes in behavior and attitude can positively influence the protection and preservation of Galveston Bay.

The GBEP and its partners are continuing to develop, support, and promote programs that seek to work collaboratively with educators on how educational materials and programs are introduced to students.

Implementation location: Action for the Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Capture list of existing K-12 programs in the region.	Within 2-5 years, develop a database of existing programs.	$0 - $200,000
Conduct gap analysis to identify K-12 program needs.	Within 2-5 years, conduct an educators summit to identify education gaps and needs.	$200,000 - $1 Million
Convene thought leaders in region to create plan of action to support K-12 programs.	Within 2-5 years, create a plan to support K-12 educators (specific goals to be determined in Educators Summit).	$0 - $200,000
Support and fund existing and new K-12 programs.	Within 5-10 years, see significant progress on plan to support K-12 educators (50% of goals met).	$0 - $200,000
Support existing and build new relationships with Independent School Districts, Professional Educator Groups, Resource Developers, etc.	Within 10-plus years, see completion of the plan to support K-12 educators (100% of goals met).	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

Local school districts
Local science teacher associations
Artist Boat
Katy Prairie Conservancy
Bayou Land Conservancy
Bayou Preservation Association
Galveston Bay Foundation
Various Partners

PERFORMANCE MEASURES

1. Database of existing K-12 education programs completed.
2. Educators Summit to identify needs and gaps in K-12 education completed.
3. Plan to support K-12 education (as identified at the Educators Summit) completed.
4. Number of programs delivered through the K-12 education plan.
5. Assessment of K-12 programs and the number of students and educators reached completed.

REFERENCES

GBP'95: PPE-4, PPE-3
SAP Reference: Public Education: Goal 1 / Objective A

Plan Priority Four:
Inform Science-Based Decision Making

To preserve Galveston Bay for future generations, the GBEP and its partners must support science-based decision making.

U.S. Geological Survey staff process water quality samples along the Trinity River (photo credit: Sarah Bernhardt).

Galveston Bay is a complex, dynamic system influenced by ever-changing human interactions and natural processes. These changes can affect the people, habitats, and species of Galveston Bay, making monitoring and research Actions essential to the GBEP and its partners' abilities to manage implementation activities.

Coordinated, quality-assured monitoring and accessible research data ensure that resource managers, elected officials, and other decision makers in the region can make informed decisions to preserve Galveston Bay. At the same time, it is crucial for those same decision makers to allocate adequate resources to the development of robust monitoring and research programs. To adequately support science-based decision making, two Action Plans should be addressed.

ACTION PLANS

Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring

Increase Access to Galveston Bay Ecosystem Information

The two Action Plans identified under this Plan Priority were developed primarily through the M&R subcommittee of the Council.

FACTORS THAT INFLUENCE PLAN PRIORITY

Galveston Bay, its tributaries, and living resources are monitored for many parameters in support of the ecosystem-based approach to resource management identified by *GBP'95* (page 145 gives more information about the Regional Monitoring Plan and the region's monitoring activities).

The GBEP and its partners seek to increase understanding of Galveston Bay by collaborating with research institutions to fill in knowledge gaps of the ecosystem's biological and physical components. However, the lack of resources and funding for applied research and additional coordinated monitoring efforts make it difficult for the GBEP and its partners to incorporate new and emerging contaminants into existing monitoring and research efforts. Responding to a rapidly changing environment, converting science to action, and promoting sound scientific procedures while at the same time remaining unbiased present challenges to maintaining robust monitoring and research efforts.

Understanding the Difference Between Monitoring and Research

Monitoring and research are related but serve two distinct purposes. First, analysis of monitoring data determines whether the health of the ecosystem is changing. Data are assembled from state and local monitoring partners, analyzed, and distributed to potential users electronically. Data that are accurate, defensible, and accessible are imperative to protecting and preserving the bay.

Second, applied research is used to better comprehend specific Galveston Bay ecosystem components. When there are data gaps in monitoring information, the program directs limited resources for targeted applied research. This research improves understanding of the bay and its relationship to human use and strengthens the connection between scientists and resource managers.

The Action Plans in *GBP'18* are informed by, and may be adapted according to, monitoring and research findings.

A Clean Rivers Program staff member prepares collection containers for water quality sampling and analysis.

Population growth affects regional monitoring and research efforts. Anticipated growth for the region is likely to result in land conversion for residential and commercial purposes and require additional water resources. This will require additional monitoring.

An increase in development means more impervious surfaces that affect the quality of stormwater runoff, which contains nutrients and microbiological contaminants that negatively affect regional water quality and may be harmful to human health. More people also means an increase in the discharge of treated wastewater and more vehicles and sources of air pollution, which could also increase deposition of air pollutants into Galveston Bay. A robust monitoring network with appropriate analysis of the data will be critical to meeting this challenge of growth with limited environmental degradation.

In the future, funding for projects focusing on these new, or in some cases expanded, monitoring and research parameters will be needed:

- contaminants and benthic communities, such as contaminant processing and freshwater inflow indicators;
- zooplankton, marine birds, and megafauna (including sea-turtles, marine mammals, sharks, and large pelagic fish);
- ecosystems in general (including wetlands, oysters, SAV, isolated wetlands, riparian wetlands, non-tidal wetlands, beaches, coastal prairie); and
- invasive species in general (including those affecting the terrestrial environment and coastal rivers and streams).

As monitoring technology becomes better, monitoring sites should experience fewer data gaps. This trend should lead to more continuous monitoring of water quality and better habitat monitoring. The historic approach to monitoring ecosystems will change due to advances in testing and analysis. Over the next 10 years, the GBEP and its partners will begin to fill knowledge gaps in the Galveston Bay ecosystem.

BUILDING ON PAST SUCCESS

The GBEP and its partners will bolster research and increase data access to support science-based decision making in the region. Since the release of *GBP'95,* this has been accomplished through monitoring and research projects. These projects include the Regional Monitoring Database (formerly called Status and Trends), and collaborations with resource managers and the NRU subcommittee on monitoring phytoplankton as an indicator of freshwater inflows (more information is given on page 149). Two such successful projects are highlighted in the text that follows.

MANGROVE RESTORATION IN GALVESTON BAY: ECOLOGICAL BENEFITS AND EFFECTIVE RESTORATION TECHNIQUES

In 2015, TAMUG began a study funded by the GBEP to assess whether change in the dominant plant community should alter restoration practices. Landscape-level shifts in plant species distribution and abundance can alter ecosystem structure and function. Such shifts are occurring on the Texas Gulf Coast where, in recent years, mangroves have grown into some areas occupied by salt marsh grass. A series of surveys were conducted at restored and reference sites with and without mangroves in Galveston Bay. Plants, soil, and fauna were surveyed at 12 sites in spring 2016, fall 2016, and spring 2017. The two objectives of the study were to compare mangrove planting techniques and quantify the ecological benefits of mangrove restoration in the Galveston Bay area.

Few of the planted mangroves at restoration sites thrived. Most of the planted shrubs remained small (less than one meter) for several years after planting, though many flowered. The healthiest mangroves were usually at relatively high elevations, near the upper edge of the *Spartina alterniflora* zone. Mangroves were actively recruited to this high elevation zone at numerous locations around Galveston Bay, independent of planting sites. Based on these observations, the recommendation for restoration practice was to focus planting efforts on fast-growing species such as *Spartina alterniflora* and allow natural recruitment of mangroves to occur gradually over time.

In addition, marsh plant diversity was lower at sites with high mangrove cover. Within marsh or mangrove stands, fish and invertebrate densities were generally similar, though the species composition differed. Stable isotope analysis indicated that salt marsh vegetation is more important than mangroves for support of coastal wetland food. At low densities, mangroves did not substantially alter wading bird or shorebird abundances. Mangroves generally increased carbon retention in the soil. The results revealed salt marshes and mangroves support different plant and animal assemblages, and mangrove growth is likely to influence complex changes in ecosystem processes.

STATE OF THE BAY

One of the most successful projects providing data access to the public is *The State of the Bay Report*. In 2011, the GBEP, with support from the HARC, published *The State of the Bay: A Characterization of the Galveston Bay Ecosystem, 3rd Edition*. The report built on the two previous published editions and included an overview of Galveston Bay, past and present human roles, physical form and processes, water and sediment quality, key habitats, living resources, impacts on public health, and a look at the future of the bay.

The report's purpose is to improve management of the valued resources of Galveston Bay and assist resource professionals as they adapt current management actions to address challenges and to inform decisions regarding future management of Galveston Bay and its watershed. These adjustments are critical to sustaining the bay ecosystem and the service it affords the region (Lester & Gonzalez, 2011, p. 4). *The State of the Bay Report* will be updated as new information becomes available.

Scenic bay view at sunset (photo credit: Justin Bower).

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ACTION PLAN 1 OF 2

COLLABORATE WITH RESEARCH INSTITUTIONS TO SUPPORT FOCUS AREA APPLIED RESEARCH AND MONITORING (RES)

Scientific research forms the basis for models that predict or describe ecosystem function, justifies standards, and supports every aspect of the regulatory process. It is crucial to successful management of Galveston Bay and its resources.

Diverse concerns relating to aquatic habitat, wildlife, resource usage, water quality, and human health cannot be adequately addressed without the involvement of multiple natural-resource agencies and bay stakeholders. Challenges of a more regional nature – those affecting the entire ecosystem – require regionally coordinated efforts and a strong commitment to partnership.

The GBEP facilitates these partnerships to support an ecosystem-based approach by establishing research focus areas, defining the overall goals of research, and coordinating activities within a set of established priorities. The GBEP provides perspective and guidelines through assessments and regular interaction with scientists, bay managers and users, private industry, and the public to identify research needs. The GBEP then helps researchers match prioritized research needs with existing and potential funding services. Nonprofit organizations and environmental organizations, as well as universities, help with this process and leverage funding for more research.

> "There is a lot of practical value in learning how natural systems work, {and} how human activities and other influences perturb these systems, what causes these perturbations, how changes in one system affect other systems; and how knowledge may guide well-informed choices about means of transforming or restoring ecologic systems." *(Omenn, 2006, p. 1697)*

Example of Applied Research and Monitoring Action Implementation

During development of *GBP'18*, the GBEP and its partners emphasized the need for continued collaboration with research institutions, as well as between the subcommittees of the Council, on applied research and coordinated monitoring activities.

There have been many such successful collaborations since release of *GBP'95*, notably the Coastal Restoration Assessment. This project was a multipartner effort that began in 2007 and is still ongoing at publication of this document. Coastal marsh ecosystems anchored by smooth cordgrass (*Spartina alterniflora*) are some of the most highly productive ecologic communities in the lower Galveston Bay watershed, providing many ecologically

critical functions and services. In response to substantial loss of these ecosystems over the past 50 years, active restoration of numerous coastal wetland systems has been undertaken. Research on restoration techniques and success occurred in conjunction with replanting projects. The GBEP, in partnership with Lee College and the University of Houston-Clear Lake, examined whether functional differences are achieved through different marsh restoration techniques on a series of restored wetlands within Pierce Marsh, located in the lower Galveston Bay watershed. While the best methodology for marsh restoration has yet to match naturally occurring marsh ecologic functional development, this research demonstrated a successful collaboration between the NRU and M&R subcommittees of the Council and has informed additional restoration research efforts. This project is an example of how the GBEP and its partners support resource management through targeted research that increases ecosystem understanding.

Action Plan Overview

The RES Action Plan includes eight Actions to support applied research and monitoring in the Galveston Bay watershed. To increase understanding of the Galveston Bay ecosystem, specialized monitoring and research of biological stressors (**RES-1**), geochemical stressors (**RES-2**), and physical stressors (**RES-3**) must be conducted. Successful implementation of all three Actions requires coordination of all four subcommittees of the Galveston Bay Council and is necessary to the protection and preservation of Galveston Bay. Physical stressors include, but are not limited to, physical impacts to the estuary such as erosion (**HC-3**), litter (**PEA-1**, **NPS-2**), and freshwater inflows (**FWI-2**).

To better understand the factors that limit safe human use of Galveston Bay, a characterization of public contact recreation affected by waterborne pathogens and bacteria must occur to identify new or emerging pathogen indicators (**RES-4**). It is essential to identify sources of pollution, including legacy pollutants and run-off that impact seafood consumption in order to establish appropriate remediation activities (**RES-5**). Successful implementation of **RES-4** requires coordination with the WSQ subcommittee of the Council on Actions **PHA-2** and **PHA-3**, included under Plan Priority One: Ensure Safe Human and Aquatic Life Use. **RES-5** will require coordination on Actions **PHA-1**, **PHA-4**, and **PHA-5** included under Plan Priority One: Ensure Safe Human and Aquatic Life Use.

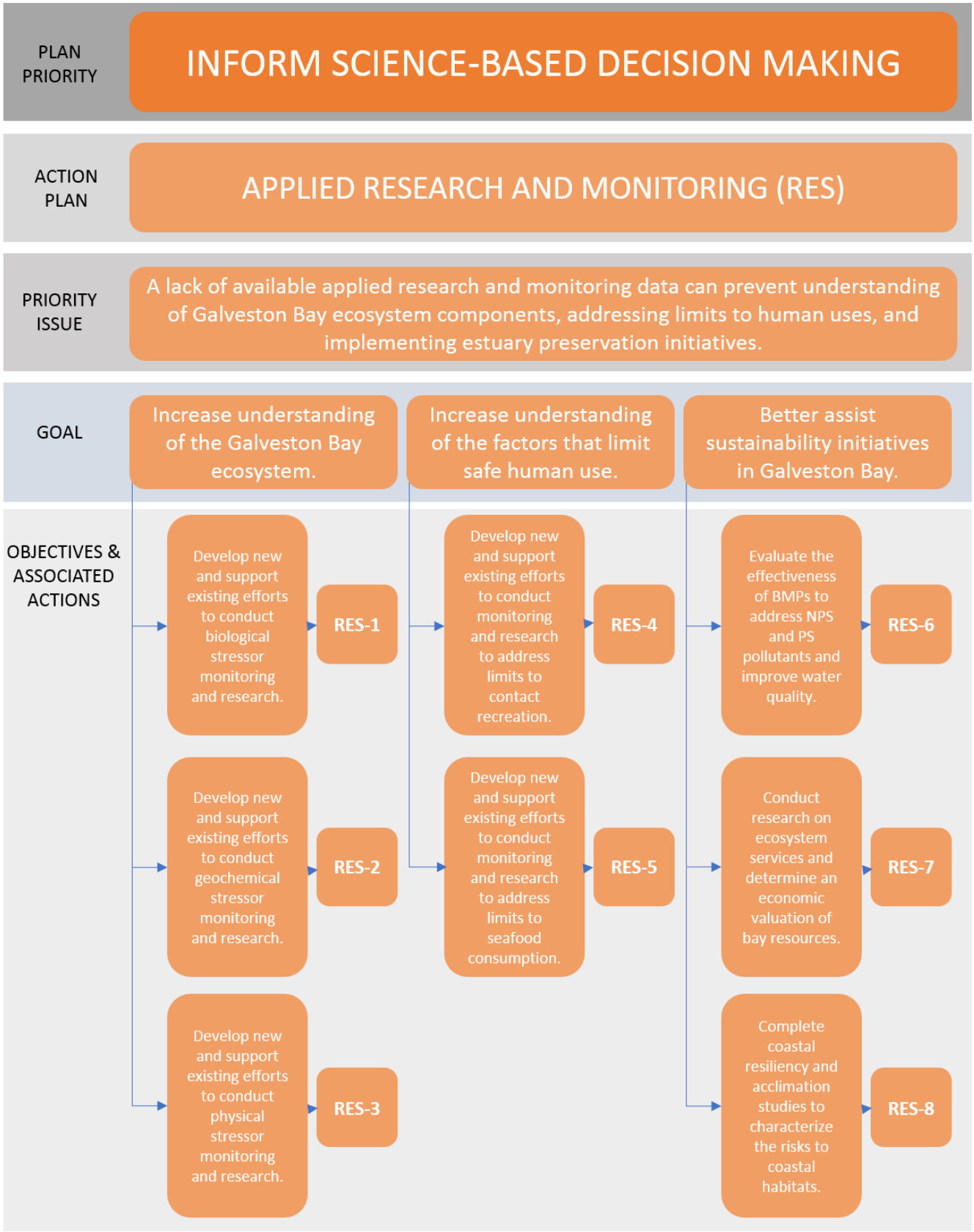
Understanding the limits to Galveston Bay's resiliency requires knowledge about BMP effectiveness for improved water quality (**RES-6**), determination of ecosystem services (**RES-7**), and the study of resiliency risk for coastal habitats (**RES-8**). Successful implementation of **RES-6** requires coordination with the WSQ Subcommittee of the Council on Action **NPS-3**, included under Plan Priority One: Ensure Safe Human and Aquatic Life Use.

FIGURE 30
RES ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES)						
	RES-1	Conduct Biological Stressor Monitoring and Research	x	x	x	x
	RES-2	Conduct Geochemical Stressor Monitoring and Research	x	x	x	x
	RES-3	Conduct Physical Stressor Monitoring and Research	x	x	x	x
	RES-4	Conduct Monitoring and Research to Address Limits to Contact Recreation	x		x	x
	RES-5	Conduct Monitoring and Research to Address Limits to Seafood Consumption	x		x	x
	RES-6	Evaluate Best Management Practice (BMP) Projects	x		x	x
	RES-7	Conduct Research on Ecosystem Service and Economic Valuation of Bay Resources				x
	RES-8	Complete Coastal Resiliency and Acclimation Studies				x

Further information is given for the following: HC-3, page 81; PEA-1, page 116; NPS-2, page 49; FWI-2, page 96; PHA Actions, pages 64-68; NPS-3, page 50.

