

Science Advisory Committee on Environmental Flows  
Sabine-Neches Estuary and Lower Tidal Sabine River: A System in Transition  
Jack W. Tatum, 4 March 2009

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Sabine Lake is a relatively large, shallow, brackish water lake located on the Louisiana-Texas state line at the southwestern corner of Calcasieu and Cameron Parishes, Louisiana, and southeastern corner of Orange and Jefferson Counties, Texas. The lower Sabine and Neches Rivers are tidally affected above I.H. 10. There is a saltwater barrier located at Neches River mile 29.7, approximately eight miles upstream of the I. H. 10 bridge. The lower Sabine River is tidally affected as far upstream as Cutoff Bayou (Sabine River mile 29.4, approximately 16 miles upstream of the I.H. 10 bridge) [see Trinity River to Calcasieu Lake Imagery: Appendix, page 3].

In his January 7, 2009, presentation to the *Science Advisory Committee on Environmental Flows Thoughts on Inflows, Things Carried by Inflows, and Adaptive Bay Management*, Paul Jensen discussed man-made changes to the bays of Texas that have resulted in the Texas bays as we know them today not being natural systems.<sup>1</sup> These changes, including agricultural activity, urbanization, industrialization, construction of navigation channels, dredging, oil and gas exploration/ extraction activities, etc., are especially pronounced in the most water-rich bay of Texas, the Sabine-Neches Estuary (Sabine Lake). Once a freshwater lake, Sabine Lake is now an intermediate and brackish lake, with average salinities which make it the freshest of the Texas bays and estuaries.<sup>2</sup> As with other bays in Texas, most of the changes occurred prior to the studies that attempt to define the sound ecological environment: conditions necessary to support sustainable and productive bay ecosystems.

Among the many challenges faced by the Science Advisory Committee (SAC) and for the Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Area Expert Science Team (Sabine-Neches BBEST) as regards Sabine Lake is developing a recommended environmental flow regime to support a sound ecological environment in an extensively modified bay system for which factors other than river-derived freshwater inflows may dominate marsh communities.

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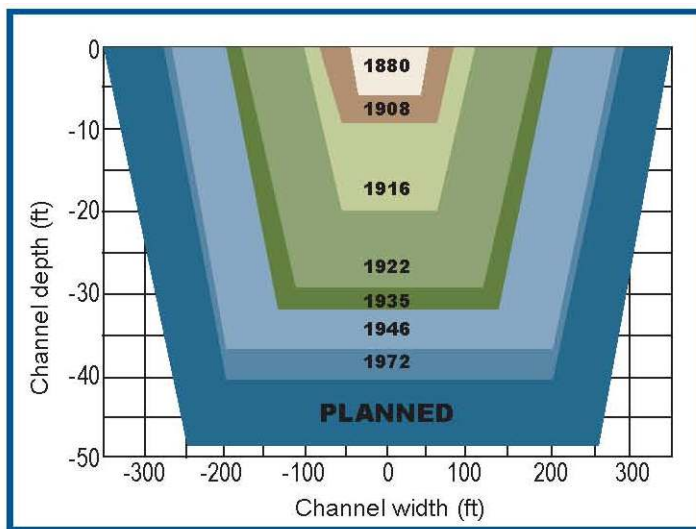
<sup>1</sup> Jensen, Paul. Thoughts on Inflows, Things Carried by Inflows, and Adaptive Bay Management. January 2, 2009. [http://www.tceq.state.tx.us/assets/public/permitting/watersupply/water\\_rights/eflows/01052009sac\\_handout\\_pj1.pdf](http://www.tceq.state.tx.us/assets/public/permitting/watersupply/water_rights/eflows/01052009sac_handout_pj1.pdf) (referenced February 11, 2009).

<sup>2</sup> TCB | AECOM (now AECOM) for the Sabine River Authority of Texas. Sabine Lake Ecological Condition of the Sabine-Neches Estuary: Executive Summary. March 2005 Updated April 2006. <ftp://ftp.sratx.org/pub/EcoConditionsReport/ExecutiveSummary.pdf> (referenced February 11, 2009).

