Sabine and Neches Rivers and Sabine Lake Bay
Basin and Bay Area Stakeholder Committee

Draft Work Plan

Submission to the Environmental Flows Advisory Group and the Texas Commission on Environmental Quality

December 2010

FOR SABINE-NECHES BBASC REVIEW

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Work Plan

Sabine-Neches Stakeholder Committee submission to the Environmental Flows Advisory Group and the Texas Commission on Environmental Quality

December 2010

The Honorable Troy Fraser,
The Honorable Allan Ritter,
Co-presiding Officers, Environmental Flows Advisory Group

Mark R. Vickery, P.G.,
Executive Director,
Texas Commission on Environmental Quality

Gentlemen,

The Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Area Stakeholder Committee, with assistance from the Sabine-Neches Expert Science team, has prepared this draft Work Plan pursuant to its charge under Senate Bill 3 (80th R, 2007).

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1 Prologue

Senate Bill 3 (SB 3) was intended to create a basin-by-basin process for developing "environmental flow standards" to provide the appropriate amount of instream flows and freshwater inflows by balancing the environmental need with the need for water for humans and other purposes. In recognition of the importance of adaptive management in this process, after making its recommendations each basin and bay area stakeholder committee, with the assistance of its expert science team, must prepare and submit a Work Plan. The Work Plan thus is the vehicle for facilitating the adaptive management of the SB 3 environmental flow analyses, environmental flow recommendations, and environmental flow standards and strategies to achieve the standards. The Science Advisory Committee (SAC) Work Plan Guidance[1] describes adaptive management in its critical role in the SB 3 process as follows:

> *Adaptive management is interpreted to encompass the entire process that is envisioned in SB3 for the work plan. Adaptive management needs three main components to be effective. It must first have a procedure for identifying what further study or clarification is required. Secondly, it must have funding and resources to address those issues. Finally, it must have a mechanism to support some level of change in the standards and/or implementation strategies. What is clear is that adaptive management will play an important role in the process and that the work plan is the appropriate instrument for outlining the framework for adaptive management in each respective basin.*

The Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Sabine Expert Science Team (Sabine-Neches BBEST) submitted its Environmental Flows Recommendations Report that developed environmental flow analyses to determine the flow needed to support a "sound ecological environment" without regard to the need for water for other uses, in November 2009. The Sabine-Neches Rivers and Sabine Lake Basin and Bay Area Stakeholder Committee (Sabine-Neches BBASC) submitted its Recommendations Report in May 2010.

[1] Considerations in the Development of an SB 3 Work Plan for Adaptive Management, Report # SAC-2010-02, August 20, 2010 (accessed 11/9/2010)

The Texas Commission on Environmental Quality (TCEQ) released pending proposed rules for HB 3/SB 3 Environmental Flows on October 14, 2010. On November 3, 2010, the pending proposed rules were adopted by the commissioners to be published in the Texas Register for public comment on November 19, 2010, and are currently *proposals*.[2] The Executive Summary of the pending proposed rules TCEQ states that, "a potential controversial concern in the proposed rulemaking related to the Sabine and Neches Rivers and Sabine Lake lies in the fact that the BBASC's adopted recommendation did not include environmental flow standards or environmental flow set asides. The basin's BBASC recommended that more time be taken to gather more information to determine the amount of water needed to support a sound ecological environment." The TCEQ states in the pending proposed rules, [3] "In the absence of a recommendation from the stakeholders, which would have balanced science with other public interests, the commission proposes standards based on available information and recommendations from the science team." Subsequently, at its October 27, 2010, Sabine-Neches BBASC/ BBEST meeting, the BBASC directed the BBEST to assist them with the specific work task to determine the impacts upon water supply strategies of a proposed BBASC flow regime for TCEQ standards that balances the Sabine-Neches BBEST HEFR[4]-based environmental flow recommendations that are in the current pending proposed standards with the need for other uses, including the needs of man. A Sabine-Neches BBASC Flow Regime Review Subcommittee of the BBEST was formed to accomplish this specific assigned task. **For the remainder of this Work Plan, "environmental flow recommendation" refers to this proposed balanced BBASC flow regime for TCEQ standards**.