FIGURE 31
APPLIED RESEARCH AND MONITORING ACTION PLAN



RES-1

Conduct Biological Stressor Monitoring and Research

Objective: Develop new and support existing efforts to conduct biological stressor monitoring and research.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are evaluating the influence of biological stressors (these may include, but are not limited to, harmful algal blooms, *Toxoplasma gondii*, *Perkinsus marinus* {Dermo}, invasive species, and commercial and recreational harvest) on aquatic, semi-aquatic, and terrestrial species populations.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present biological stressor research results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect data and share biological stressor research results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of biological stressor research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate biological stressor research results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of biological stressor research studies completed.
2. Number of biological stressor white papers, presentations, and workshops completed.
3. Number GBEP website visits.

REFERENCES

GBP'95: Regional Monitoring Plan**,** RSC-2**,** RSC-3**,** RSC-4, PH-2, PH-3, SP-1, SP-2, SP-3, SP-4, SP-5, SP-8, SP-10
SAP Reference: Ecosystem and Human Health - Sustain and Restore Native Species Populations: Goal 1 / Objective A / Objective D; Ecosystem and Human Health - Sustain and Restore Native Species Populations: Goal 2 / Objective B **;** Ecosystem and Human Health – Water and Sediment Quality: Goal 1 / Objective C / Objective D**;** Monitoring and Research: Goal 1 / Objective A **;** Monitoring and Research: Goal 2 / Objective D**;** Monitoring and Research: Goal 1 / Objectives A and B, Goal 2: Objectives A, B, C, D**;** Freshwater Inflow and Bay Circulation: Goal 1 / Objective B

RES-2

Conduct Geochemical Stressor Monitoring and Research

Objective: Develop new and support existing efforts to conduct geochemical stressor monitoring and research.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are investigating the effect of geochemical stressors (e.g., eutrophication, biomagnification of legacy toxins, and endocrine disrupters) on aquatic, semi-aquatic, and terrestrial species populations found in the Galveston Bay watershed. They will also evaluate fate and transport through the environment and develop baselines for future comparison.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present geochemical stressor research results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect geochemical stressor research data and share results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of geochemical stressor research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate geochemical stressor research results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of geochemical stressor research studies completed.
2. Number of geochemical stressor white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: Regional Monitoring Plan, RSC-2, RSC-3, RSC-4, PH-1, SP-10, WSQ-1, WSQ-2, WSQ-6, WSQ-7, NPS-3
SAP Reference: Ecosystem and Human Health - Sustain and Restore Native Species Populations: Goal 1 / Objective A / Objective D ; Ecosystem and Human Health - Public-Health Protection: Goal 3 / Objective A; Ecosystem and Human Health - Public-Health Protection: Goal 2 / Objective B; Monitoring and Research: Goal 1 / Objective A ; Monitoring and Research: Goal 2 / Objective D; Monitoring and Research: Goal 1 / Objectives A and B, Goal 2: Objectives A, B, C, D; Public-Health Protection: Goal 1/ Objective C, Goal 2/ Objective B, Goal 3, Objective Freshwater Inflow and Bay Circulation: Goal 1 / Objective B

RES-3

Conduct Physical Stressor Monitoring and Research

Objective: Develop new and support existing efforts to conduct physical stressor monitoring and research.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are studying the influence of physical changes to the estuary (e.g., litter and illegal dumping, modified freshwater inflows, bay circulation, coastal erosion, shoreline hardening, land use changes, and loss or fragmentation of habitats) on aquatic, semi-aquatic, and terrestrial species populations found in the Galveston Bay watershed.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present physical stressor research results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect physical stressor research data and share results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of physical stressor research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate physical stressor research results into the *State of the Bay Report.*	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Houston Wilderness
Texas Living Waters Project / National Wildlife Federation

Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of physical research stressor studies completed.
2. Number of geochemical stressor white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: HP-3, FW-5, FW-7, RSC-2, SM-4
SAP Reference: Monitoring and Research: Goal 1 / Objectives A and B, Goal 2: Objectives A, B, C, D; Ecosystem and Human Health - Sustain and Restore Native Species Populations: Goal 1 / Objective A / Objective D; Ecosystem and Human Health - Freshwater Inflow and Bay Circulation: Goal 1 / Objective B

RES-4

Conduct Monitoring and Research to Address Limits to Contact Recreation

Objective: Develop new and support existing efforts to conduct monitoring and research to address limits to contact recreation.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are initiating and completing studies that characterize the public's contact recreation risks from waterborne pathogens in Galveston Bay and its tributaries. Partners are conducting bacteria source tracking to characterize sources of pathogens and evaluate the emergence of new pathogen indicators.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present contact recreation research results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect contact recreation research data and share results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of contact recreation research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate contact recreation research results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

GLO
EPA
Local Governments
TCEQ
USGS
Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of contact recreation research studies completed.
2. Number of contact recreation white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: PH-3, RSC-2
SAP Reference: Monitoring and Research: Goal 1 / Objectives A and B, Goal 2: Objectives A, B, C, D; Public-Health Protection: Goal 1 / Objective C

RES-5

Monitoring and Research to Address Limits to Seafood Consumption

Objective: Develop new and support existing efforts to conduct monitoring and research to address limits to seafood consumption.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are identifying sources and evaluating remedial actions to address legacy pollutants, run-off, illegal dumping, and air deposition that can affect the size of recreational shellfish harvest areas or number of seafood advisories. Known pollutants of concern include PCBs, dioxins, and mercury.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present seafood consumption limitation research results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect seafood consumption research data and share results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of seafood consumption research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate seafood consumption research results into the *State of the Bay Report.*	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

City of Houston
EPA
Food and Drug Administration
Houston Wilderness
NOAA
Research Institutions
TCEQ
Texas Department of State Health Services
Texas Parks and Wildlife Department

PERFORMANCE MEASURES

1. Number of research studies conducted addressing limits to seafood consumption completed.
2. Number of limitation of seafood consumption white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: PH-1**,** WSQ-2**,** RSC-2
SAP Reference: Ecosystem and Human Health - Public-Health Protection: Goal 2 / Objective B**;** Ecosystem and Human Health - Public-Health Protection: Goal 3 / Objective A**;** Monitoring and Research: Goal 1 / Objective A; Monitoring and Research: Goal 2 / Objective C

RES-6

Evaluate Best Management Practice Projects

Objective: Evaluate the effectiveness of BMPs to address NPS and PS pollutants and improve water quality.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are evaluating data from BMPs or from future planned BMPs. Partners will monitor new BMPs to collect stormwater run-off in watersheds with impaired waters.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present BMP project results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect data and share present BMP project results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of BMP project research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate BMP project results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Houston Wilderness
Local Governments

Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of BMP project evaluations completed.
2. Number of BMP project evaluation white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: NPS-2, NPS-5, NPS-11, RSC-2
SAP Reference: Ecosystem and Human Health – Water and Sediment Quality: Goal 1 / Objective C; Monitoring and Research: Goal 1 / Objective A; Monitoring and Research: Goal 2 / Objective C

RES-7

Evaluate Ecosystem Services and Determine Economic Valuation

Objective: Conduct research on ecosystem services and determine an economic valuation of bay resources.

Priority Issue: A lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are describing the ecosystem services provided by Galveston Bay and upland habitats and determining an economic value for each.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present ecosystem services and economic valuation results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect ecosystem services and economic valuation data and share results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of ecosystem services and economic valuation research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate ecosystem services and economic valuation results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Houston Wilderness

Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of ecosystem service and economic evaluation research studies conducted.
2. Number of ecosystem service and economic evaluation white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: N/A
SAP Reference: Ecosystem and Human Health - Habitat and Landscape Level Conservation: Goal 1 / Objective A / Objective D; Monitoring and Research: Goal 1 / Objective A; Monitoring and Research: Goal 2 / Objective D

RES-8

Complete Coastal Resiliency and Acclimation Studies

Objective: Complete coastal resiliency and acclimation studies to characterize the risks to coastal habitats.

Priority Issue: A lack of available applied research and monitoring data can prevent the understanding of Galveston Bay ecosystem components, addressing limits to human uses, and implementing estuary preservation initiatives.

Description: The GBEP and its partners are characterizing the risks to coastal habitats from changing sea levels, altered precipitation patterns, and changes to the frequency and size of tropical systems. Partners will determine the effects and ecosystem adaptations to a changing environment.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Present coastal resiliency research results at the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect coastal resiliency research data and share results and partner publications through GBEP website.	Within 2-5 years, collect data and share results through GBEP website.	$200,000 - $1 Million
Support the development and public delivery of coastal resiliency research.	Within 2-5 years, provide support on the development and public delivery of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Incorporate coastal resiliency research results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000

POTENTIAL IMPLEMENTERS

Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Number of coastal resilience and assimilation research studies conducted.
2. Number of coastal resilience and assimilation white papers, presentations, and workshops completed.
3. Number of GBEP website visits.

REFERENCES

GBP'95: N/A
SAP Reference: Monitoring and Research: Goal 1 / Objective A; Monitoring and Research: Goal 2 / Objective D

ACTION PLAN 2 OF 2

INCREASE ACCESS TO GALVESTON BAY ECOSYSTEM INFORMATION (ACS)

Access to Galveston Bay ecosystem information is a crucial element in decision making by resource managers and policy makers. Bay ecosystem data support decisions on current and future management needs, informing policies, applicable to the bay and its living resources, that are necessary to maintaining the health of the bay.

Ecosystem data should also be easily accessible to other members of the environmental decision-making process, as well as stakeholders and the public. Access to data ensures adequate understanding of the components comprising the Galveston Bay ecosystem. This will assist residents' understanding of how they impact the estuary and motivate them to change their actions.

Prior to the GBEP Regional Monitoring Plan (the current Plan begins on page 145), it was difficult to access these data because there was no clearinghouse for all information related to the health of the bay, resulting in some duplication of efforts. In addition, the efforts of each partner agency and organization were typically directed at fulfilling partner-specific mandates. Therefore, these datasets were not automatically compatible with the ecosystem scale assessments desired by the GBEP. These issues, coupled with a lack of standard formats for collected data and inconsistent quality assurance/quality control (QA/QC), decreased the availability and utility of the information.

Through coordinated efforts and the development of environmental indicators, the GBEP and its partners introduced data-tracking consistency. Creating the regional monitoring database, implementing better QA/QC, and engaging in a more collaborative approach to data sharing has allowed the GBEP and its partners to provide successful access to a broad cross-section of end users on environmental and programmatic successes. In the future, the GBEP and its partners will continue to enhance the system for tracking the implementation efforts of *GBP'18* and provide implementation updates to the public.

Example of Access to Information Action Implementation

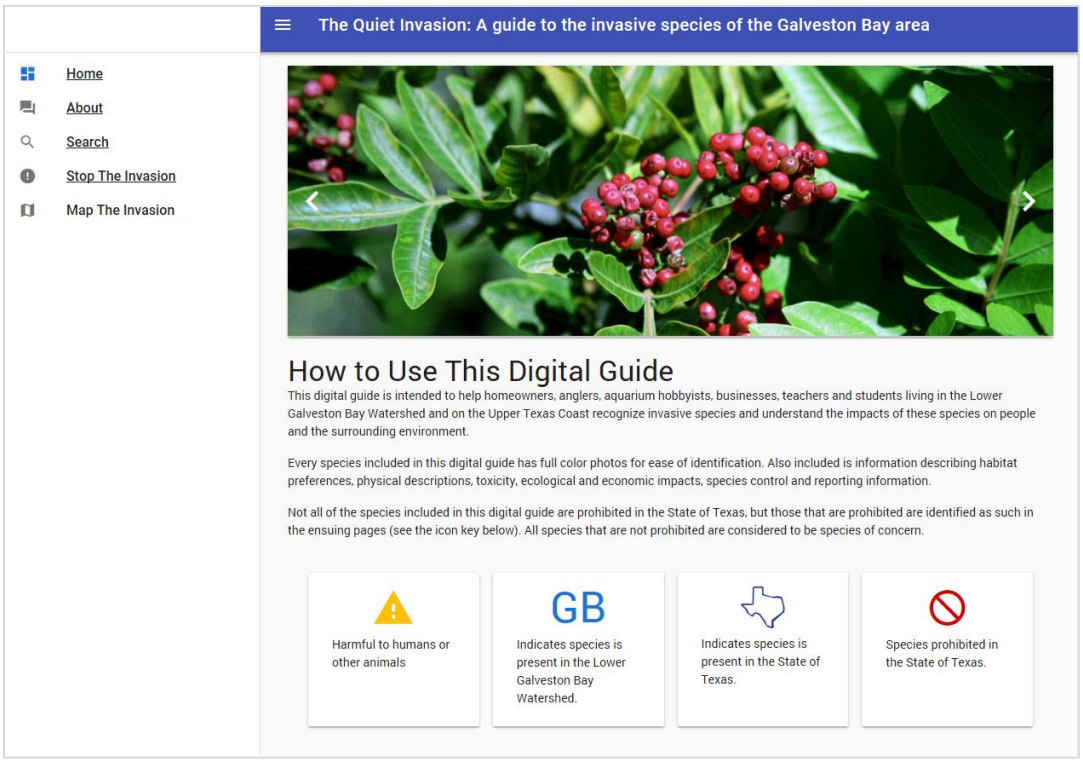
The GBEP provides access to information that can be used to improve understanding of the Galveston Bay ecosystem and disseminates relevant data to partners, research institutions, stakeholders, and the public. This is accomplished in part through public awareness initiatives, such as Back the Bay, Cease the Grease, and Pump Don't Dump, and through larger regional projects, such as the Regional Monitoring Database, which provides web-based data access. More information on the Regional Monitoring Database is given in the Regional Monitoring Plan that begins on page 145.

Another successful example of increased data access for a broad cross-section of audiences is the Invasive Species Work Group (ISWG). In 2001, the NRU subcommittee of the Council formed ISWG after a review of *GBP'95*

elevated certain activates to a high-priority status. The ISWG comprises invasive species experts and stakeholders, acting as a coordinating body for invasive species management activities.

In 2004, the Galveston Bay Invasive Species Risk Assessment was completed by the Environmental Institute of Houston and HARC. The risk assessment identified 296 species (including 166 plant species) as current and potential invaders of the lower portion of the Galveston Bay watershed. Each species was ranked according to ecological risk by a group of experts. The risk assessment also outlined a series of recommendations to enhance prevention and control of invasive species, including large-scale public outreach and education efforts, programs restoring aquatic habitats degraded by invasive species, and general invasive species research related to impacts by invasive species.

Since 2005, ISWG has completed several successful invasive species research, control, and education efforts. A direct outcome of the ISWG was the GBEP's funding of two invasive species field guides. *The Quiet Invasion: A Guide to Invasive Plants of the Galveston Bay Area* was created in 2006, and *The Quiet Invasion: A Guide to Invasive Animals of the Galveston Bay Area* was created in 2010 by the HARC.



Screenshot of the digital format invasive species field guide.

These pocket-sized field guides are designed to help gardeners, land managers, and landscape architects identify invasive plants and animals that can be harmful to local habitats. The plant guide suggests native species alternatives which are better choices for planting, providing access to key ecological data in an easy-to-read format. In 2017 these efforts were updated through a partnership between the HARC and TPWD to a digital format. More information about efforts to remove invasive species is given on page 85.

The GBEP and its partners facilitate technical workshops for professional organizations to disseminate important information that can be used to inform the public. Presentations are given to the Council quarterly to keep agencies, industries, and organizations involved with preserving Galveston Bay abreast of research and current conditions. This information is distributed within Council members' entities where they can provide updates to their stakeholders. Presentations are given to a broad-based audience at universities, symposia, and conferences. The GBEP updated their website in 2018 to house GBEP-funded final reports, one-page project summaries, presentations, and links to research related to the Galveston Bay ecosystems. These resources provide access to the most current information available.