## History / Timeline of Sabine Lake

Historical sources indicate that in 1777 Sabine Lake was essentially a freshwater lake. About 100 years later man-made alterations began with construction of a 7-mile long, 25-ft deep pass. In the past 120 years a wide range of man-made activities have altered Sabine Lake and its surrounding wetlands and marshes. Municipal, agricultural, timber, industrial, defense, and recreational interests have influenced the direction and amount of hydrologic change through channelization and control structures.

Navigation channels such as the Gulf Intracoastal Waterway (GIWW) and the Sabine-Neches Waterway (SNWW) allow saltwater to intrude into Sabine Lake and further upstream into the Sabine and Neches rivers.<sup>3</sup> The current ship channel completed in 1972 maintains a 40-ft channel to the Port of Beaumont and a 30-ft channel to the Port of Orange.<sup>4</sup> Other alterations that have changed the hydrology of Sabine Lake include dredging of channels for oil and gas drilling in the marshes. These alterations have resulted



in saltwater intrusion, with subsequent land subsidence in some areas, and resulted in loss of vegetation and erosion of organic soil down to a hard pan clay bottom substrate. Moreover, additional navigational access improvements are expected to continue. The U.S. Army Corps of Engineers (USACE) has completed a draft study of the feasibility and environmental impact for deepening the SNWW from 40-ft to 48-ft and widening it from 400-ft up to 700-ft in certain segments.<sup>5</sup>

**Figure 1. Historic widening and deepening of the Sabine-Neches Ship Channel**

Problems caused by these alterations need to be addressed through physical changes (including habitat restoration) involving the secondary channels to lessen saltwater intrusion and restore natural flow patterns in the marsh habitat areas. This problem cannot reasonably be addressed just by maintaining freshwater inflows. This is particularly true because the present marsh areas are not stable and continue to degrade with time, even under existing inflow conditions. **The Sabine Lake (Sabine-**

<sup>3</sup> AECOM for the Sabine River Authority of Texas. Preliminary Investigation Saltwater Barrier – Lower Sabine River.

<sup>4</sup> Graphic taken from Preliminary Investigation Saltwater Barrier [see Appendix, page 34].

<sup>5</sup> <http://www.swg.usace.army.mil/pe-p/snww/> (referenced February 18, 2009).

**Neches Estuary) we know today is a system still undergoing transition due to these ongoing man-made alterations.**

### **Need for Habitat Restoration/ Protection**

Habitat restoration is underway in the marshes around Sabine Lake in Texas and Louisiana [see Trinity River to Calcasieu Lake Imagery: Appendix, page 3]. For example, in Bessie Heights Marsh in the Neches River Basin, Texas, close to 6,000 acres of mostly emergent marsh was changed to open water by dredging numerous channels for petroleum activities and deepening and widening of the Neches River [see Bessie Heights 1995 Imagery: Appendix, page 7; and Bessie Heights 2004 Imagery: Appendix, page 8]. In response to the extensive loss of wetland habitat, in 1998 Texas Parks and Wildlife Department (TPWD) developed an interagency restoration plan for this area.<sup>6</sup> Due to the nature of the hydrology and salinity regime caused by these changes, terracing was selected as the primary means of habitat restoration. TPWD's goals for the restoration of Bessie Heights Marsh included:<sup>7</sup>

- Restore hydrology
- Restore elevation
- Create a system of ponds, channels, and emergent marsh to provide habitat for a variety of wildlife and fish species
- Restore native vegetation and prevent exotics
- Protect restored areas from loss or degradation by erosion and saltwater intrusion

In Louisiana, extensive coastal wetlands loss prompted Congress to pass the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) in 1990. It funds wetland enhancement projects nationwide, designating approximately \$60 million annually for work in Louisiana.<sup>8</sup> Several of the some 175 CWPPRA projects are in the Calcasieu-Sabine (CS) area including but not limited to the following:<sup>9</sup>

- East Sabine Lake Hydrologic Restoration (CS-32) [see Appendix, page 13]
- Black Bayou Hydrologic Restoration (CS-27) [see Appendix, page 9]
- Sabine National Wildlife Refuge Erosion Protection (CS-18) [see Appendix, page 11]

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<sup>6</sup> [http://www.fws.gov/texascoastalprogram/bessie\\_heights.htm](http://www.fws.gov/texascoastalprogram/bessie_heights.htm) (referenced February 16, 2009).