[2] Proposals, TCEQ, http://www.tceq.state.tx.us/rules/prop.html (accessed 11/8/2010)
[3] Chapter 298 – Environmental Flow Standards for Surface Water, Subchapter C. Sabine, Neches Rivers, and Sabine Lake Bay.
[4] Hydrology-Based Environmental Flow Regime

In addition, a Sabine-Neches BBEST Work Plan Monitoring, Studies, and Activities Subcommittee was formed to provide assistance to the Sabine-Neches BBASC for this draft Work Plan related to specific monitoring, studies and activities needed to perform analyses to determine flows which are needed to support a sound ecological environment as defined by the Sabine-Neches BBASC.

To assist in the SB 3 rulemaking process, the Sabine-Neches BBASC is pleased to provide this draft Work Plan to the Environmental Flows Advisory Group (EFAG) and the Texas Commission on Environmental Quality (TCEQ).

2 Overview of Sabine-Neches BBEST/ BBASC Recommendations Reports

The Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Expert Science Team (Sabine-Neches BBEST) submitted its Environmental Flows Recommendations Report in November, 2009,[5] and the Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Area Stakeholder Committee submitted its Recommendations Report in May, 2010.[6]

2.1 Sabine-Neches BBEST Environmental Flows Recommendations Report

Under its SB 3 Charge, the Sabine-Neches BBEST used the "best science available" to develop environmental flow analyses and recommend flow regimes for the Sabine and Neches Basins and the Sabine-Neches Estuary, without regard to the need for water for other uses. These recommendations were provided to the Sabine-Neches BBASC, the Texas Environmental Flows Advisory Group (EFAG), and the Texas Commission on Environmental Quality (TCEQ) in November, 2009. The primary findings of the BBEST are as follows:

- the current conditions of the Sabine and Neches Rivers and Sabine Lake Estuary are sound;
- flows in the Sabine and Neches Rivers and inflow to the Sabine Lake Estuary will change over time; and
- future study, data gathering and adaptive management are necessary to determine whether these changes in environmental flow will maintain a sound ecological environment.

The Sabine-Neches BBEST made their recommendations and recognitions where recommendations were not made, with qualifying language and in some cases identified unresolved issues that will need future study and adaptive management as described in this Work Plan.

[5] http://www.sratx.org/BBEST/RecommendationsReport/ (accessed 10/11/2010)
[6] http://www.sratx.org/BBASC/RecommendationsReport/ (accessed 10/11/2010)

2.2 Sabine-Neches BBASC Recommendations Report

In keeping with its Charge, the Sabine-Neches BBASC reviewed and made the following comments on the Sabine-Neches BBEST Recommendations Report:

- The Sabine-Neches BBEST's definition of a sound ecological system does not focus on the current makeup of important species and does not adequately cover all of the important habitat types in the study area;
- The flow regime produced by the Sabine-Neches BBEST is more reflective of the existing flows than environmental need for flows; and
- Estuary soundness can best be addressed through physical changes (marsh restoration) to reduce the frequency and distance of saltwater intrusion into the surrounding tidal wetlands rather than imposing the HEFR-created flow regimes from the most downstream gages.

The Sabine-Neches BBASC also recommended the following definition of a "sound ecological environment" for balancing the needs of Texas citizens with a sound ecological environment for the Sabine and Neches River Basins and Sabine Lake Estuary.

A sound ecological environment is one that:

- supports a healthy diversity of fish and other aquatic life;
- sustains a full complement of important species;
- provides for all major aquatic habitat types including rivers and streams, reservoirs, and estuaries;
- sustains key ecosystem processes; and
- maintains water quality adequate for aquatic life.

The Science Advisory Committee (SAC) Work Plan Guidance cautions that designing a monitoring plan to evaluate whether a system is maintaining a

sound ecological environment can be accomplished assuming that the work plan has a specific definition for what constitutes a "sound ecological environment." For the purposes of this Work Plan, the Sabine-Neches BBASC adopts the above definition of a "sound ecological environment" that it recommended in its Recommendations Report.[7]

[7] TCEQ adopted the BBASC's definition of a "sound ecological environment" in its pending proposed rules.