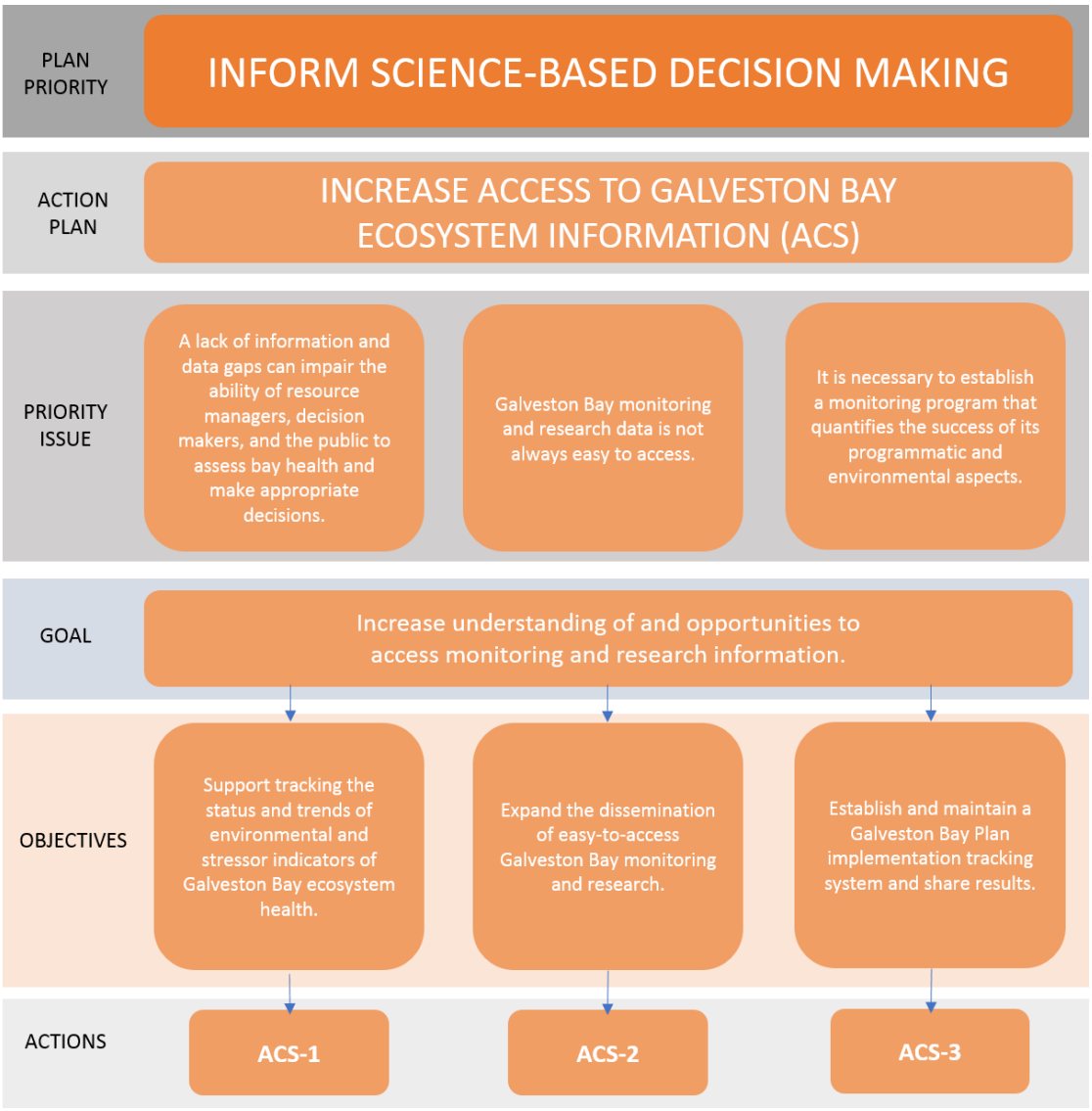
Action Plan Overview

The ACS Action Plan includes three Actions to increase understanding of and access to monitoring and research information in Galveston Bay. First, continue supporting the development and tracking of the GBEP's Regional Monitoring Database in collaboration with local research institutions and organizations (**ACS-1**). Second, disseminate monitoring and research results using a variety of outreach tools tailored to each audience (**ACS-2**). Third, track implementation of Actions identified in *GBP'18* and share with the Council and stakeholders (**ACS-3**). All three Actions support all Plan Priorities in *GBP'18* by providing support data- and tracking-implementation efforts.

FIGURE 32
ACS ACTION PLAN MATRIX

ACTION PLANS AND CORRESPONDING ACTIONS			PLAN PRIORITIES			
			Ensure Safe Human and Aquatic Life Use	Protect and Sustain Living Resources	Engage Communities	Inform Science-Based Decision Making
Action Plan: Increase Access to Galveston Bay Ecosystem Information (ACS)						
	ACS-1	Tracking Ecosystem Health Indicators	x	x	x	x
	ACS-2	Access to Monitoring and Research Data	x	x	x	x
	ACS-3	Track Galveston Bay Plan Implementation	x	x	x	x

FIGURE 33
INCREASE ACCESS ACTION PLAN



ACS-1

Track Ecosystem Health Indicators

Objective: Support tracking the status and trends of environmental and stressor indicators of Galveston Bay ecosystem health.

Priority Issue: A lack of information and data gaps can impair the ability of resource managers, decision makers, and the public to assess bay health and make appropriate decisions.

Description: The GBEP and its partners are obtaining, analyzing, and synthesizing routine monitoring data sources and determining the status and trends of Galveston Bay indicators, parameters, and stressors directly related to the health and sustainability of the bay. Results are shared in formats that increase access and understanding.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Support and promote the Galveston Bay Regional Monitoring Database (formerly called Status and Trends).	Within 2-5 years, update the Galveston Bay Regional Monitoring Database, post data to the website.	$0 - $200,000
Support regional monitoring and data reporting efforts.	Within 2-5 years, support continuation of the annual *Galveston Bay Report Card.*	$0 - $200,000
Create the *State of the Bay Report.*	Within 5-10 years, create the *State of the Bay Report*	$0 - $200,000
Evaluate the need to update *GBP'18*.	Within 5-10 years, review Galveston Bay indicators data and determine if new information indicates the need for any updates to *GBP'18*.	$0 - $200,000
Evaluate the need to revise *GBP'18*.	Within 10-plus years, review Galveston Bay indicators data and determine if new information indicates the need for any revisions to *GBP'18*.	$0 - $200,000

POTENTIAL IMPLEMENTERS

GBEP

Various Industry Partners

PERFORMANCE MEASURES

1. Galveston Bay Regional Monitoring Database completed.
2. Annual *Galveston Bay Report Card* completed.
3. State of the Bay reports completed.
4. Assessment of the Galveston Bay indicators data completed.

REFERENCES

GBP'95: RSC-3
SAP Reference: Monitoring and Research: Goal 2 / Objective A / Objective B

ACS-2

Provide Access to Monitoring and Research Data

Objective: Expand the dissemination of easy-to-access Galveston Bay monitoring and research.

Priority Issue: Galveston Bay monitoring and research data is not always easy to access.

Description: The GBEP and its partners are disseminating monitoring and research results through a variety of outreach activities for different audiences, including the GBEP partners, decision makers, bay user groups, and the public.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Continue the State of the Bay Symposia.	Within 2-5 years, host a State of the Bay Symposium.	$0 - $200,000
Collect data and create a data and mapping research hub (database).	Within 2-5 years, collect research data and use it to create a data and mapping research hub (database).	$200,000 - $1 Million
Support the development of white papers, technical presentations, and workshops.	Within 2-5 years, provide support on the development of white papers, technical presentations, and workshops (number TBD).	$0 - $200,000
Create the *State of the Bay Report.*	Within 5-10 years, use research data to create the *State of the Bay Report.*	$0 - $200,000
Evaluate the need to update *GBP'18*.	Within 5-10 years, review new monitoring and research data and determine if new information indicates the need for any updates to *GBP'18*.	$0 - $200,000
Create a research synthesis report.	Within 10-plus years, use research data to create a research synthesis report, an annotated bibliography of new research on Galveston Bay.	$0 - $200,000
Evaluate the need to revise *GBP'18*.	Within 10-plus years, review new monitoring and research data and determine if new information indicates the need for revisions to *GBP'18*.	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

Galveston Bay Foundation
GBEP
HARC
Texas A&M University
Texas Parks and Wildlife Department
Various Industry Partners
Various Research Institutions, Agencies, and Nonprofit Organizations

PERFORMANCE MEASURES

1. Mapping research database completed.
2. Improved access to monitoring and research database.
3. Research synthesis report completed.
4. Number of visits to web-based resources.

REFERENCES

GBP'95: RSC-3
SAP Reference: Monitoring and Research: Goal 2 / Objective

ACS-3

Track Galveston Bay Plan Implementation

Objective: Establish and maintain a Galveston Bay Plan implementation tracking system and share results.

Priority Issue: It is necessary to establish a monitoring program that quantifies the success of its programmatic and environmental aspects.

Description: The actions of the GBEP and its partners toward CCMP implementation will be tracked and shared with the Council and stakeholders. Implementation results, in addition to ecosystem, socioeconomic, and other indicators of bay health, will be evaluated and the need to update or revise *GBP'18* determined.

Implementation location: Lower Galveston Bay watershed.

ACTIVITIES	TIMEFRAME AND OUTPUT(S)	IMPLEMENTATION COST
Establish an implementation- tracking system.	Within 2-5 years, create tracking system in coordination with stakeholders	$0 - $200,000
Share results at State of the Bay Symposia.	Within 5-10 years share results.	$0 - $200,000
Incorporate results into the *State of the Bay Report*.	On a cycle of every 5-10 years, use implementation data to create the *State of the Bay Report.*	$0 - $200,000
Assess the need for updating *GBP'18*.	Within 5-10 years, evaluate the need to update, then if needed, update *GBP'18*.	$0 - $200,000
Assess the need for revising *GBP'18*.	Within 10-plus years, evaluate the need to revise, then if needed, revise *GBP'18*.	$200,000 - $1 Million

POTENTIAL IMPLEMENTERS

GBEP

PERFORMANCE MEASURES

1. Development of a plan implementation tracking system completed.
2. Evaluation of the need to update or revise The Galveston Bay Plan completed.

REFERENCES

GBP'95: Regional Monitoring Plan
SAP Reference: N/A

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Regional Monitoring Plan

Adaptive management involves exploration of alternative ways to meet objectives, prediction of outcome alternatives based on the current state of knowledge, implementation and monitoring of those alternatives, and use of the results to adjust management (Williams, Szaro, & Shapiro, 2009, p. 1).

Frog at Armand Bayou Nature Center (photo credit: Lyman Brown).

A UNIFIED APPROACH TO MONITORING

The Galveston Bay watershed has a network of more than 300 water quality stations that are actively maintained by partners in the Clean Rivers Program. The Clean Rivers Program, considered the backbone for water quality monitoring in the region, is a crucial partnership between the TCEQ and water management authorities.

Many additional environmental and socioeconomic indicators are monitored by the GBEP federal and state partners. It is important to use a unified approach to determine the efficacy of regional monitoring.

This section of *GBP'18* uses those monitoring data to inform the Regional Monitoring Plan (RMP). The RMP recommends collection of all various monitoring data to help the GBEP track how effectively implementation is managed by answering two questions.

Red-bellied woodpecker at the Armand Bayou Nature Center (photo credit: Lyman Brown).

1. ARE THE GOALS AND OBJECTIVES SET FORTH IN THE GALVESTON BAY PLAN BEING MET?

Programmatic monitoring assesses progress in reaching the stated goals and objectives of *GBP'18* by tracking all Actions and determining the effectiveness of each. The results of programmatic monitoring are used to inform annual work plans and updates and revisions to the CCMP, ensuring efficient use of financial and human resources.

2. IS THE HEALTH OF THE ECOSYSTEM IMPROVING?

Environmental monitoring assesses ecosystem health by establishing environmental baselines for key ecological indicators and measuring data against those baselines over *GBP'18* time horizon. Environmental indicators track changes to ambient conditions, ecological functions, and biological trends in populations and communities. Results of ecosystem monitoring are used in program decision making, and access to data and analyses are provided through an online database and web-accessible reports.

RMP Background

The RMP, previously referred to as the regional monitoring program, was developed in 1994 to determine what monitoring measures were readily available or easy to acquire to answer programmatic and environmental questions set forth by the CCMP. It was established early on that the GBEP would collaborate and coordinate with organizations monitoring the watershed. Historically, the monitoring program in Galveston Bay was guided by the following goal statement:

> *The [RMP] is a statistically sound, holistic monitoring effort designed to provide environmental data of known quality and confidence. It will be responsive to [GBP'95] management goals and objectives and will also have a larger goal of providing knowledge of bay-wide ecosystems, their variability, and societal impacts both environmental and ecological.*
>
> *The [RMP] promotes a cooperative effort by all agencies, organizations, and other stakeholders who participate in bay monitoring activities. The Galveston Bay regional monitoring program will integrate and expand the disparate monitoring efforts currently active in Galveston Bay into a comprehensive and unified monitoring plan. The [RMP] will integrate current monitoring efforts to the maximum extent possible, while acceding to the independent objectives of the groups involved (Regional Monitoring Program for the Galveston Bay Plan, GBNEP-45, November 1994).*

The revised RMP maintains this approach. Federal, state, and local governments, in cooperation with universities and research organizations, continue to collect and analyze environmental data for individual programs with differing objectives. The GBEP gathers those datasets into a collection to evaluate progress in reaching a sustainable Galveston Bay ecosystem. As part of the RMP, the GBEP seeks to identify gaps in available monitoring programs, changes in technology, emergence of new challenges, and other monitoring needs that require program action.

Regional Monitoring Success

The RMP is a success. The Council and its partners have developed and supported successful monitoring and research programs over the past 22 years. Access was provided to Galveston Bay data and information, and studies that fill gaps and expand the working understanding and knowledge of the Galveston Bay ecosystem were funded. The following are some of the successful regional monitoring and research efforts completed by the GBEP and its partners.

SUBCOMMITTEES OF THE GALVESTON BAY COUNCIL

All four subcommittees of the Council meet quarterly to discuss emerging issues, identify priorities for implementation of the CCMP, and share results of ongoing and completed research, monitoring, conservation, and restoration efforts. This information is used to develop annual work plans, with projects vetted and developed collaboratively using the annual budget following approval by the Galveston Bay Council. The members of these subcommittees also represent the Council to local organizations that implement the CCMP in the watershed. Figure 39 on page 163 demonstrates the cyclical nature of the annual planning process and development of Work Plans.

The M&R subcommittee provides a quarterly forum for presenting issues and research results, discussing gaps in data and information for the Galveston Bay estuary, overseeing the RMP, and directing and approving monitoring design changes. M&R recommends specific research projects for implementation through the GBEP annual work plan. The other three subcommittees, WSQ, NRU, and PPE, provide a forum for project coordination by sharing best practices, leveraging resources, and identifying funding sources.

GALVESTON BAY DATA AND INFORMATION

During development of the CCMP, over 40 technical reports were published to establish the factual basis for its Goals, Actions, and Objectives. Since that time, the GBEP maintained the Regional Monitoring Database, a robust database of Galveston Bay information; published three *State of the Bay Reports;* convened 10 State of the Bay Symposia; and funded many individual and coordinated research projects and studies.

The GBEP's Regional Monitoring Database is an online tool that houses agency data on Galveston Bay in a single, easy-to-access location. Data files for independent analysis and query options are available online to all users.

The State of the Bay Reports provide readers access to information about the Galveston Bay ecosystem with an overview of Galveston Bay, human roles, physical form and processes, water and sediment quality, key habitats, living resources, effect on public health, and the future of the bay. The third edition, published in 2011, was made available both online and via interactive CD.

FRESHWATER WETLAND FUNCTIONAL ASSESSMENT STUDY

In 2005 research found that coastal prairie wetlands were disappearing faster than any other type of wetland in the coastal Texas region (Jacob and Lopez, 2005). With expected population growth in the Harris-Galveston county region, development pressure on this habitat is expected to continue. Researchers from Baylor University received funding from the GBEP to conduct a study on the connectivity of coastal prairie wetlands to the water entering the Galveston Bay ecosystem.

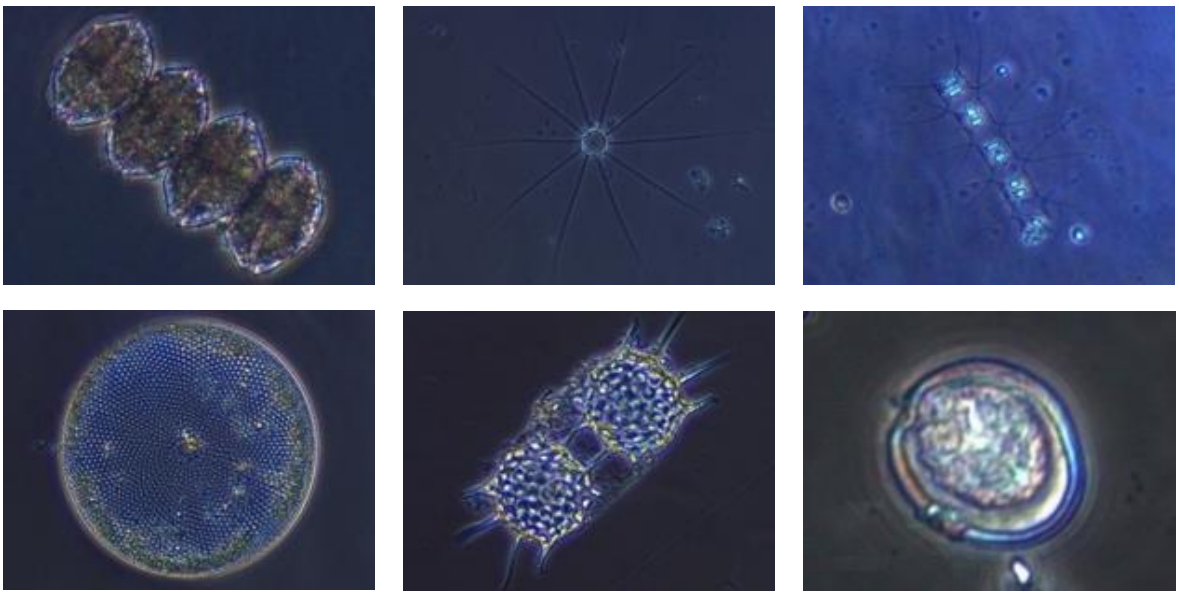
The goal of the Baylor study was to highlight the importance of these wetlands in maintaining water quality in the Houston-Galveston region. The study found that each coastal prairie wetland was capable of greatly reducing the amount of inorganic nitrogen in water that passed through it. Inorganic nitrogen has been linked to eutrophication of coastal waters in the Gulf of Mexico and algal blooms in Galveston Bay. This study also found that coastal prairie wetlands filtered water so that it had lower levels of ammonia (Forbes et al., 2012, p. 705).

