Element I- Monitoring Program & Schedule

The Highland Bayou Watershed is on the TCEQ 303(d) list for elevated bacteria and low DO. Nutrients are also understood to be contributing to the impairment. The monitoring resources and strategies outlined here will be implemented to verify that bacteria and nutrient reductions are occurring in the Highland Bayou Watershed, and that the water quality goals set in this WPP are being achieved. The monitoring strategy will rely on the use of water quality data collected through routine sampling to ultimately demonstrate success. As currently implemented, the existing monitoring network cannot achieve all the objectives recommended to measure actual environmental progress. Additionally, no sampling is currently being conducted in support of the Highland Bayou Watershed Protection Plan. As of today, existing sampling programs are insufficient to assess progress towards attaining water quality standards. However there are programmatic resources in the region that through cooperative agreements and program adjustments can provide support in resources and capacity for a successful monitoring program in the watershed.

Historical and Current Monitoring

Several programs have monitored or currently monitor water quality in the Highland Bayou Watershed:

1. TCEQ's SWQM program
2. Texas Stream Team
3. Galveston County Health District
4. 2010-2011 Highland Bayou Sampling Program
5. Real Time Monitoring USGS stations

TCEQ's SWQM Program

TCEQ monitors water quality through its SWQM Program. The program consists of four monitoring categories: routine, special, permit-support, and systematic. The routine and systematic categories both support TCEQ's objective to evaluate aquatic systems in the state for attainment of use standards. Routine monitoring is generally long-term (longer than five years) and is conducted at most of the Texas' 367 classified streams. Systematic monitoring is conducted for shorter time frames and in support of TMDL implementation and assessment of 303(d) segments. Permit support and special monitoring are localized project-specific sampling programs.

Sampling locations are coordinated through the Texas Clean Rivers Program and is funded through TCEQ, in partnership with regional and local organizations. The program is coordinated by Texas State University (San Marcos) and in partnership with TCEQ, H-GAC, and the US EPA. Sampling is conducted by professional water quality specialists and under strict quality assurances using National Environmental Laboratory Accreditation Conference certified labs and methods. *At this time no sampling under this program is being conducted in support of the Highland Bayou Watershed Protection Plan*.

Texas Stream Team

In the Houston region, the Clean Rivers Program also supports the Texas Stream team program conducted by citizen volunteers. This too is administered in part by H-GAC and supports TCEQ's SWQM program. The Texas Stream Team program is structured into volunteer groups that are managed at the community level by organizations such as the GBF and the Galveston Master Naturalists. This program is not covered

by the same quality assurances whereas the main SWQM program is. Rather, the results from the Stream Team are used to identify emerging water quality issues and trends, which may be used to justify a more rigorous and quality-assured sampling effort through TCEQ's SWQM programs. *Texas Stream Team conducts sampling in the study area, but no sampling is being conducted in support of the Highland Bayou Watershed Protection Plan.*

Galveston County Health District

The Air and Water Pollution Services Division of GCHD conducts a water quality sampling program supported by county funds, staff, and facilities. The sampling program is conducted in support of sewage treatment plant inspections, stormwater sampling, and investigation of citizen complaints. Its sampling program relies on standards and locations that differ from the SWQM program. This means that any monitoring supported by GCHD as part of this WPP will require coordination about these standards and locations. Funding for non-Health District sampling efforts is extremely limited or non-existent, and any support from the county will have to be coupled with additional funding to cover the effort, either as grants or as county appropriations.

2010-2011 Highland Bayou Sampling Program

The Highland Bayou Sampling program was a short-term water quality study conducted in support of the characterization report and watershed protection planning. Sampling was funded by the American Recovery and Reinvestment Act and conducted in accordance with an existing amended Quality Assurance Project Plan. The effort was managed by the Texas Coastal Watershed Program and conducted by water quality specialists from the Environmental Institute of Houston, University of Houston Clear-Lake. The program was designed to assist with the characterization of the watershed and to monitor the impacts of NPS on local waterways in the basin. Results of the program were submitted for entry in TCEQ's SWQM database and will be used in ongoing efforts by TCEQ to assess segments in the study area.