3 Work Plan Charge

SB 3 offers the following language for the development of a Work Plan.

> Section 11.02362 (p) In recognition of the importance of adaptive management, after submitting its recommendations regarding environmental flow standards and strategies to meet the environmental flow standards to the commission, each basin and bay area stakeholders committee, with the assistance of the pertinent basin and bay expert science team, shall prepare and submit for approval by the advisory group a work plan. The work plan must:
>
> (1) establish a periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, environmental flow standards, and strategies, to occur at least once every 10 years;
>
> (2) prescribe specific monitoring, studies, and activities; and
>
> (3) establish a schedule for continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards.
>
> Section 11.1471 (f) An environmental flow standard or environmental flow set-aside adopted under Subsection (a) may be altered by the commission in a rulemaking process undertaken in accordance with a schedule established by the commission. In establishing a schedule, the commission shall consider the applicable work plan approved by the advisory group under Section 11.02362(p).

The SAC has provided Work Plan Guidance for interpretation of the Work Plan charge and identification of topics to consider in the development of a Work Plan.

The SAC identified the following three questions that must be resolved to develop a Work Plan to meet its charge:

1. what monitoring, special studies, or other information is required to fill data gaps and validate and refine the environmental flow analyses and environmental flow regime, as well as the environmental flow standards and achievement strategies;

2. what will be the appropriate schedule for studies and review of standards; and

3. how will the work be paid for?

The remainder of this Work Plan provides answers to these critical questions within the specific and unique context of the Sabine-Neches River Basins.

The SAC Work Plan Guidance states that throughout the initial BBEST and BBASC process, a recurring theme echoed from both basins engaged in SB 3 to date has been that there is limited information to describe or define the ecological role that flow plays in supporting aquatic and/or riparian communities. Consequently, the SAC Work Plan Guidance suggests that "**the principal immediate technical goal of a work plan for these two basins is to fill in data gaps and assist in establishing a cause-and-effect relationship of some measure(s) of ecosystem health to the magnitude, timing, and duration of environmental flows**."[8] Thus the research studies, surveys, and monitoring programs ("Work Plan Approach") within this Work Plan should keep this goal at the forefront as they are refined from the general guidance given here into specific study design documents.

Per the SAC Work Plan Guidance, **short-term research and focused surveys** (short- or long-term) should address data gaps and address shortcomings in BBEST and/ or BBASC recommendations with the goal to establish linkages between flow and ecology to better document what flows

[8] Emphasis added.

are necessary and/ or better define the role of the prescribed flow components (subsistence flows, base flows, and high flow pulses, for the Sabine-Neches Basins). **Long-term monitoring** should focus on whether the recommendations, standards, and implementation strategies are meeting the goals and objectives set forth in SB 3, which as stated above are foremost to provide the appropriate amount of instream flows by balancing the environmental need with the need for water for humans and other purposes.

4 Periodic Review

TCEQ should establish a five-year cycle of review of the Sabine-Neches Basin environmental flow analyses and environmental flow recommendations, environmental flow standards adopted by the Commission, and the strategies to achieve those standards integrated with the SB 1 Regional Planning five-year cycle.[9] The SAC Work Plan Guidance acknowledges the linkage between the SB 3 environmental flows process and the SB 1 regional planning process suggested by both the Sabine-Neches BBASC and the Trinity-San Jacinto BBASC. The SAC notes that the results of the SB 3 work should provide for improving the level of technical knowledge and regulatory certainty to inform future deliberation by the Regional Water Planning Groups (RWPGs). And reciprocally, the detailed water needs analysis provided by the RWPGs should inform the work of the BBASCs.

In advance of the preparation of the next State Water Plan (2012), the RWPGs recently submitted their Initially Prepared Plans (IPPs, to be adopted in 2011) to the Texas Water Development Board (TWDB). The SB 3 periodic review schedule should be aligned such that the review is available for the RWPGs to consider in each round of regional planning (the next being in preparation for the 2017 State Water Plan). For the SB 3 process in the Sabine and Neches River Basins, the RWPGs in Regions I, D, C, and H must be involved in the planning in order to balance the needs of man with the environment.