PLANKTON RESPONSE

The GBEP provided support to TAMUG in 2014 for research which focused on understanding the downstream ecological effects of changes to freshwater inflows on estuaries, using phytoplankton, *Vallisneria* (plant), and *Rangia* (clam) communities as indicators.

With rising demand for freshwater and a concern for environmental flows in Texas bays, stakeholders agreed there is a need to better understand the freshwater requirements for Galveston Bay. TAMUG used a novel approach of in situ monitoring stations and dataflow transects to analyze water quality parameters, phytoplankton, *Vallisneria,* and *Rangia*.

Many other GBEP research initiatives and projects have been completed or are ongoing. These projects will answer questions related to freshwater inflows and will help the GBEP, the Council, and partners to implement the CCMP.



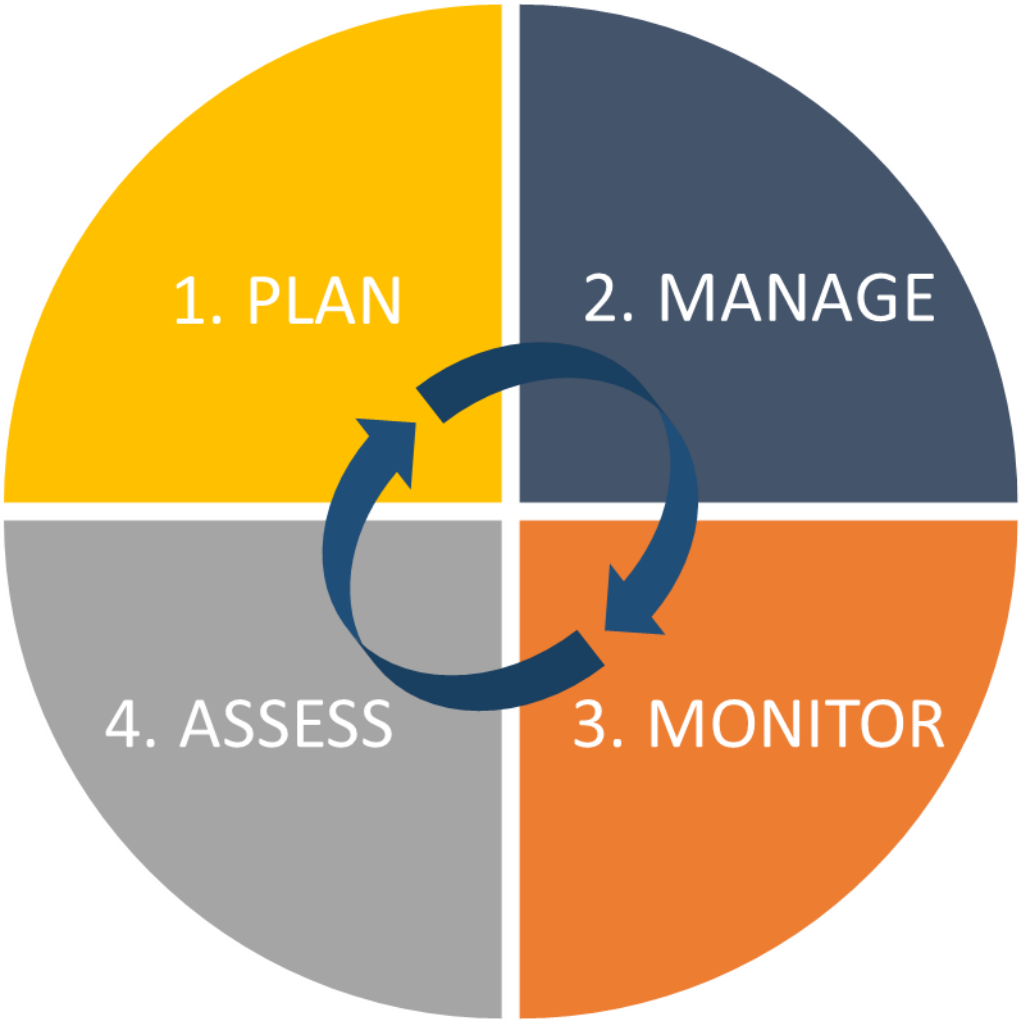
Galveston Bay supports numerous species of phytoplankton. From left to right starting on the first row, the images are of: Alexandrium sp., Bacteriastrum sp., and Chaetoceros sp.

On the second row from left to right is Coscinodiscus sp., Odontella sp., and Prorocentrum sp. (photo credit: Phytoplankton Dynamics Laboratory).

Adaptive Management Approach

The revised RMP reflects the work of the GBEP and its partners and follows an adaptive management approach. Adaptive management is an iterative approach used to redirect and refocus resources during implementation activities to address emerging challenges and new opportunities as they become apparent (illustrated in Figure 34: Adaptive Management Cycle). As a part of the adaptive management approach, the GBEP will incorporate partner-produced, external data into the RMP for future planning purposes.

FIGURE 34
ADAPTIVE MANAGEMENT CYCLE



Step 1: Plan

The first step in adaptive management is planning. *GBP'18* outlines Actions and Objectives necessary to preserve Galveston Bay. It is a living document and maintains a degree of flexibility in its Actions and Objectives to address emerging challenges and new opportunities.

Updates to the CCMP avoid the requirements of major revisions. Updates are considered at the five-year mark, while revisions should be considered after 10 years of implementation or if major changes are needed to improve implementation sooner. Revisions to the CCMP provide an opportunity to determine if major changes are needed to improve management implementation. During the CCMP revision process, stakeholders work with the GBEP to ensure each aspect is reviewed, impediments to implementation are identified, and new Actions are created as needed.

An integral part of *GBP'18* is the RMP. The RMP has a strong QA/QC system. As a program of the TCEQ, the GBEP falls under the TCEQ's Quality Management Plan. Projects collecting, acquiring, or generating environmental data funded by the GBEP require Quality Assurance Project Plans (QAPP) and routine audits by the TCEQ.

Data collected by organizations independent of the GBEP gathered for the Regional Monitoring Database maintain their own quality assurance methods and protocols. The GBEP requires that work performed to maintain the Regional Monitoring Database will follow an approved QAPP. The Regional Monitoring Database QAPP documents the procedures to evaluate and document independent sampling, analytical methods, and QA/QC protocols that various agencies have and how that data is acquired, stored, and analyzed.

Step 2: Manage

Implementation of *GBP'18* is the second crucial step in adaptive management. This is managed through implementation of outlined Actions and Objectives.

Tracking implementation funded through the GBEP is a simple task and a requirement of the EPA. Tracking implementation by partner programs and organizations outside of the direct sphere of the Council is more difficult, but it is important for the adaptive management model and truly assessing the long-term sustainable use of Galveston Bay and preservation of the ecosystem. The GBEP will use new information technology to make identifying partner needs easier and less cumbersome and will continue to implement methods for capturing information at the State of the Bay Symposia and other venues, as appropriate.

Step 3: Monitor

Monitoring is an essential part of adaptive, ecosystem-based management because this promotes accountability. Monitoring establishes baselines to evaluate environmental response to episodic changes (e.g. storms, oil spills, and drought). There are several monitoring programs that support implementation and provide updates and/or revisions of the *GBP'18*.

GALVESTON BAY INDICATORS REPORT

To refine the monitoring scope of the RMP, HARC-- with the GBEP and its partners-- completed the Galveston Bay Indicators Project in 2005, which resulted in the creation of the Galveston Bay indicator framework. The indicator framework consists of 16 assessment questions and 28 indicators, describing aspects of the lower portion of the Galveston Bay watershed's physical environment (included in Category 1: Media) and indicators that describe the state of human uses of bay resources (included Category 2: Uses).

Using the framework, the GBEP generated a *2005 Indicators Report*, in which key data sources and datasets were identified as priorities for the region. The *2005 Indicators Report* is used as a guide in the development of the Regional Monitoring Database. There are six organizations (noted in Figure 35) that routinely monitor the water, sediment, biota, or habitat of the bay for some environmental purpose. The data collected by these organizations are known as the status and trends parameters.

FIGURE 35
MONITORING ENTITIES AND ASSOCIATE PARAMETERS

ENTITY	PARAMETERS
GLO	Oil Spills
EPA	Toxic Release Inventory
NOAA	Digital Coast
Texas Colonial Waterbird Society	Colonial Nesting Waterbirds
TCEQ	Aromatic Organics in Sediment Field Water Quality Metals in Sediments Microbiological Nutrients Pesticides in Sediment Physical Variables
TPWD	Field Water Quality Fisheries Data

FIGURE 36
INDICATORS FRAMEWORK – CATEGORY 1

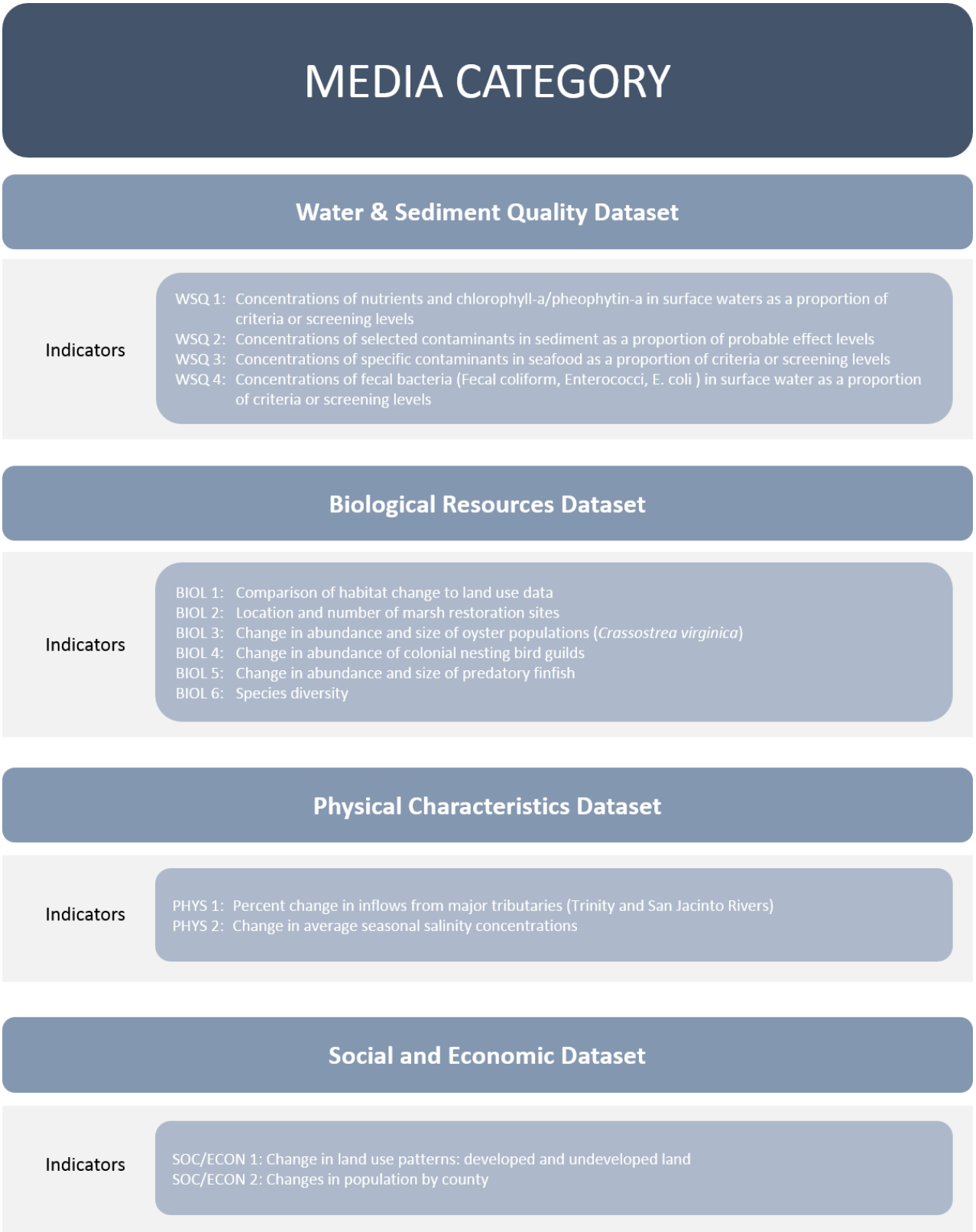
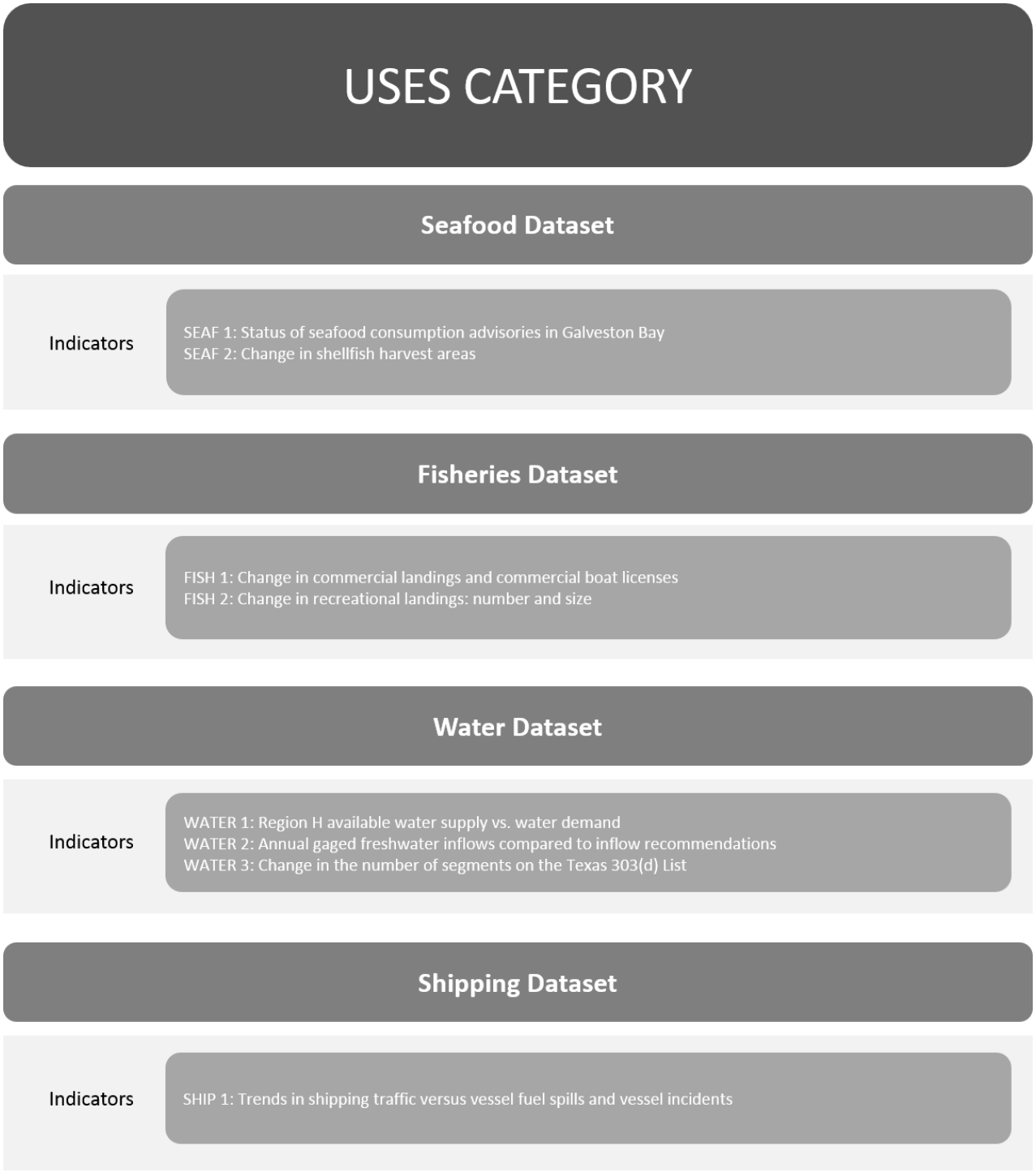


FIGURE 37
INDICATORS FRAMEWORK – CATEGORY 2



SUPPLEMENTAL MONITORING PROGRAM

The RMP establishes a baseline set of routinely available monitoring data. The GBEP uses this monitoring data to identify research and monitoring gaps, changes in technology, emergence of new challenges, and other management monitoring needs. The GBEP then collaborates with its monitoring partners and research institutions to fill the data gaps and, when necessary, fund new monitoring and research.

Step 4: Assess

Assessment takes monitoring data and evaluates it to determine whether management actions resulted in progress toward stated environmental goals. Assessment is not independent of planning and management, but rather directs changes to CCMP Actions, identifying knowledge gaps and informational needs which require further research or supplemental monitoring. The monitoring plan requires reassessment, and the GBEP forms special work groups to discuss changes or additions to the monitoring approach.
To apply the results from the routine and supplemental monitoring, the GBEP created assessment tools that include both programmatic and environmental assessments. Monitoring assessments are part of the planned funding structure of the program. Funding is divided among grant projects, a program website, and monitoring assessments. Because funds are limited, the monitoring assessments are funded on a rotation and may change over time to address priorities.