<sup>7</sup> <http://www.swg.usace.army.mil/OD/2004DC/2004%20Mike%20Rezsutek%20-%20TPWD%20BHM.pdf> (referenced February 16, 2009).

<sup>8</sup> <http://www.lacoast.gov/> (Referenced February 16, 2009).

<sup>9</sup> <http://www.lacoast.gov/projects/list.asp> (referenced February 16, 2009).

- Brown Lake Hydrologic Restoration (CS-09) [see Appendix, page 15]

Because of the devastation of hurricanes Katrina and Rita, in December 2005 the Louisiana Legislature restructured the State's Wetland Conservation and Restoration Authority to form the Coastal Protection and Restoration Authority (CPRA<sup>10</sup>). This agency recently published *Louisiana's Comprehensive Master Plan for a Sustainable Coast*, a guide for all coastal restoration and hurricane protection efforts in Louisiana over the next several decades [see Appendix, page 17].

Restoration projects are underway in Texas and Louisiana to restore coastal marsh habitat and slow the conversion of these wetlands to shallow, open water lakes. Critical components of these efforts include dikes, levees, water control structures (weirs), and beneficial use of dredge materials to rebuild lost wetlands.

### Hydrology of Sabine Lake

Freshwater inflows are an important factor affecting marine organisms in coastal estuaries along with tides, winds, and salinity intrusion from the Gulf of Mexico. Freshwater inflows into Sabine Lake originate from four distinct sources [see also Figure 2, next page]:

Source	Cumulative % Contribution <sup>11</sup>
Sabine River and its tributaries (50% Texas, 50% Louisiana)	46.2%
Neches River and its tributaries	42.6%
Adjoining coastal watersheds (Texas/Louisiana)	8.9%
Net Direct Precipitation – Evaporation	2.3%

<sup>10</sup> <http://www.lacpra.org/> (referenced February 16, 2009).

<sup>11</sup> TCB | AECOM (now AECOM). March 2005 Updated April 2006.