[9] Water Resources Planning & Information, TWDB, http://www.twdb.state.tx.us/wrpi/index.htm (accessed 11/8/2010)

5 Monitoring, Studies, and Activities

5.1 Major Habitat Categories and Data Collection Disciplines

The following river basin habitat categories and disciplines within each category require additional data. A better understanding of these systems will guide adaptation of recommended flow regimes toward more accurate and defensible solutions as needed. River basins have a long history of anthropogenic influences that must also be considered with all future studies. Each component should be considered as an integral part of an interrelated system with a recent and long-term history of dynamic equilibrium. Flow, habitat, biota, water chemistry, and physical processes are interrelated and monitoring studies will include concurrent measurements within each discipline. It should be noted that climate change issues throw too many unknown variables into an already variable-laden process; for now, climate change issues need not be considered in development of SB 3 studies.

5.1.1 Riverine

Hydrology (flow components: subsistence, base, and high flow pulses)

Water Quality (temperature, dissolved oxygen, pH, conductivity, nutrients, and others as appropriate)

Biology (riverine focal species and habitat)

Geomorphology (physical processes)

5.1.2 Estuarine

Hydrology (freshwater inflows; rainfall; channelization; depths; salinity; wind; tides) in open water and wetlands/ marsh habitat

Water Quality (temperature, dissolved oxygen, pH, conductivity, nutrients, and others as appropriate)

Biology (estuarine focal species and habitat)

Geomorphology (physical processes)

5.2 Activities Related to Data Collection and Monitoring

The Sabine-Neches BBEST Work Plan Monitoring, Studies and Activities Subcommittee has provided assistance to the Sabine-Neches BBASC for this draft Work Plan with the qualification that the descriptions regarding needed research and monitoring to provide better understanding of the relationships of biology, water quality and geomorphology to environmental flows are dependent on funding through existing agency programs or new proposals. Dr. Winemiller has suggested that the way to proceed with such data collection and research in the Sabine and Neches River Basins and Sabine Lake Estuary System would be through a request for proposals (RFP) or request for qualifications (RFQ) process when such funds become available. It is suggested that the BBEST or other independent advisory group could evaluate the proposals and make recommendations for selection of contractors for each study.

Due to the continuing time constraints in the SB3 process, this draft Work Plan provides only general guidance for such studies. It is anticipated that proposers for funded studies such as Universities and consulting firms would respond with the needed detail for their proposals. It is important, as Dr. Winemiller has pointed out, to recognize that funding for such work may be limited, and this approach would result in the greatest efficiency, highest quality studies and the most objective way to move forward to fill the recognized data gaps.

5.2.1 Establishment of Central Geo-referenced Database

Existing and future data (hydrology, biology, water quality, and geomorphology) should be gathered to a central geo-referenced database, placing a priority on user-friendly retrieval and end-use-friendly formatting of the data. For example, the TWDB contracted with Stephen F. Austin State University (Sabine-Neches BBEST member Dr. Matthew McBroom) to provide a literature database for the Neches River Basin which may be used as a template for additional data. The geo-location database is currently being expanded and integrated to include other parts of the Sabine-Neches basin, which should be an ongoing effort as new studies are completed. The geo-location data base can also be used to identify gaps in knowledge within the basin, and short-comings in the database should be identified.

5.2.2 Identification of Data Gaps

The purpose of data collection is to fill gaps and provide additional insight into flow-based parameters that will assist validation and/ or refinement of flow regime recommendations. The Sabine-Neches BBEST identified specific areas of study that would have assisted in their recommendations and recognized that data were not readily available or did not exist at sufficient resolution to make flow regime recommendations which could be defended as a minimum recommendation. A centralized database will assist in assembly and review of existing information and additional data needs will be addressed through current monitoring, new studies, or modifications to existing programs.