FIGURE 38
MONITORING AND ASSESSMENT SCHEDULE

PROJECTS	FREQUENCY
State of the Bay Report	Every 5 years
State of the Bay Symposia	Every 3 - 4 years
Regional Monitoring Database	Ongoing (or Every 2-3 years)
Monitoring and Research Web Page	Ongoing
Implementation Assessment of CCMP	Ongoing; every 5 -10 years
The Galveston Bay Report Card (not funded by the GBEP)	Annually
CCMP Update	Assess need every 5 years
CCMP Revision	Assess need every 10 years

STATE OF THE BAY REPORT
The State of the Bay Report is the hallmark publication of the GBEP. The first edition was published in 1994. The first and second (2002) editions of *The State of the Bay Report* were published as printed books, and the third edition (2011) was published as an interactive CD and internet-available PDFs. *The State of the Bay Report* summarizes monitoring data, research findings, and management actions along with information describing historical resource use and modern social and economic features of the lower Galveston Bay watershed.

To present a more user-friendly, accessible, and dynamic version of the report, future editions will be developed with a website that is easy to update. The updated *State of the Bay Report* will present a summary of CCMP implementation and research, and an analysis and presentation of the indicators and metrics available for Galveston Bay based on acquired and quality-assured monitoring data from the Regional Monitoring Database.

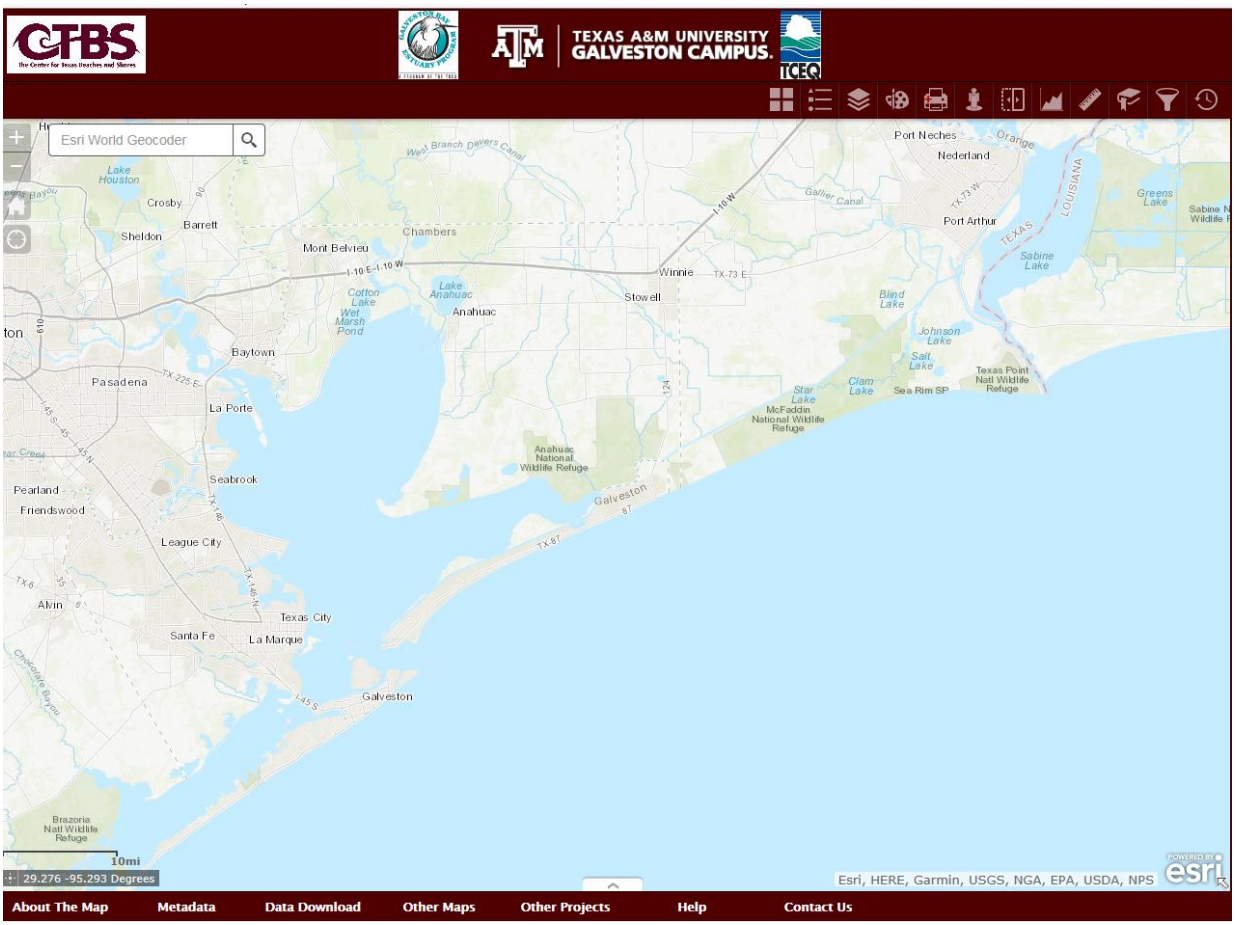
STATE OF THE BAY SYMPOSIA

The GBEP coordinates the State of the Bay Symposia which provide an opportunity for stakeholders to interact and share environmental policy and management successes, disseminate the latest monitoring and research findings, develop consensus for actions, and illuminate challenges facing Galveston Bay.

Each symposium audience is made up of representatives from resident and environmental groups; business and industry; commercial and recreational fishing; ecotourism and recreation; K-12 education and academia; and local, state, federal, and regional governments.

Presentations, posters, and panel sessions cover all aspects of the CCMP. Specific areas of interest as they relate to topics include new environmental threats; effects of human population growth; understanding physical and biological factors of estuarine ecosystems; environmental policy and management; successes, lessons learned, and challenges; and innovative tools, incentives, and techniques.

Photos from the 2016 State of the Bay Symposium (photo credits: Sarah Bernhardt).



Screenshot of the online Regional Monitoring Database, hosted by TAMUG.

REGIONAL MONITORING DATABASE

The goal of the Regional Monitoring Database is to make the environmental and social data about the Galveston Bay watershed accessible to a variety of user groups with diverse knowledge levels, while providing information the GBEP needs to evaluate progress. The Regional Monitoring Database builds on and extends the previous work produced by the HARC. Since 2000, project data have been available online.

The 2015 to 2017 update adds interactive features available through the web-mapping application (www.texascoastalatlas.com). Users can select, query, chart, print, and view data temporally. The web-mapping application is connected to Google maps and allows user to observe and see trends from the regional level to a street view. Future updates of the Regional Monitoring Database will take advantage of new online technology (such as web-based applications, geospatial or story maps, and data analytical tools).

MONITORING AND RESEARCH WEB PAGE

The goal of the monitoring and research page of the GBEP's website is to encourage greater research interest in Galveston Bay and expand the access to monitoring and research information. During development of *GBP'18*, stakeholders expressed an interest in expansion of the GBEP website to include monitoring and research.

The monitoring and research page on the website will include white papers and final reports from projects funded by the GBEP, presentations, links to research and peer reviewed papers by investigators funded by the GBEP, links to the *State of the Bay Report*, the Regional Monitoring Database, and one-page documents which describe CCMP implementation projects.

More information is available at the GBEP's website.

GALVESTON BAY REPORT CARD

The Galveston Bay Report Card is an annual, resident-driven, scientific analysis of the health of Galveston Bay. This partner-led initiative is an example of a data source outside the GBEP. The report card is supported by the Houston Endowment and produced by the Galveston Bay Foundation and HARC. The Report Card grades the health of the Galveston Bay ecosystem in six topic areas: Water Quality, Pollution Events and Sources, Wildlife, Habitat, Human Health Risks, and Coastal Change. The goal is to engage the public and inspire actions to protect and preserve the Bay.

More information is available at the Galveston Bay Report Card's website.

The GBEP maintains a quality-assured monitoring program. The program uses the information learned from routine monitoring partners and supplemental projects to improve implementation and management planning. The Galveston Bay Regional Monitoring Database and *State of the Bay Reports* provide access to data for use by program partners and other user groups. With the revised RMP, the GBEP will continue to use identified monitoring programs and supplemental monitoring to inform decisions. The GBEP improved assessment tools by the use of technology and information in developing the Regional Monitoring Database and report documents. The GBEP will expand access to other sources of monitoring, research, and implementation information by expanding the Galveston Bay website.

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Finance Plan

Two types of costs are associated with *GBP'18*: (1) funding the GBEP office and employees and (2) implementing the Action Plans outlined in the CCMP.

The following information provides an update to the Finance Plan as outlined in *GBP'95*. The 1995 Finance Plan is incorporated by reference to this revision, with additional information providing supplemental updates and revisions where appropriate.

Scenic view from the shores of Brays Bayou at Mason Park (photo credit: Sarah Bernhardt).

FUNDING THE GALVESTON BAY ESTUARY PROGRAM

Federal, state, and partner contributions are critical to the success of the GBEP. The GBEP is funded annually with EPA funds from Section 320 of the Clean Water Act, which are matched (1:1) with state funds from the TCEQ. The partnership between TCEQ and EPA is critical to successful implementation of *GBP'18*, since some Actions fulfill the tenets of the CWA and Texas Water Code and support the missions of both agencies.

Leveraging Partner and State Funding

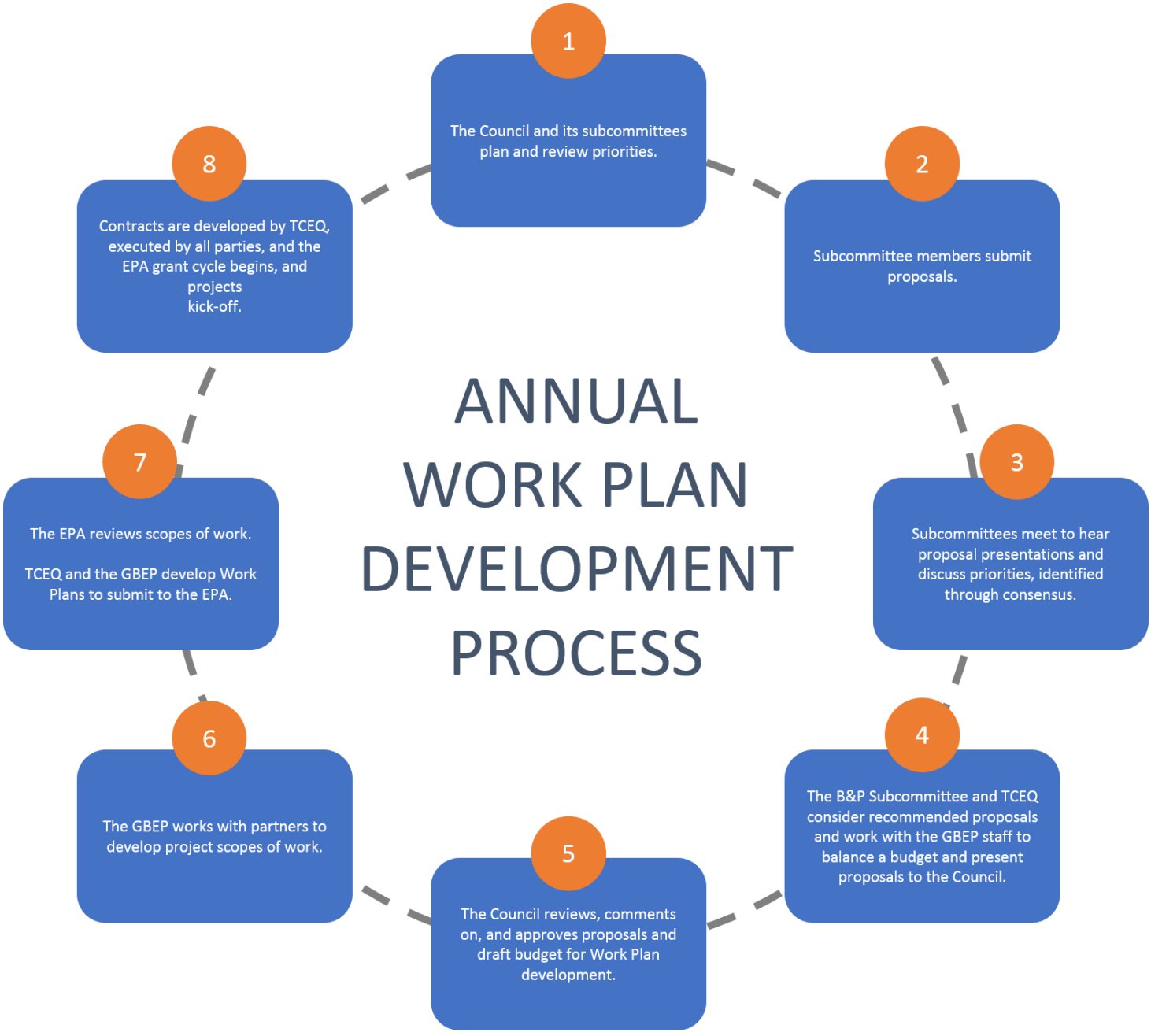
While funding received from the EPA and the state is integral to meeting operational needs, the GBEP's ability to plan and leverage additional monies is what makes the program a valuable partner in the region.

The GBEP provides technical support to its partners in developing and securing funding for a variety of project types and applies for external funding when applicable. Awards received include the CIAP, which was administered by the U.S. Fish and Wildlife Service in partnership with the GLO, and the Gulf Environmental Benefit Fund administered by the National Fish and Wildlife Foundation.

Since 2000, the GBEP leveraged an average of $13.40 in partner and state funding for every $1 of EPA funding received. For every $1 of state funding received, the GBEP leveraged an average of $5.96 in partner contributions.

Great egret carrying nesting material at the rookery at High Island (photo credit: Jason Leifester).

FIGURE 39
WORK PLAN DEVELOPMENT PROCESS



GBEP IMPLEMENTATION OF PLAN ACTIONS

The GBEP recognizes that successful implementation of the Actions* identified in *GBP'18* are subject to potential changes in national funding levels, environmental and weather related factors, the national economic climate, and other variables beyond its control.

The GBEP also recognizes that changes to the Objectives, Priority Issues, and Activities can be influenced by revisions to national EPA guidance. Subsequently, the GBEP, in coordination with the Council and its subcommittees, may choose to re-evaluate and update Work Plans generated through *GBP'18* to adjust for such changing factors. This adaptive management approach enables the GBEP to make appropriate modifications. More information about the Adaptive Management Approach is presented in the Regional Monitoring Plan section of this document.

The GBEP continues to seek funds to implement the actions recommended by *GBP'18* from a variety of sources to avoid creating a disproportionate financial burden on any group and to aid partners pursuing additional funds for implementation of Actions wherever possible. Funding includes grants, contract operations with partners, and private and nonprofit organization sources.

** Outputs that appear in multiple Actions are not intended to count toward total Implementation Costs multiple times but are instead a shared cost between multiple Actions. An example of this is the State of the Bay Symposium, which will be the final output for many research Activities under multiple Actions.*

Grants

The GBEP typically pursues grants from major federal assistance programs administered by:

- The EPA
- The NOAA
- The U.S. Fish and Wildlife Service
- The U.S. Department of Agriculture
- Sources related to the Deepwater Horizon Oil Spill, such as the Natural Resource Damage Assessment; Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (referred to as the RESTORE Act); and Gulf Environmental Benefit Fund

The GBEP also passes grant funds through to organizations responsible for implementing Actions, or pursues grant funding on behalf of the organizations responsible for implementation activities. State and federal funding provided to the GBEP from the TCEQ and EPA is leveraged as match for partners in the pursuit of these funds, when applicable. For example, EPA Section 319 nonpoint source funding through the Texas State Soil and Water Conservation Board and TCEQ annual grant programs has been successfully matched with GBEP state funding to implement local WPPs, such as in Double Bayou, that implement the Action Plan: Improve Water Quality Through Nonpoint Source Pollution Abatement. This demonstrates how the GBEP successfully works with its partners to maximize funding sources.

Contract Operations

The GBEP predominantly conducts implementation activities under interlocal and interagency contracts with other units of government and academia. Contract services for nonprofit organizations and private sector organizations may be pursued by the GBEP if the identified activities are consistent with *GBP'18* and qualify under federal and state law. This allows the GBEP to adopt existing agency programs to accomplish the Objectives identified in *GBP'18.*

Private and Nonprofit Organization Sources

Funding from nonprofit organizations and foundations that support projects related to environmental conservation may be obtained by the GBEP and will be pursued, when applicable.

PARTNER IMPLEMENTATION OF PLAN ACTIONS

Many actions identified in *GBP'95* and *GBP'18* will be pursued independent of fiscal support from the GBEP, but will be supported by the GBEP and stakeholder guidance. Other actions may be completed independent of both fiscal and other support from the GBEP. Partner implementation of actions may be funded through a variety of state, local, private, foundation, federal, or other funding sources. Numerous existing and proposed programs will expend funds to benefit Galveston Bay outside the annual GBEP EPA funds from Section 320 of the CWA; therefore, these costs do not add to the cost of *GBP'18*.

In fact, CCMP costs are small in comparison to the total expenditures in the region on water quality improvement programs alone. These externally funded programs are an important part of *GBP'18*'s bay-wide strategy for stewardship, but are not funded through CCMP by their separate mandates (i.e., they would occur regardless of *GBP'18*). An important role of *GBP'18* is in coordinating these programs through the Galveston Bay Council and subcommittees, to assure the bay's most significant problems are addressed.