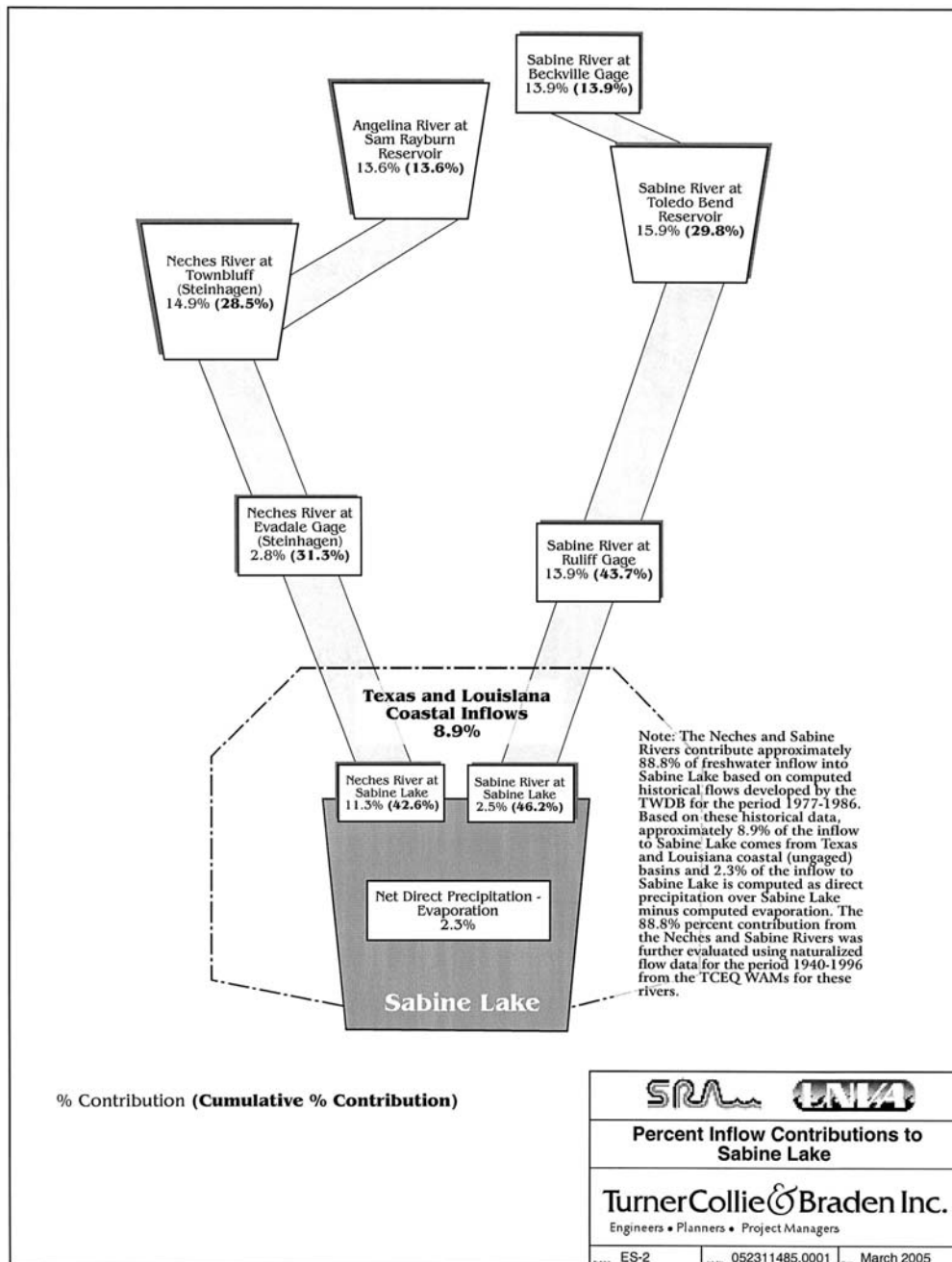


Figure 2. Inflow Contributions to Sabine Lake

Sabine Lake is the smallest major Texas estuary (55,000 to 60,000 surface acres with approximately 300,000 acre-feet capacity), has the greatest amount of freshwater inflows with an annual mean freshwater inflow of approximately 14 million acre-feet, has the lowest average salinity, and has the lowest number of fish species.<sup>12</sup> Estimates of fills per year vary from 25<sup>13</sup> to 53<sup>14</sup> depending upon methodology; all other bays in Texas (and Calcasieu Lake, the nearest bay in Louisiana), have average fill rates of five fills per year or less [see Graphic Fill Rates of Major Estuaries: Appendix, page 30; and also Draft Sabine Lake and Lower Sabine River Fact Sheet: Appendix, page 26]. However, much of the river-derived inflows are diverted from flowing directly into Sabine Lake and surrounding marshes due to the man-made alterations.

### **Tidal River Hydrology/ Habitat**

*Blue Elbow Swamp* The Blue Elbow Swamp in the tidal reach of the Sabine River near I.H. 10 consists of Cypress-Tupelo forest regrowth. The area was first harvested during the 1800s and early 1900s. After World War II, diesel powered draglines mounted on barges dug canals into the swamp and winched cut logs back to these canals resulting in radial patterns of ditches throughout the swamp. These canals and ditches have changed the natural patterns of water flow in these swamps. Additionally, Little Cypress Bayou has been channelized through the swamp to the river to reduce flooding in developed areas. The Tony Houseman State Park and Wildlife Management Area established in 1996 has protected some 3,300 acres of this area.

*Preliminary Investigation for a Saltwater Barrier on the Lower Sabine River* As mentioned above, man-made alterations to the Sabine Lake Estuary and surrounding wetlands and marshlands, particularly navigation channels, have allowed saltwater to intrude into Sabine Lake and farther upstream into the Sabine and Neches rivers. The USACE planned deepening and widening project will accelerate saltwater intrusion and associated impacts. A temporary saltwater barrier was installed on the Lower Neches River for most years between 1950 and 2003, at which time a permanent saltwater barrier was completed. A similar structure would be beneficial on the Lower Sabine River, and SRA-TX is re-evaluating its feasibility [see SRA-TX Saltwater Barrier: Appendix, page 34]. Preliminary planning has identified five

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<sup>12</sup> Environmental Flows Advisory Committee. Final Report. December 2006. [http://www.twdb.state.tx.us/EnvironmentalFlows/pdfs/REPORT/EFAC\\_FINAL\\_REPORT.pdf](http://www.twdb.state.tx.us/EnvironmentalFlows/pdfs/REPORT/EFAC_FINAL_REPORT.pdf) (referenced February 11, 2009).