5.2.3 Currently Ongoing Data Collection Programs

The following programs, and possibly others, may provide resources for refinement of environmental flow regimes. Cooperation and communication will reduce costs and increase applicability of data from all programs to the environmental flows process. SB 3 did not address funding for monitoring studies and activities associated with validation and refinement of flow regimes. If funding isn't appropriated, additional data needs may depend primarily upon modifications to existing federal, state, and local monitoring programs. Without specific funding, new information may be less specific to Texas Instream Flow Program (TIFP[10]) needs and may also take longer to acquire.

5.2.3.1 Existing Federal Programs and Potential Resources

USGS National Water Information System (NWIS) The USGS NWIS provides stream flow, reservoir level, and water quality data[11] through cooperative funding at priority locations in the Sabine and Neches Basins. Local cooperators (river authorities) originally picked up about 50% of the cost of the gaging program. The federal budget has remained fixed over time, but the cost to maintain the program has increased. Local cooperators are now picking up more than 70% of the operating costs and full cost for any gages outside the scope of the federal mission. If other

[10] Texas Instream Flow Program, TWDB, http://www.twdb.state.tx.us/instreamflows/index.html (accessed 11/9/2010)

[11] http://waterdata.usgs.gov/nwis (accessed 10/13/2010)

data are needed, modifications to locations and/or parameters can be made to further assist SB 3 studies, but these modifications are currently not funded. There is a continuing effort to seek additional funding that would return the USGS cooperative water resources investigations program to its historical 50/50 cost-sharing.

Toledo Bend Project Federal Energy Regulatory Commission (FERC) Relicensing The Toledo Bend Project, which was originally licensed by FERC's predecessor agency, the Federal Power Commission, in 1963, was licensed and developed as a water supply reservoir, with secondary uses including hydroelectric power generation and recreation. The Toledo Bend Project's existing FERC license expires in September 2013. Studies and data collected during the relicensing process will increase knowledge of reservoir, instream and riparian processes and will also be used to fill SB 3 data gaps.

U.S. Army Corps of Engineers (USACE) Sabine-Neches Waterway Channel Improvement Project The Sabine-Neches BBEST recognized the ongoing efforts by the USACE in modeling salinity in the estuary as a part of its ongoing considerations for further deepening the Sabine-Neches Ship Channel, a project that proposes to deepen the channel from 40-ft to 48-ft (with selective widening) from the Gulf of Mexico through Sabine Lake and upstream to the Port of Beaumont.[12] The USACE report included a sophisticated hydrodynamic salinity model of Sabine Lake and the tidal waters in Texas and Louisiana associated with Sabine Lake. In addition to the approximately 50,000 surface acres of open water in Sabine Lake, this report studied some 110,000 acres of associated wetlands in Texas and some 200,000 acres of associated wetlands in Louisiana. The USACE study included existing and 2060 water usage from the 2007 Texas Water Plan. Specific recommendations are made in this report for mitigation and restoration of wetlands habitat in Texas and Louisiana to offset the incremental changes resulting from deepening the ship channel.

National Park Service (NPS) Big Thicket National Preserve Study, NPS and Texas A&M University (TAMU). On April 15, 2009, The Conservation Fund donated

[12] Sabine-Neches Waterway Channel Improvement Project, USACE, http://www.swg.usace.army.mil/pe-p/SNWW/SNWW.asp (accessed 11/9/2010)

nearly 6,600 acres of cypress-tupelo swamp, bottomland hardwood forest, and freshwater marsh to the Big Thicket National Preserve. Most of the donated lands are in a 6,000-acre wetlands complex called the Lower Cypress tract. The Big Thicket National Preserve has proposed to work cooperatively with researchers at TAMU to: 1) identify focal species, 2) recommend an environmental flow regime to maintain the ecological integrity and persistence of biological communities of the Lower Cypress tract wetlands, and 3) recommend monitoring strategies to measure key ecological responses to freshwater flows. The deliveries of freshwater to the Lower Cypress tract offsets saltwater intrusion and delivers sediment, both being essential for the maintenance of wetland productivity and mitigation against relative sea-level rise and increased salinity. The funding for this project is currently pending in the Federal Budget.