The sampling program consisted of six events at 6 stations within the Highland Bayou Watershed. Sampling began in November 2010 and concluded in July, 2011. All the major non-point source water quality parameters were tested, including:

- Water Temperature
- Specific Conductance
- Salinity
- DO
- pH
- Instantaneous Flow
- Secchi Depth
- Chlorine
- Total Suspended Solids
- Chloride
- Chlorophyll-a
- *Enterococci*
- Total Nitrates
- Orthophosphate
- Total Phosphate
- Sulfate

USGS Real Time Monitoring

As of 2016, there is one operating USGS stream gauge in the project area. The USGS gauges monitor flow conditions and precipitation, but they do not monitor water quality parameters. The operating USGS station in the basin is located at the La Marque pump station in the Texas City Levee, station 08077740. The station is supported in part by Galveston County (USGS, 2016).

Two other stations were established within the Highland Bayou Watershed, but their use has been discontinued. Between 1997 and 2003, a USGS station (08077690) was operating at a point near the diversion point from Highland Bayou to the Diversionary Canal. For fourteen months, beginning in 2006, a continuously data monitoring station was set up for field sampling where TX Route 6 crosses Highland Bayou.

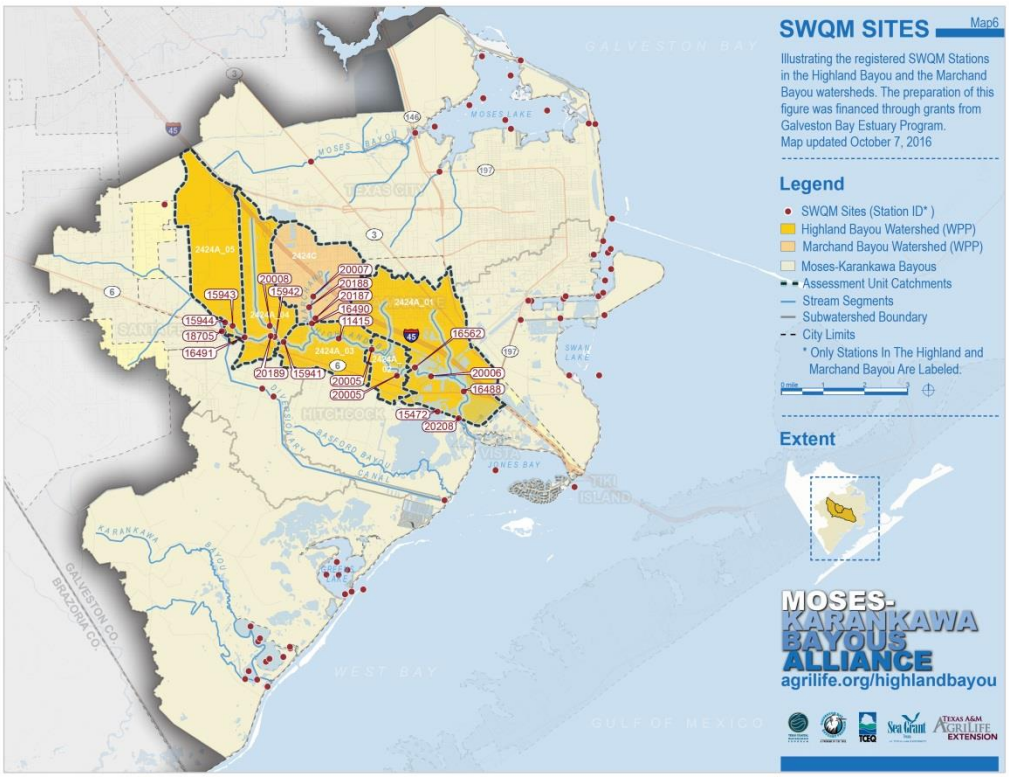
Proposed Monitoring

Watershed Protection Plans have certain levels of uncertainty when they are developed and implemented. As the action areas outlined in Element C are put into practice it will be necessary to measure and test water quality for certain parameters over time and adjust the WPP as necessary if water quality goals are not being achieved. This practice of adaptive management will allow results to guide future strategies and implementation efforts. The monitoring strategy outlined below will be implemented to check if bacteria and nutrient reductions are occurring at a sub-watershed level, and that the goals set by this WPP are being achieved according to schedule. Ambient water quality data will be routinely monitored at downstream SWQM stations at the subwatershed level.