<sup>13</sup> Ward, George and TCB | AECOM (now AECOM). Determination of Target Freshwater Inflows for the Sabine Lake Estuary: Review and Critique. April 2006.

<sup>14</sup> Longley, William L. 1994. Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs. Available at [http://midgewater.twdb.state.tx.us/bays\\_estuaries/b\\_nEpage.html](http://midgewater.twdb.state.tx.us/bays_estuaries/b_nEpage.html) (referenced February 12, 2009)

alternate locations for a barrier, with a site near Blue Elbow Swamp best meeting study objectives.<sup>15</sup> In September 2008, Hurricane Ike drove a saltwater tidal surge up the Sabine River to Cutoff Bayou with saltwater going into both SRA-TX and SRA-LA canal systems.

SRA-TX has discussed funding opportunities with the USACE to further investigate the benefits of a Lower Sabine River saltwater barrier.

*Low Flow Conditions Sabine and Old Rivers, Orange, Texas* The Sabine River splits into two main channels about six river miles downstream of SH12 in Orange County (river mile 29.39). The eastern split (Old River) is utilized via a raw water diversion canal by SRA-LA for its lower basin water supply source. The western split (Sabine River) is utilized via a raw water diversion canal by the SRA-TX as its lower basin water supply source. The Sabine River Compact<sup>16</sup> [see also Sabine River Compact: Appendix, page 37] provides that the States of Texas and Louisiana share the water supply of the Sabine River equally, and historically the split has been near equal under low flow conditions. In September 2005 Hurricane Rita made landfall near Sabine Lake and proceeded north, roughly up the Sabine River. During assessment of damages after the storm, SRA-TX measured flows at the split (Cutoff Bayou) and evidence of a change in the proportion of flows to Louisiana and Texas was noted [see Low Flow Conditions on the Lower Sabine: Appendix, page 45]. In low flow conditions, the percentage of main stem flow remaining in Texas can be below 25%. On November 28, 2007, SRA-TX met with the USACE Galveston District to discuss the problem and background history, and requested USACE input on possible remedies and associated permitting requirements. The USACE responded with a meeting summary which included discussions of approaches to monitoring and remediation of possible future loss of water supply to the SRA-TX Gulf Coast pump station. Options included hydraulic modeling, data collection, and structural alternatives. In March 2008 Dr. Jonathan D. Phillips, University of Kentucky, Lexington, Kentucky, published *Avulsion Regimes in Southeast Texas Rivers*<sup>17</sup> which discussed channel movement associated with the Cutoff Bayou region.

SRA-TX is continuing to monitor Cutoff Bayou, including flow measurements, erosion gauging, and aerial photography, and is evaluating options for possible future remediation.

*Lower Sabine Tidal Study (LSTS*<sup>18</sup>) This study documented the extent of saltwater intrusion, the affects of tide on flow, the sediment and nutrient concentrations of freshwater flowing into Sabine Lake and

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<sup>15</sup> AECOM for the Sabine River Authority of Texas. Preliminary Investigation Saltwater Barrier – Lower Sabine River.

<sup>16</sup> [http://www.tceq.state.tx.us/permitting/water\\_supply/water\\_rights/sabine.html](http://www.tceq.state.tx.us/permitting/water_supply/water_rights/sabine.html) (referenced February 18, 2009).

<sup>17</sup> <http://www3.interscience.wiley.com/journal/119139721/abstract?CRETRY=1&SRETRY=0> (referenced February 12, 2009).

<sup>18</sup> Sabine River Authority of Texas. Prepared in cooperation with the TCEQ under the authorization of the Texas Clean Rivers Act. Study Period February 2006 to February 2007.

attempted to better understand the dynamic nature of this complex river system. The LSTS was conducted by the Sabine River Authority of Texas under the Texas Clean Rivers Program in cooperation with the Texas Commission on Environmental Quality (TCEQ). Sampling was conducted bi-monthly from February 22, 2006, through February 22, 2007, from S.H. 12, at river mile 40.2 at the Sabine River near Ruliff, Texas, to the mouth of the Sabine River at the northeast end of Sabine Lake. The study area included sites in Adams and Cow Bayous in Texas and on the Gulf Intracoastal Waterway and Black Bayou in Louisiana. The most upstream intrusion of the saltwater wedge was on the Old River Channel near Niblett's Bluff, Louisiana.