FIGURE 40
EXAMPLES OF EXTERNALLY FUNDED PLAN ACTIONS

GBP'18 ACTION	FUNDING SOURCE	PROJECT DESCRIPTIONS (INCLUDING FUNDING PARTNERS)
HC-1	GEBF, Deepwater Horizon, National Fish and Wildlife Foundation (NFWF)	TPWD and Audubon Texas received $3 million to build and restore bird islands in Galveston Bay.
HC-2	NOAA Marine Debris Program	The Galveston Bay Foundation received funding to remove derelict and abandoned vessels and pilings. The GLO provided matching funds.
RES-4	National Academy of Sciences Gulf Research Program	The Galveston Bay Foundation received funding for "Making Monitoring Matter," a Galveston Bay volunteer water quality-monitoring program.
RES-8	Gulf of Mexico Alliance (GOMA)	Rice University SSPEED Center received funding to host the "Upper Texas Resiliency Conference" in 2010.
ACS-1; Regional Monitoring Plan	Houston Endowment	The annual *Galveston Bay Report Card* is produced by the Galveston Bay Foundation and HARC.
PEA-3	NOAA B-Wet	The Artist Boat received funding to conduct educational training for K-12 educators on watershed issues related to Galveston Bay.
SPO-3	U.S. EPA Gulf of Mexico Program	The Galveston Bay Foundation received funding for the G-BAN Mobile App and Outreach.

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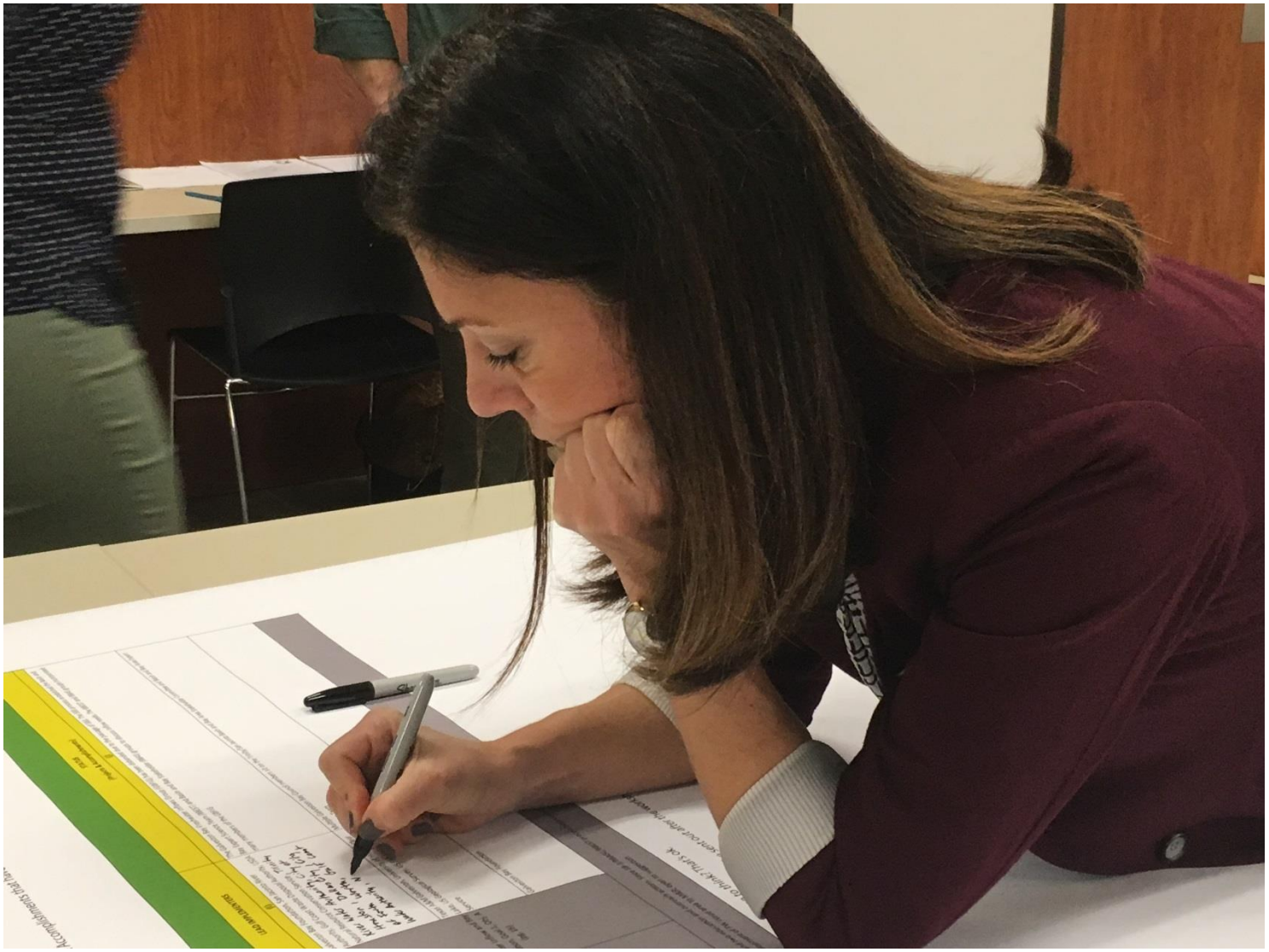
Public Review Process

GBP'18 is the result of strong and sustained involvement by the Council and its subcommittees. It serves as a guidance document for improved coordination among stakeholders across the Galveston Bay watershed to optimize the efficiency and efficacy of regional efforts and to avoid duplication.



A Workshop #2 participant providing framework feedback (photo credit: Houston-Galveston Area Council).

The continued involvement of Galveston Bay stakeholders will be critical to implementation of *GBP'18* and in the protection and preservation of Galveston Bay. This section includes an overview of the public review process, the GBEP's public engagement activities, and a summary of public comments.

PUBLIC ENGAGEMENT PLAN AND FULL EXECUTION PLANS

In October 2016, the GBEP developed a Public Engagement Plan (PEP). The PEP outlines the process used to inform and engage stakeholders about *GBP'18*.

The PEP was designed to:

- create a clear foundation for public engagement methods,
- identify stakeholders that should actively participate on the project, and
- establish the schedule for task completion and critical milestones, including three project workshops.

The PEP identified two audience groups: critical audience and secondary audience. The critical audience included the Council and subcommittee members. Most of the scheduled coordination and outreach focused on this group. The secondary audience was composed of members of various interested parties.

FIGURE 41
PUBLIC ENGAGEMENT PLAN AUDIENCE GROUPS

Critical Audience for *GBP'18*. Most scheduled coordination and outreach focused on this group.

GALVESTON BAY COUNCIL

SUBCOMMITTEES TO THE COUNCIL

Secondary Audience for *GBP'18*. Composed of various conservation and academic groups, as well as government authorities.

LOCAL / REGIONAL GOVERNMENTAL AUTHORITIES

City representatives

County representatives

Other programs of TCEQ

TPWD

Texas State Soil and Water Conservation Board

ADJACENT PROFESSIONAL SERVICES PARTNERS / NONPROFIT ORGANIZATIONS

Bayou Preservation Association

Galveston Bay Foundation

HARC

Houston Audubon

Houston Wilderness

Texas A&M AgriLife Extension Service

Texas A&M Forest Service

In addition to the PEP, the GBEP developed a Full Execution Plan (FEP) for each of the three workshops held in the development of *GBP'18*. Each FEP includes details about goals for the workshop, a detailed agenda, promotional information, and data needs. Appendix B: List of Public Engagement Materials gives information on where to view the PEP and three FEPs.

PROJECT WEBSITE

In October 2016, the GBEP launched a project website. The website included links to *GBP'95*, *SAP*, and current project information; provided details on workshops and other events; and served as the online public comment forum for the release of *GBP'18* draft. All documents and e-blasts providing information on *GBP'18* included links to the website.

The Galveston Bay Plan Revision website, hosted by the Houston-Galveston Area Council, is a major resource for project information.

Opportunities for public comment on *GBP'18* draft were provided online through the project website for a 30-day period. The website is located at www.GalvestonBayPlan.org.

NATIONAL ESTUARY PROGRAMS COORDINATION

The GBEP is one of 28 NEPs in the United States. As such, there are 27 current CCMPs available for process reference and comparison.

In September 2016, the GBEP distributed an online questionnaire to the directors and / or CCMP revision coordinators from other NEPs. Representatives from 12 NEPs provided feedback on the public engagement techniques used in revising their CCMPs, as well as the effectiveness of those techniques and lessons learned. The GBEP used this feedback as a basis for developing a plan of action for the public engagement process for *GBP'18.*

Respondents said in-person stakeholder workshops and public meetings were widely used, with stakeholder workshops deemed the most effective form of engagement (noted in Figures 42 and 43). Respondents also preferred facilitated meetings by a wide margin, with structured questionnaires used to supplement in-person efforts (noted in Figure 43). Using respondent feedback, the GBEP included early and iterative coordination with the Council and its subcommittees, with a focus on small-group meetings.

FIGURE 42
NEP QUESTIONNAIRE RESULTS: PUBLIC ENGAGEMENT TECHNIQUES USED

Responses	Number of Responses	Response Ratio	Effectiveness Score
Public Meetings	9	69%	Neutral
Stakeholder Workshops	13	100%	Effective
Electronic Media (e-blasts, website, etc.)	9	69%	Effective
Social Media	4	31%	Neutral
Other*	6	46%	[redacted]

**Other included print and media advertisements, community work groups, presentations, assessments, and listening sessions.*

In addition, the GBEP established a Technical Advisory Committee, including some members of the Council and the chairs of its subcommittees, to guide stakeholder engagement activities and the development of *GBP'18* content.

FIGURE 43
NEP QUESTIONNAIRE RESULTS: CONSENSUS TOOLS USED

Responses	Number of Responses	Response Ratio	Effectiveness Score
Facilitated Meetings	12	92%	Effective
Questionnaires	9	69%	Effective
Video Conferencing	1	7.6%	Ineffective
E-mail / Online Discussion	7	54%	Neutral
Other	0	0%	[redacted]

The GBEP incorporated feedback from the NEPs into the comprehensive PEP (noted in Appendix B: List of Public Engagement Materials) and scheduled stakeholder and public engagement activities.

WORKSHOP #1 AND OPEN HOUSE

On October 26, 2016, the GBEP hosted Workshop #1 and an Open House to review existing priorities in *GBP'95* and the *SAP* and emerging issues to incorporate into *GBP'18.*

APPROACH AND AGENDA

The Council and subcommittee members were invited to the workshop via e-mail invitations. Respondents registered in advance to allow for thorough pre-planning.

EXERCISE #1 – EXISTING PRIORITIES

Fifty Council and subcommittee members attended Workshop #1, participating in small-group facilitated discussion and exercises at five stations:

- Implementation and Vision
- Monitoring and Research
- Natural Resource Uses
- Public Participation and Education
- Water and Sediment Quality

FIGURE 44
EXERCISE #1: TOP EXISTING PRIORITY FOR EACH STATION

STATION / CATEGORY	EXISTING PRIORITIES	WKSHP VOTES	DIGITAL WKSHP VOTES	TOTAL	% OF VOTES
Water and Sediment Quality	Reduce Nonpoint Source Pollutant Loads	39	8	47	28%
Natural Resource Uses	Protect Existing Coastal Habitats	42.25	12	12	33%
Public Participation and Education	Create a Sense of Personal Ownership and Shared Responsibility Among All Cultural Components of the Community, Including the Public, Industry, and Government	52	11	63	36%
Monitoring and Research	Increase Understanding of the Galveston Bay Ecosystem	32.5	8	40.5	78%

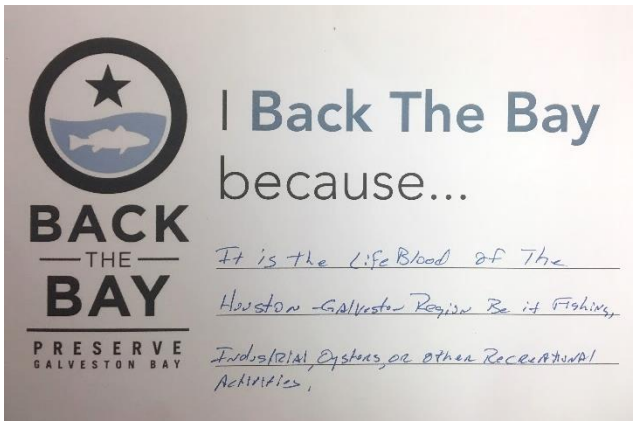
For four of the five stations, participants placed dots on existing priorities they believed should be the focus of *GBP'18*. The top existing priority for each station, excluding Implementation and Vision, are noted in Figure 44.

EXERCISE #2 – EMERGING PRIORITIES

Participants listed emerging priorities on sheets provided during the facilitated small-group discussion. The GBEP collected this information during the early portion of the workshop, then created a list of summarized emerging priorities. The list was posted at the venue, and participants were asked to note whether they agreed or disagreed with each summarized emerging priority (indicating whether it should be included in *GBP'18*).

Stakeholders identified multiple emerging priorities; however, resilience and sea level change were mentioned with the greatest frequency across all categories.

Unlike the other four stations, the Vision and Implementation station provided stakeholders an opportunity to discuss the boundaries of *GBP'95* service area, as well as the implementation feasibility of *GBP'95* and *GBP'18*.



Comment card received at Workshop #1.

OPEN HOUSE

The GBEP hosted an open house immediately following Workshop #1. The open house invitation was sent via Constant Contact to a list of 1,853 members of the public and the secondary audience group. Participants were invited to participate in the existing priorities exercise; however, because they did not participate in a facilitated small-group discussion, they did not participate in the emerging priorities exercise. Instead, open house participants took part in a "Why I Back the Bay" activity.

INCLUSION OF DIGITAL WORKSHOP QUESTIONNAIRE

The Council and subcommittee members unable to attend Workshop #1 were provided a Digital Workshop #1 questionnaire with activities and exercises from the workshop available from November 3, 2016, to November 10, 2016.

The Workshop #1 Digital Questionnaire received 12 completed responses. Incomplete submissions were not included. The results from the Digital Workshop #1 Questionnaire are included in the *Findings Report*, and were marked accordingly.

Appendix C: Workshop Findings Report gives information on how to view the complete Workshop #1 Findings Report.

SUBCOMMITTEE MEETINGS

In December 2016 and January 2017, the GBEP met with the four subcommittees to discuss Workshop #1 outcomes and to draft technical frameworks developed around those results. The subcommittees discussed each programmatic focus area, providing input and updates to Objectives, Plan Actions, and Outputs. A total of six meetings were held. Based on these meetings, the GBEP revised the draft frameworks in preparation for Workshop #2.

WORKSHOP #2

The GBEP held Workshop #2 on March 1, 2017. Fifty-four people attended to vet the frameworks and Action Plans, with a focus on implementation feasibility.

Upon arriving, participants received an informational packet, including an agenda; project reference information and acronym list; materials for Exercise #2; and framework reference sheets for M&R, PPE, NRU, and WSQ subcommittees.

APPROACH AND AGENDA

The Council and subcommittee members were invited to the workshop via e-mail invitations.

Respondents registered in advance to allow for thorough pre-planning. Registrants received Workshop #2 primer materials on February 24, 2017, which included a project status update, PDFs of the four subcommittee-specific frameworks, and prompts for workshop exercises.

EXERCISE #1 – EXISTING PRIORITIES

For Exercise #1, revised frameworks for each focus area were mounted on 60-by-40-inch boards. Participants reviewed the revised frameworks and provided additional Projects and Accomplishments, as well as Implementers to the frameworks.

EXERCISE #2 – OUTPUTS AND COST TO IMPLEMENT

Exercise #2 focused on Outputs, ensuring that they will be achievable, measurable, and support identified Objectives (goals). Respondents checked “yes” or “no” for each Targeted Output. Those respondents who selected “no” for a Targeted Output(s) were asked to provide further feedback.