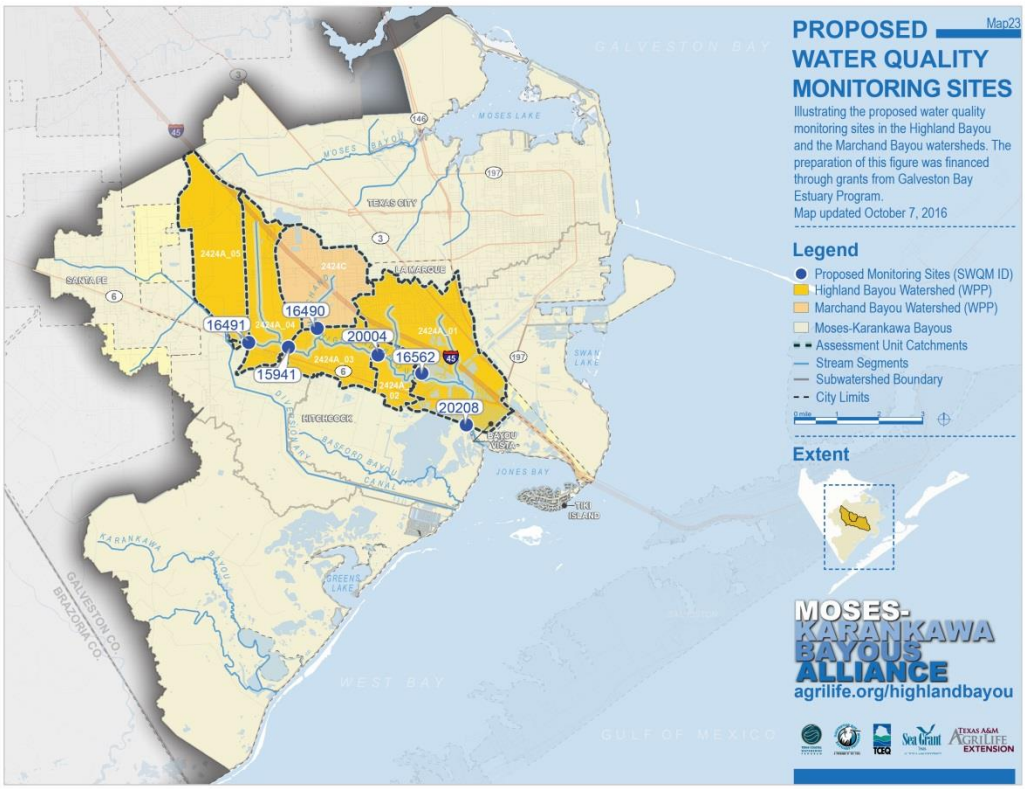
Table I-1 below summarizes the SWQM stations that will be used for evaluating short term and long term water quality conditions at the subwatershed level to guide the adaptive management approach. SWQM stations were selected for coincidence with the limits of listed segments, or alternatively AU ID catchments. Data collection will focus on collecting routine water quality samples from the 6 stations listed in Table I-1and shown on Map-23. These samples can be used for WPP implementation and in future waterbody assessments. Parameters monitored are listed in Table 1-2. Data from the last 7 years of bacteria and nutrient levels should be analyzed every 2 years and compared to interim target goals. Analyzing results every 2 years will also show spatial and historical trends that will assist with adjusting management strategies.

Table I- 1. Priority Monitoring Stations Selected for Measuring Progress

Subwatershed	Segment ID	SWQM Station ID	SWQM Station Description	County	Monitoring Frequency Proposed in WPP
Highland Bayou	2424A_01	16562	Highland Bayou at end of Bayou Lane in Freddiesville	Galveston	Monthly
Highland Bayou	2424A_02	15941	Highland Bayou tidal at FM 519, 335 meters north of HWY 6 in City of Hitchcock	Galveston	Monthly
Marchand Bayou	2424C_01	16490	Marchand Bayou tidal at FM 519 in City of Hitchcock	Galveston	Monthly
Highland Bayou	2424A_03	16491	Highland Bayou at FM 2004 in City of Hitchcock	Galveston	Monthly
Highland Bayou	2424A_04	20004	Highland Bayou approximately 100 m downstream of City of La Marque. WWTP #WQ0010410001 is located 170 m upstream of Lake Road terminus	Galveston	Monthly
Highland Bayou	2424A_05	20208	Highland Bayou at railroad bridge 1.10 km downstream of HWY 6 near City of Texas City	Galveston	Monthly