5.2.3.2 Existing State Agency Programs and Potential Resources

Texas Clean Rivers Program The Texas Clean Rivers Program (CRP[13]) is a state fee–funded program for water quality monitoring, assessment, and public outreach. The CRP is a collaboration of 15 partner agencies and the TCEQ. It provides a framework and forum for managing water quality issues within a river basin, both locally and regionally, by coordinating the efforts of diverse organizations.[14] The Sabine River Authority of Texas (SRA-TX), Lower Neches Valley Authority (LNVA), and Angelina & Neches River Authority (ANRA) participate in the CRP monitoring program and possible modifications to the programs may assist in filling data gaps.

Senate Bill 2 Texas Instream Flow Program The purpose of the Texas Instream Flow Program (TIFP) is to perform scientific studies to determine flow conditions necessary to support a sound ecological environment in rivers and streams of Texas. The lower Sabine River is the only river segment in the Sabine and Neches River Basins selected for the first tier SB 2 studies. The Lower Sabine

[13] Texas Clean Rivers Program, TCEQ, http://www.tceq.state.tx.us/nav/eq/texcleanriver.html (accessed 11/9/2010)
[14] http://www.tceq.state.tx.us/compliance/monitoring/crp/ (accessed 10/13/2010)

Study Design Workgroup[15] adopted the following Goal for the study that is intended to be consistent with a "sound ecological environment"

Our goal is a healthy, functioning Lower Sabine River Basin that has:

- *high quality water*
- *sufficient flow*
- *a sustainable ecosystem*

to assure a dynamic balance between human needs and the environment.

This program is currently preparing a draft Study Design.

Texas State Soil and Water Conservation Board (TSSWCB) The TSSWCB is the lead agency for planning, implementing, and managing programs and practices for preventing and abating agricultural and silvicultural nonpoint sources of water pollution. These activities are provided through a Clean Water Act 319(h) Nonpoint Source grant program through the TSSWCB and the U.S. Environmental Protection Agency (EPA). Watershed Protection Plans are developed for addressing water pollution issues and implementing voluntary best management practices that assure the long-term health of a watershed.

Additional State Agency Programs and Potential Resources

The SAC Work Plan Guidance includes a survey regarding statewide monitoring activities and studies conducted by the agencies that may provide resources for refinement of environmental flow regimes.[16]

5.3 Priority Monitoring, Studies and Activities

Monitoring and data collection activities should prioritize verification of assumptions and fill data gaps identified by the BBEST and BBASC, assist in flow regime effectiveness monitoring, and provide data necessary to adjust flow regimes through adaptive management.

[15] Lower Sabine River Basin, TWDB, http://www.twdb.state.tx.us/instreamflows/sabineriverbasin.html (accessed 11/9/2010)

[16] SAC Work Plan Guidance, Appendix B – Responses to SAC Workplan Questionnaire

5.3.1 Sabine-Neches BBEST Recommendations for Future Research Activities

The Sabine-Neches BBEST Biological Overlay Document[17] recommended the following to assist in refining environmental flow recommendations for future research activities:

1. More data and improved knowledge of the ecological conditions and responses to flow variation are needed for the zone between the subsistence flow and dry base flow thresholds for each season. Field studies are needed in multiple stream and river segments of the basins to reveal relationships between key environmental parameters and biotic components during periods of low flow.

2. Additionally, more thought and deliberation are needed regarding alternative implementation guidelines (policies) for water diversions as flows change within the zone lying between the thresholds for subsistence and dry base flows. The concern here is that diversions under dry-year base flow conditions could drive flows to the subsistence flow threshold for long periods of time. The subsistence flow defines a very rare occurrence, on the order of the lowest 1-2 percentile of all recorded flows.

3. More research is needed to establish, with greater precision and accuracy, the relationships between discharge and inundation of riparian bottomland hardwood and wetland zones of the floodplain. We were only able to obtain data for a limited number of our stream and river segments, but more aerial images may be available for analysis, and additional high quality images should be obtained in the future.