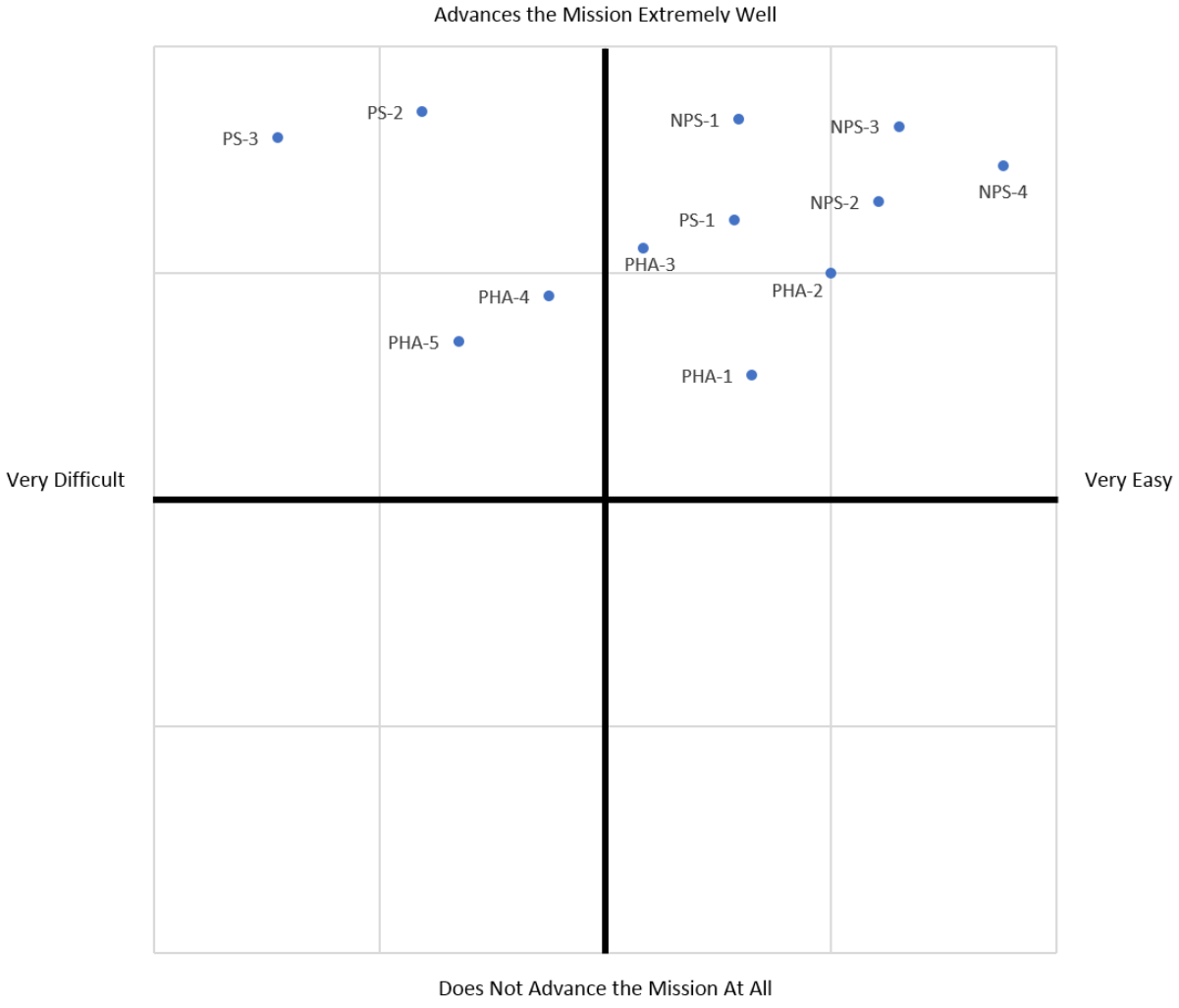
Respondents provided cost estimates for each Targeted Output, but only if they felt comfortable doing so.

EXERCISE #3 -- IMPLEMENTATION FEASIBILITY

Exercise #3 focused on implementation feasibility. Participants pinned pre-printed Objectives (referred to as Actions in the technical sections of *GBP'18*) to a grid, according to their answers to two questions:

1. To what extent would accomplishing this Specific Objective advance the mission of *The Galveston Bay Plan*? (y axis)
2. How easy or difficult would accomplishing this Specific Objective be? (x axis)

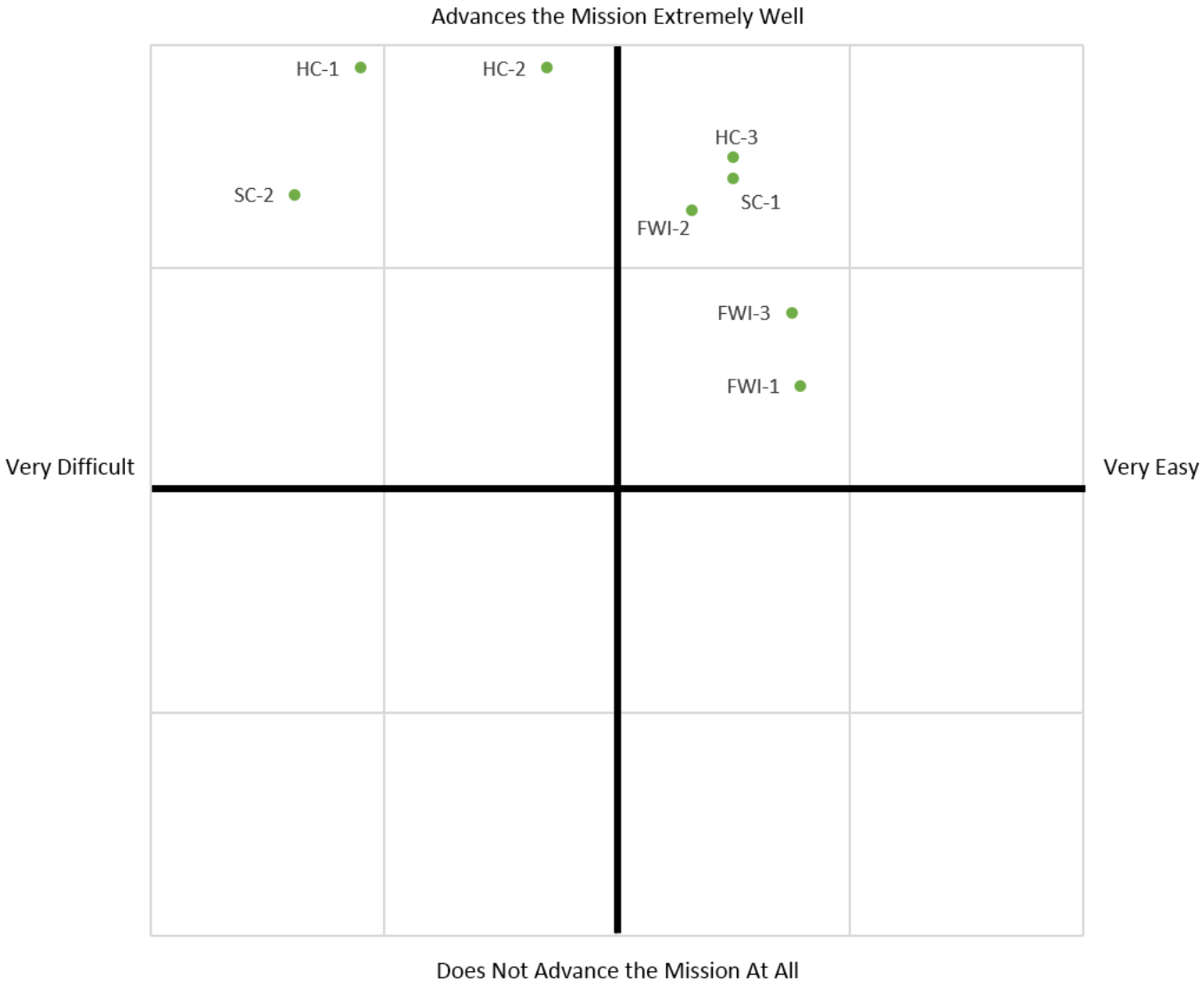
FIGURE 45
EXERCISE #3: WATER AND SEDIMENT QUALITY IMPLEMENTATION FEASIBILITY



For WSQ, Objectives contained the most variability between "Ease" and "Mission."

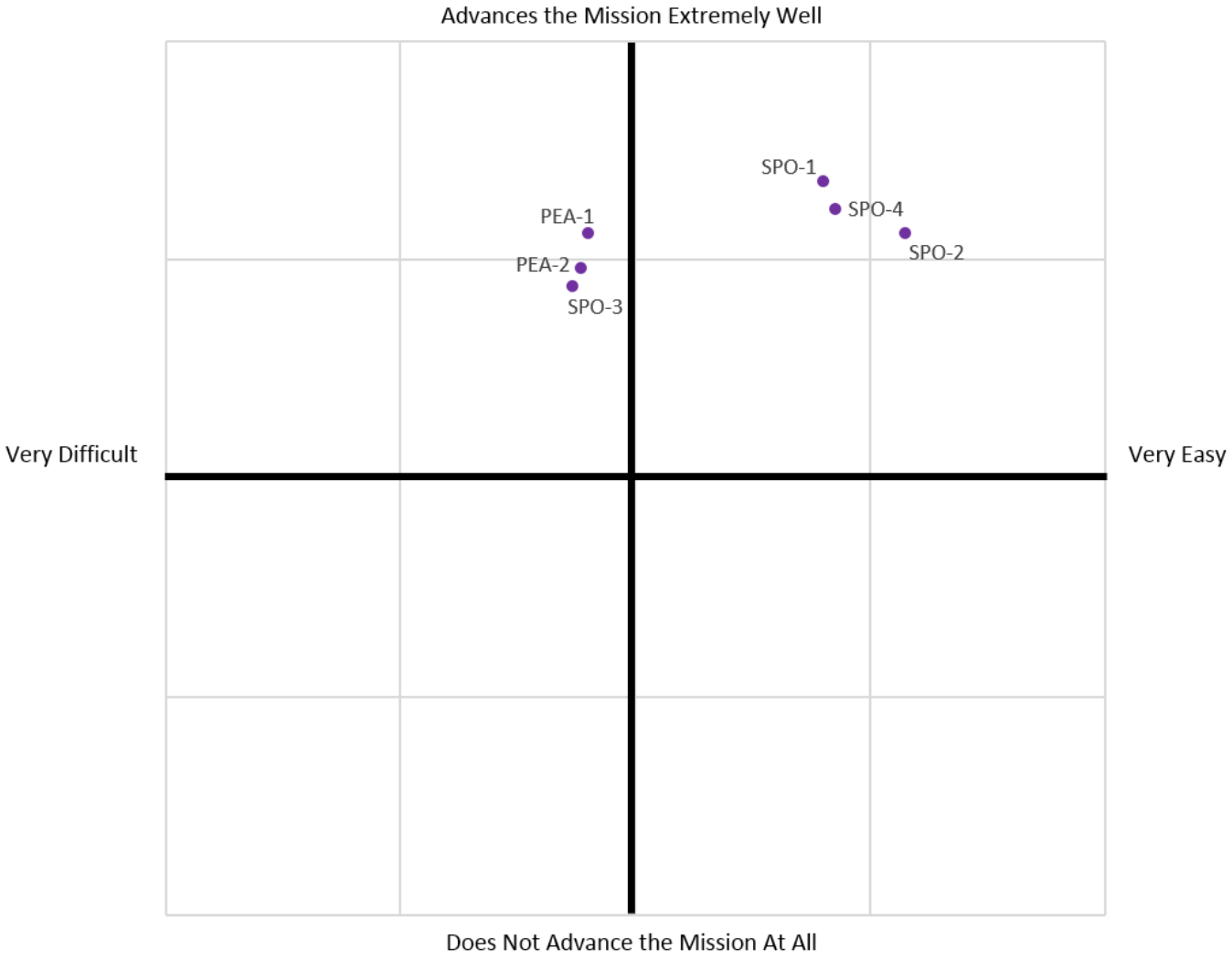
- 67 percent of Objectives were considered easy to very easy to implement.
- 75 percent of Objectives strongly support mission implementation.

FIGURE 46
EXERCISE #3: NATURAL RESOURCE USES IMPLEMENTATION FEASIBILITY



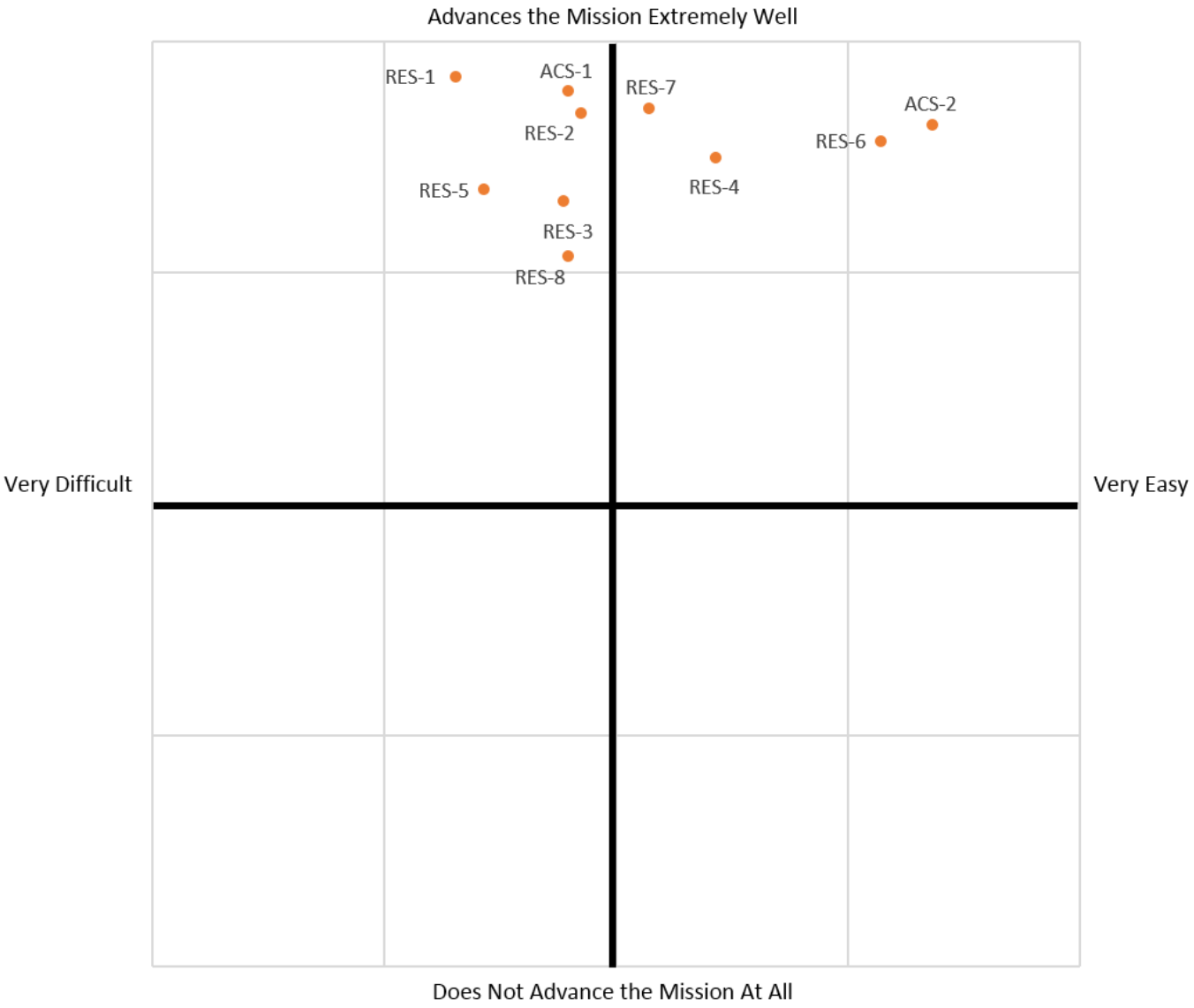
Seventy-five percent of NRU Objectives advanced the mission extremely well. Sixty-three percent of NRU Objectives were considered easy to implement, with 25 percent considered very difficult to implement.

FIGURE 47
EXERCISE #3: PUBLIC PARTICIPATION AND EDUCATION IMPLEMENTATION FEASIBILITY



PPE clustered the most of the four Focus Areas. Fifty percent Objectives were considered easy to implement. Sixty-seven percent of Objectives were considered as strongly implementing the mission.

FIGURE 48
EXERCISE #3: MONITORING AND RESEARCH IMPLEMENTATION FEASIBILITY



One hundred percent of M&R Objectives strongly advance the GBEP's mission. Forty percent of Objectives were considered easy to implement.

INCLUSION OF DIGITAL WORKSHOP QUESTIONNAIRE

Council and subcommittee members unable to attend Workshop #2 received Digital Workshop #2 Questionnaires (12) with activities and exercises from the workshop available from March 23, 2017, to April 5, 2017.

Appendix C: Workshop Findings Report provides information on Workshop #2 Findings Report.

WORKSHOP #3

The GBEP held Workshop #3 on March 5, 2018. Thirty-five stakeholders attended to review *GBP'18* draft and provide feedback. This meeting kicked off a 30-day public comment period, during which the GBEP received comments from the Council and its subcommittees, as well as other agencies, governments, and the public.

The primary audience for Workshop #3 remained the Galveston Bay Council, its subcommittees, and stakeholders that participated in the Open House and Workshops #1 and #2. However, Workshop #3 was advertised more widely to reach more members of the public.

APPROACH AND AGENDA

Unlike the facilitated approach taken for Workshops #1 and #2, Workshop #3 was set up as an Open House with five manned stations.

1. **Plan Priority One: Ensure Safe Human and Aquatic Life Use of Galveston Bay**
   Technical content from this section of *GBP'18* was presented through posters and exhibits, designed to provide attendees with a broad understanding of the three Action Plans under this Plan Priority and 12 associated Actions.

2. **Plan Priority Two: Protect and Sustain the Living Resources of Galveston Bay**
   Technical content from this section of *GBP'18* was presented through posters and exhibits, designed to provide attendees with a broad understanding of the three Action Plans under this Plan Priority and eight associated Actions.

3. **Plan Priority Three: Engage the Communities of Galveston Bay**
   Technical content from this section of *GBP'18* was presented through posters and exhibits, designed to provide attendees with a broad understanding of the two Action Plans under this Plan Priority and seven associated Actions.

4. **Plan Priority Four: Inform Science-Based Decision Making in Galveston Bay**
   Technical content from this section of *GBP'18* was presented through posters and exhibits, designed to provide attendees with a broad understanding of the two Action Plans under this Plan Priority and 11 associated Actions.