Map- 6. Registered SWQM Stations



Map- 23. Proposed WQM Stations for Tracking Water Quality Improvements

Table I-2 provides a subset of key parameters collected through the routine monitoring program that will be utilized to demonstrate progress toward reducing bacteria and nutrient concentrations in subwatersheds over time.

Table I- 2. Water Quality Parameters Used for Measuring Progress.

Field Data	
Dissolved oxygen (mg/L)	Specific conductance
pH	Flow (collected at USGS gage station)
Days since last rainfall	Instantaneous Flow
Odor of water	Biological activity
Water temperature	Illegal dumping activity
Salinity	Animal activity
Total Suspended Solids	Secchi Depth
Bacteria Data (All Sections of 2424A & C are tidally influenced)	
E. coli (#/100mL) freshwater only	*Enterococci* (#/100mL) saltwater only
Nutrients Data	
Chlorine	Chloride
Total Nitrates	Chlorophyll-a
Total Phosphate	Sulfate
Orthophosphate	Total dissolved solids

Additional Monitoring

The Highland Bayou work group expressed interest in employing Bacterial Source Tracking techniques as an additional management tool for the Highland Bayou Watershed, even though it did not rise to the level of a top-10 priority action area. Bacterial Source Tracking is a relatively new approach that utilizes a bacteria DNA library, which is prepared using known sources from within the watershed. Water quality monitoring samples are compared to the library to determine the most significant contributors of bacteria. This data could be used to confirm and/or adjust ongoing and planned implementation efforts. Funding for targeted Bacterial Source Tracking analysis within the Highland Bayou Watershed will be pursued as a part of the implementation strategy. Costs to perform this analysis have come down sharply in recent years, enhancing the feasibility of this type of monitoring in future years.

Monitoring Objectives and Timeline

Continue Texas Stream Team & Clean Rivers Program surface water quality monitoring

- Establish an interest in Texas Stream Team with Universities and schools within the Highland Bayou Watershed

- Recruit more volunteers for Texas Stream Team water quality monitoring efforts within the Highland Bayou Watershed
- Train more volunteers for Texas Stream Team water quality monitoring efforts that can sample within the Highland bayou Watershed
- Work with the Clean Rivers Program to include Priority Monitoring Sites in their monitoring program
    - Timeline: Recruit volunteers in Year 1. Monthly sampling throughout the year beginning in Year 2 and ongoing thereafter

Galveston County Health District stormwater sampling

- Identify locations in the Highland Bayou Watershed ideal for stormwater sampling (areas with OSSFs, near sewage treatment plants, drainage ditches or water bodies that flow into State waters) and that align with the GCHD sampling program
- Compile and review stormwater monitoring results within MS4 Phase II annual reports from the City of Hitchcock, the City of La Marque and Galveston County
- Compile and review WWTP effluent reports, in particular the occurrence of bacteria exceedances in effluent and how that might relate to ambient water quality monitoring results
- Evaluate relationships between ambient water quality monitoring results and management activities of entities in the basin that discharge effluent, and collaborate to improve coordination
    - Timeline: Contingent on discussions with GCHD.

TCEQ's SWQM Program

- Work with TCEQ to include priority monitoring sites in their SWQM program
    - Timeline: Sampling event every 1-2 months throughout the year.

Conduct Bacterial Source Tracking to determine leading sources of bacteria

- Utilize library dependent methods at the subwatershed level to improve targeting of management strategies
- Focus on evaluating human sources (OSSFs, collection systems), domestic animals (pets, cattle), birds, and feral hogs
- Support tracking by identifying funding sources for BST analysis
- Develop a report based on results from BST at the sub-watershed level (AU catchments) in the Highland Bayou Watershed
    - Timeline: Contingent on grant funding; begin after Year 1.

Any sampling program timeline mentioned above will be contingent on available funding and resources.