Tidal saltwater flowed predominately upstream during low stream flow and during high tide conditions. Adams and Cow Bayous followed the general flow direction of the Sabine River; however this was not true of the flow in Black Bayou and the Gulf Intracoastal Waterway. The flow in Black Bayou was consistently counter to the tidal flow in the river and was most likely the result of hydrologic changes from the Gulf Intracoastal Waterway [see SRA-TX Tidal Study Schematic: Appendix, page 31].

## Summary

The Sabine-Neches Estuary (Sabine Lake) and lower tidal reaches of the Neches River and Sabine River ecological environment that we are studying today has been affected by numerous man-made changes over the course of the past 100 plus years. In order to recommend an environmental flow regime to support a sound ecological environment, we must also consider the factors other than river-derived freshwater inflows that have dominated Sabine Lake, the surrounding marsh communities, and the tidal reaches of the Neches and Sabine Rivers.

1. The Sabine-Neches Waterway (ship channel) and Gulf Intracoastal Waterway have forever altered Sabine Lake. The present marsh communities are not stable and continue to degrade with time, even under existing inflow conditions. As a result, **the Sabine-Neches Estuary we know today is a system still in transition**. Hurricanes Rita (2005) and Ike (2008) have further degraded these habitats.
2. Habitat restoration efforts have been initiated in Texas and Louisiana utilizing structural and non-structural measures designed to prevent saltwater intrusion from the ship channel and Intracoastal Waterway into marsh areas and to increase freshwater retention time. These efforts are being implemented project by project as funds allow. This effort includes: beneficial use of dredged materials to rebuild damaged areas; open water terracing with replanting of native vegetation; impoundments for preserving freshwater marsh and fisheries; shoreline protection levees; mechanical/chemical and biological control of invasive non-native species;

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[http://www.sratx.org/srwmp/tcrp/state\\_of\\_the\\_basin/special\\_studies\\_on\\_priority\\_watersheds/2006-2007/LowerSabineTidal/default.asp](http://www.sratx.org/srwmp/tcrp/state_of_the_basin/special_studies_on_priority_watersheds/2006-2007/LowerSabineTidal/default.asp) (referenced February 13, 2009).

environmental education; law enforcement for protection of fish and wildlife resources; and public/ private partnerships to achieve long range management goals.

3. Sabine Lake normally receives so much freshwater inflow (25 to 53 fills/ year) that it at times does not function effectively as an estuary system. In many instances, freshwater also short circuits via the Intracoastal Waterway or the ship channel located on the western shore of Sabine Lake (separated from Sabine Lake proper by the man-made Pleasure Island) into the Gulf of Mexico and is lost to the marsh communities.
4. Low flow conditions at Cutoff Bayou (river mile 29) where the historical split has been near equal (half to Louisiana and half to Texas) have been altered by Hurricane Rita and need to be addressed to determine alternatives for future remediation. This is critical not only to SRATX and SRALA diversion canals for man's needs but to also protect downstream fish and wildlife resources in Texas and Louisiana.
5. Saltwater intrusion in the lower Sabine River has resulted in preliminary planning for installation of a saltwater barrier. The proposed deepening and widening of the ship channel will accelerate the need for this project. The lower Neches River and Calcasieu River both have saltwater barriers to protect upstream freshwater resources. SRATX evaluated five possible locations; the most downstream site would be most protective of the Blue Elbow Swamp.

The Sabine and Neches Rivers and Sabine Lake Bay Expert Science Team (Sabine-Neches BBEST) are charged with developing environmental flow analyses and recommending flow regimes for the river basins and bay system. The Sabine-Neches BBEST must consider all available science and base their recommendations on the best science available. The Neches and Sabine River and Sabine Lake systems as we know them today are generally in good health and exhibit the best overall water quality and diverse fish and wildlife communities that we have knowledge of in years. There have been large amounts of information and data collected in these areas albeit mostly in more recent years and much of it not for the specific purposes set out before us. In this light, it is my opinion that in view of the limited time frame available to us, we will need to exercise a great deal of professional judgment (educated guess) and most likely hedge our recommendations on the high degree of uncertainty attached to them.