5. **General Plan Information**
   This station included posters and exhibits for content from sections of *GBP'18* not included under a Plan Priority, such as the Regional Monitoring Plan and Finance Plan.

To provide for more in-depth discussion, Plan Priority stations were manned primarily by the GBEP staff and subcommittee chairs / vice chairs. Each station included a mechanism for providing content feedback, though all Workshop #3 attendees expressed a preference for using the online feature after more careful review of the draft *GBP'18*.

PUBLIC COMMENT LOG

In addition to the formal communications channels outlined in this section, the GBEP received multiple letters and e-mails from stakeholders pertaining to *GBP'18* content, revision process, and functionality of the GBEP.

A log of these comments is presented in Appendix D: Public Comment Log.

Workshop #2 attendee participates in an exercise (far left). Participants at Workshop #1 review prioritization exercise results (center). Another Workshop #2 attendee participates in an exercise (top right). Participants add their thoughts to the PPE technical framework at Workshop #2 (bottom right) (photo credits: Houston-Galveston Area Council).

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Appendices

APPENDIX A: GLOSSARY

abundance	The number of individuals of a given species found in an area over a given time period.
algal bloom	Population explosion of phytoplankton in response to optimal growth conditions, including nutrient over-enrichment from wastewater and nonpoint sources.
ambient	Prevailing environmental conditions, as opposed to those measured in a laboratory or waste stream.
assemblage	A subset of a taxonomic group located in a given area. Used in community ecology.
assessment unit	A stream and/or water body that has been individually defined by the TCEQ and assigned a unique identification number.
bacteria implementation group	Thirty-member committee preparing an implementation plan to remedy high levels of bacteria in waterways identified in four TMDL projects in the Houston Region.
benthic	Of, relating to, or occurring at the bottom of a body of water.
best management practice	Pollution-control techniques applied to waste disposal, spill control, site runoff, and other activities. Implemented to prevent or reduce the amount of pollutants entering a water body.
biodiversity	Degree of variability in the living world. The term can describe the number of species, the amount of genetic variation, or the number of community types present in a given area.
biomagnification	The concentration of toxins in an organism resulting from ingestion of other plants or animals in which the toxins are more widely disbursed.
brackish	The mixture of saltwater and fresh water in estuaries. Salinity can range from 0.5 to 35 parts per thousand.
coastal prairie	A native habitat consisting of a mixture of upland and wetland geomorphology, hydrology, and vegetation located along the Gulf Coastal Plain.
colonial nesting	The propensity for some bird species, e.g., most egrets and herons, to nest in dense colonies.
community	An assemblage of various plant and animal species that share a given habitat at the same time.
competition	Rivalry by multiple individuals or populations in pursuit of a limited resource (e.g., food or space).
conservation easement	An agreement between a landowner and a government authority or qualified land trust for conserving habitat. The agreement restricts the way in which a land parcel can be used in the future.
conservation	Management that preserves, protects, and restores natural resources (e.g., habitat) in the presence of social and economic needs.
contact recreation	Activities that are presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, handfishing as defined by Texas Parks and Wildlife Code, §66.115).
cordgrass	Any member of the genus *Spartina*; a partially submerged wetland plant common to brackish and salt marshes of the Gulf Coast.
delta	An exposed or submerged deposit of stream-borne sediments found at the mouths of rivers.
dermo	A disease of oysters caused by the parasitic protozoan *Perkinsus marinus.*

dioxins	A class of chemical contaminants formed during combustion processes such as waste incineration, forest fires, and backyard trash burning, as well as during some industrial processes, such as paper-pulp bleaching and herbicide manufacturing.
dissolved oxygen	Oxygen dissolved in water that is necessary for the survival of most aquatic life.
diversity	A measure of the variety of living things in a community, based upon one of several mathematical formulae which account for both numbers of species and numbers of individuals within species.
dredge and fill	The movement of sediments from one location to another, typically for navigation channel maintenance, shoreline development, or habitat-restoration activities. Dredge-and-fill activities typically require a Section 10/404 permit issued by the U.S. Army Corps of Engineers.
E. coli	*Escherichia coli* is a subgroup of fecal coliform bacteria that is present in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens. *E. coli* is currently an accepted indicator of contamination in freshwater.
ecological services / ecosystem services	Human benefits arising from the ecological functions of ecosystems (e.g., fisheries harvests, nature tourism, and provision of clean water).
ecosystem approach	Management of ecological systems that integrates ecological, social, and economic goals and recognizes humans as key components of the ecosystem.
ecosystem	A natural system that includes the totality of living things, their physical environment, and the interrelationships among them.
ecotourism	Tourism involving travel to areas of natural or ecological interest for observing wildlife and learning about the environment, e.g., birdwatching.
education	Refers to efforts to increase the knowledge of specific audiences through intentional, structured communications or trainings. Specific audiences might include K-12 students, college students, teachers and instructors at all academic levels, or adult members of the public.
effluent	Wastewater discharged from any point source prior to entering a water body.
emergent wetlands	Marshes in which vegetation is rooted underwater and the tops exposed (as contrasted with submerged vegetation or upland habitats).
Enterococcus	A subgroup of fecal streptococci bacteria (mainly Streptococcus faecalis and Streptococcus faecium) that is present in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens. *Enterococcus* is currently an accepted indicator of contamination in saltwater.
estuary	A coastal, semi-enclosed body of water within which saltwater from the sea mixes with freshwater from land drainage.
eutrophication	Nutrient over-enrichment of a water body resulting in overgrowth of algae, frequently followed by algae die offs and oxygen depletion.

fecal coliform	A portion of the coliform bacteria group that is present in the intestinal tracts and feces of warm-blooded animals; heat tolerant bacteria from other sources can sometimes be included. It is used as an indicator of the potential presence of pathogens
finfish	Fish, as opposed to shellfish.
food chain	A series of interconnected feeding relationships; the process of energy capture (by green plants) and successive transfer to grazers (primary consumers) and predators (secondary consumers and above).
food web	The network of trophic relationships in an ecosystem; a complex network of food chain interactions.
fragmentation	The breaking up of large expanses of habitat into smaller tracts,
freshwater inflow	Freshwater that flows into an estuary from rivers, streams, and creeks, including the contribution of wastewater effluent discharges, return flows, and stormwater runoff into the bay and its tributaries.
habitat	The place in the environment where an organism lives or can be found.
impairments	Water quality that fails to meet surface water quality standards for rivers, lakes, and estuaries, as defined by the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency.
impervious surface	Land surface with a low capacity for soil infiltration, e.g., parking lots or roadways. Degrades water quality by increasing surface runoff and the quantity of nonpoint source pollution.
impingement	The accumulation of organisms on a water-intake screen, e.g., at a power-plant cooling-water intake.
indicator bacteria	Types of bacteria used to detect and estimate the level of fecal contamination of water.
inflow	The water feeding an estuary, generally referring to river sources.
inlet	A channel of water between adjacent barrier islands that connects a bay with the open ocean.
intertidal	The portion of shoreline exposed at low tide and inundated by high tide.
invasive species	Non-native species that establish, reproduce, and spread in the region to which they were introduced.
jetty	An artificial structure that projects into a body of water and is used to direct water currents or accommodate maritime vessels.
landings	The part of fishing vessel's fisheries catch that is brought ashore. Landings are the total catch minus the discards.
loading	The rate of introduction of a constituent (e.g., contaminant) to a receiving water, for example in pounds per day. Loading is significant in relation to the volume and circulation of the receiving water; problems occur when high loadings occur into receiving waters with limited assimilative capacity.
microbiological	Pertaining to biology that deals with microorganisms.
microplastics	Small plastic particles in the environment, defined by NOAA as less than 5 mm in diameter.
microscopic	Too small to be seen by the unaided eye but large enough to be studied under a microscope.
most probable number	A method of measuring the concentration of fecal coliform bacteria in a water sample.

National Estuary Program	A non-regulatory program of the U.S. EPA that encompasses 28 estuaries of national importance. It requires that each estuary develop a comprehensive conservation and management plan. Its goal is to improve the quality of the nation's estuaries.
nonpoint source	Any source other than a point source; any of a number of diffuse, land-based sources of constituents (including pollutants) in water, which are generally transported in runoff from precipitation. Contrasts with point source pollutants, or end-of-the-pipe constituents generally transported in wastewater from a discrete source.
nursery areas	Portions of the estuary where marine species spend their early life stages, fulfilling requirements for adequate food and protection from predators. Examples include emergent marshes and seagrass beds.
outfall	A site where there is a point loading of domestic, industrial, or heat wastes to an aquatic system; a discharge point for a wastewater stream, e.g., a sewage treatment plant or refinery.
outreach	Any attempt to engage the public, stakeholders, or partners in activities or discussions that enhance connection to Galveston Bay. Typically, outreach activities apply to a broad audience with a less specific structure.
partner	Any person, group, or entity actively working in the Galveston Bay Watershed to implement GBP'18.
pathogen	A disease-causing microbe.
phytoplankton	Green plants (for example algae) inhabiting waters, unattached and drifting with the currents.
point source	End-of-the-pipe constituents (including pollutants) generally transported in wastewater from a discrete source.
polychlorinated biphenyls	A family of organic compounds; mixtures of up to 209 individual chlorinated compounds. They have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they do not burn easily and are good insulators.
population	An aggregation of organisms of a given species, capable of interbreeding.
predation	Capture and consumption of one organism by another.
preservation	The management of a natural resource which strives to maintain the natural state of the ecosystem so that it is not artificially interrupted or destroyed and natural resources are not depleted.
primary producer	An organism capable of producing biomass from inorganic compounds; the base of the food web.
restoration	Returning a degraded system to a natural, healthy, and undegraded state.
return flow	Water that returns to surface or ground water after human use.
riparian	Associated with the bank of a watercourse, for example, the riparian woodlands bordering a river.
saline water (saltwater)	Water that contains a significant concentration of dissolved salts. The salinity of water in the ocean averages about 35 parts per thousand.
salinity	A measure of salt concentration in water, ranging from zero to about 33 parts per thousand in estuaries.
salinity gradient	A spatial salinity transition, e.g., from a fresh river mouth to saline ocean inlet.
salinity wedge	A layer of dense saltwater that lies below less dense, lower-salinity waters. The salinity wedge in Galveston Bay moves northward (particularly through the Houston Ship Channel) with high tides and low freshwater inflows.

salt marsh	Coastal wetlands that occur on the intertidal shorelines of estuaries where salinities vary due to mixing of freshwater and seawater. The dominant salt-marsh plant species in Galveston Bay is salt-marsh cordgrass (*Spartina alterniflora*).
seafood advisory	Warning issued by a public-health authority recommending avoidance or reduced intake of certain species of seafood that may pose increased health risks to consumers.
stakeholder	An individual or organization with an interest in a natural resource or other issue by virtue of livelihood or simple personal concern. A "stakeholder" could be an elected official, government employee, nonprofit employee, local business owner, land owner, volunteer, recreational bay user, or industry representative.
storm surge	The increase in water depth caused by a hurricane, due to a combination of low atmospheric pressure (which creates a bulge in surface waters) and wind-piling of water against the shore. Serious damage can result when a storm surge moves onshore and as waters flow back to their source.
stormwater runoff	Water from rain or snowmelt that does not soak into the ground but runs off the land and flows, untreated, into waterways.
submerged aquatic vegetation	Rooted, submerged vegetation, including seagrasses and freshwater rooted macrophytes; contrasts with emergent species such as smooth cordgrass.
subsidence	The loss of land elevation due to groundwater or petroleum withdrawal and natural settling and compaction.
substrate	The material or substance on which an organism lives, grows, or obtains its nourishment.
terrestrial	Refers to land, as opposed to the aquatic or marine environment.
Texas Clean Water Act Section 303(d) List	The list of impaired surface waters in Texas, updated annually by the TCEQ under section 303(d) of the federal Clean Water Act.
tidal flats	Non-vegetated areas of sand or mud that are alternately submerged or exposed to air, depending on the tides.
total maximum daily load	As defined in the federal Clean Water Act, the maximum amount of a pollutant a water body can receive and still meet water quality standards.
treatment wetlands	Constructed wetlands that are designed and created to filter and treat storm water runoff or wastewater effluent using natural physical, biological, and chemical treatment processes.
trophic level	The position in the food chain relative to eating and being eaten; includes primary producers, primary consumers, and higher consumers.
turbidity	The relative lack of clarity (cloudiness) of water, caused by suspended material (e.g., sediments), colored materials in solution, and plankton. Turbidity correlates inversely with available light for photosynthesis.
water quality standards	The criteria used to establish explicit goals for the quality of streams, rivers, lakes, and bays.
watershed	The land area drained by a river or stream. The natural hydrologic unit associated with numerous ecological and physical processes involving water.
watershed-based plan	A comprehensive land-use and water management plan targeted at improving water quality.

wetland	An area where saturation with water is the dominant influence on characteristics of the soil and on composition of the plant community.
zooplankton	Animals that are suspended in, and move within, the water column.

APPENDIX B: LIST OF PUBLIC ENGAGEMENT MATERIALS

Go to www.GalvestonBayPlan.org or www.gbep.texas.gov to view and download copies of relevant public engagement materials.

Galveston Bay Estuary Program – Comprehensive Conservation Management Plan Revision: Public Engagement Plan

Galveston Bay Plan Revision – Workshop #1 Full Execution Plan

Galveston Bay Plan Revision – Workshop #2 Full Execution Plan

Galveston Bay Plan Revision – Workshop #3 Full Execution Plan

APPENDIX C: WORKSHOP FINDINGS REPORTS

Go to www.GalvestonBayPlan.org or www.gbep.texas.gov to view and download copies of findings reports.

The Galveston Bay Plan Revision – Workshop #1 Meeting Summary and Findings Report

The Galveston Bay Plan Revision – Workshop #2 Meeting Summary and Findings Report

The Galveston Bay Plan Revision – Workshop #3 Meeting Summary and Findings Report

APPENDIX D: PUBLIC COMMENT LOG

The table that follows references a draft version of *GBP'18*, released for public comment on March 5, 2018. Page, paragraph, and line references may differ from this document based on edits and / or additions. Some comments have been modified for clarity.

LIST OF COMMENTERS

More than 150 stakeholders provided content, comment, and feedback for *GBP'18*. The following individuals provided formal comment between March 5, 2018 – April 4, 2018.

COMMENTER	NUMBER OF COMMENTS PROVIDED
Brandt Mannchen, Sierra Club - Houston (LETTER)	171
Doug Jacobson, EPA (VERBAL / E-MAIL)	25
Jan Culbertson, TPWD (ONLINE FORM)	3
Jeff Taebel, H-GAC (E-MAIL)	3
John Wuttke, Building Everyone a Cleaner Houston (ONLINE FORM)	1
Jorge Brenner, The Nature Conservancy (ONLINE FORM)	1
Kenneth Teague (LETTER)	183
Paula Paciorek, Galveston Bay Foundation (ONLINE FORM)	2
Sarah Gossett, Galveston Bay Foundation (ONLINE FORM)	5
Scott Jones, Galveston Bay Foundation (ONLINE FORM)	27
Stennie Meadours, 3P Project (ONLINE FORM)	1
T'Noya Thompson, Galveston Bay Foundation (ONLINE FORM)	4
Anonymous Commenter (E-MAIL)	1

APPENDIX E: TECHNICAL CROSSWALK

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APPENDIX F: PERFORMANCE MEASURES

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APPENDIX G: BIBLIOGRAPHY

Credits for page 71: H-GAC Community and Environmental Geographic Information System

Description: The dataset was developed based on 2015 LandSat 8 Operational Land Imager and the Thermal Infrared Sensor scenes of 30 meter resolution acquired from the USGS. Four scenes with 0-5% cloud cover were used to cover the entire area. Using supervised and unsupervised classification techniques in ENVI Software remote sensing package, the imageries were classified into 10 major land cover classes. Classification classes were determined based on the NOAA and National Land Cover Database land cover classification schemes. The output cell size is in 30 meter resolution.

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APPENDIX H: ADDITIONAL RESOURCES

All website and document links included in *GBP'18* are current as of publication date {September 25, 2018}.

GBEP Website
www.gbep.texas.gov

Regional Monitoring Database (Status and Trends)
http://www.texascoastalatlas.com/AtlasViewers/StatusAndTrends/SnTatlas.html

Galveston Bay Report Card
http://www.galvbaygrade.org/

Basin Highlights Report – How's the Water
http://www.h-gac.com/community/publications/water-resources.aspx

Texas Department of State Health Services Website - Fishing Advisories, Bans, and FAQs about Bodies of Water - Seafood and Aquatic Life
https://www.dshs.texas.gov/seafood/advisories-bans.aspx

EPA Impaired Waters and TMDLs: Program Overview: Total Maximum Daily Loads (TMDL)
https://www.epa.gov/tmdl/program-overview-total-maximum-daily-loads-tmdl

TCEQ: Watershed Protection Plans for Nonpoint Source Water Pollution
https://www.tceq.texas.gov/waterquality/nonpoint-source/mgmt-plan/watershed-pp.html

Water Resources Information Map
www.h-gac.com/Go/WRIM

GBAN
http://www.galvbay.org/GBAN

Trash Bash
www.trashbash.org

HERE in Houston
http://www.hereinhouston.org

Invasive Field Guide
http://www.galvbayinvasives.org/

State of the Bay Report - 2011
http://galvbaydata.org/www.galvbaydata.org/StateoftheBay/tabid/1846/Default.html

Texas Coastal Atlas
www.texascoastalatlas.com

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