4. Research is needed to quantify relationships between flow pulses (timing, duration, frequency) and reproduction and recruitment of important fish populations, within mainstem and tributary segments

[17] Sabine/Neches BBEST Biological Overlay Approach, November 30, 2009, http://www.sratx.org/BBEST/RecommendationsReport/LinkedDocuments/SN-BBEST-BiologyOverlay-Appendix-XIII.pdf (accessed 11/9/2010)

of the basins. Research is needed for species that complete their life cycle within the main channel as well as those that use both channels and backwaters (aquatic floodplain habitats).

5. More research is needed to establish relationships between the freshwater inflows established under the fluvial environmental flow recommendations and biological components of Sabine Lake. Given the heterogeneity and diversity of the estuarine ecosystem, focal species should receive greatest attention.

6. Relationships between freshwater inflows and salinity in fringing marshes, especially in the northern regions of Sabine Lake are needed. The influence of wind, tides, and depth of human-constructed channels on salinity dynamics in these regions should be examined.

7. Further evaluation of inputs and outputs for desk-top and other methodologies for hydrologic analysis are needed to evaluate implications of various flow partitions on environmental flow assessments. In other words, what limitations are imposed on the ecological assessments when larger or smaller percentages of the flows during a time interval are placed into the base-flow category or the various categories of high flow pulses?[18]

5.3.2 Data Collection Disciplines

Areas of study which presently appear to be needed are included below. These data needs are based on data gaps noted in the Sabine-Neches BBEST Biological Overlay Appendix and more generally in the Sabine-Neches BBASC recommendations. Depending on goals for data collection, studies may be short-term research studies, short or long-term focused surveys, or long-term monitoring programs. For each study it is important to collect sufficient data to isolate the effects of flow from other ecological response mechanisms. As the SAC Work Plan guidance states, there are many factors in addition to flow that can lead to a change in organism

[18] Number 7 was added subsequent to the Sabine-Neches BBEST Biological Overlay.

response and any study, survey, or monitoring activity must be designed to tease out this information to obtain a defensible answer.

5.3.2.1 Riverine

Hydrology Collection of data for further evaluation of inputs and outputs for desk-top and other methodologies for hydrologic analysis are needed to evaluate implications of various flow partitions on environmental flow assessments. Field studies are needed for the 11 measurement points (USGS gages) to reveal relationships between hydrology and focal species during periods of subsistence, base, and pulse flows. Connectivity (longitudinal, lateral, vertical, and temporal) as it relates to different flows and the timing of flows as well as movement and exchange of water, nutrients, sediments, organic matter, and organisms from the watershed to the river proper are integral to focal species studies.

Water Quality The Sabine-Neches BBEST recognized the need to target additional water quality data collection at very low flows. These conditions occur infrequently and are not adequately reflected in routine ambient water quality monitoring. Water quality monitoring should also be integrated with other discipline studies (integration). Typical water quality study parameters should include temperature, dissolved oxygen, chlorophyll-*a*, pH, conductivity, turbidity, total dissolved solids and others such as nutrients, metals, etc., which may be appropriate and related to site-specific studies.

Biology

Physical Habitat The Sabine-Neches BBEST instream flow recommendations relied upon statistical flow evaluations and general knowledge about focal species lifecycle needs such as reproductive behavior and temperature preference ranges. Data is needed to establish site-specific information for habitats required by important species within mainstem and tributary segments of the basins. Longitudinal connectivity and wetted habitat measures should be assessed using biological habitat cross-section measurements described in the TCEQ SWQM Surface Water Quality

Monitoring Procedures, Volume 2.[19] Some modifications may be required for non-wadeable streams.

Pitfalls of Flow Regime "Requirements" Little data is available to establish required flow regimes for fish populations or other functional groups in the Sabine and Neches River Basins. Establishing a "required" flow regime necessitates an understanding of life cycle/ flow dynamics relationships for local species that is not currently available. Attempting to establish relationships using inadequate data for biological systems is very error-prone. Ecological relationships include complexities of food supply, predator/ prey relationships, spawning habitat availability, disease factors, reproductive strategy modifications and other counterintuitive factors which allow species to succeed in habitats which are naturally variable between seasons and from wet to dry multi-year periods. These types of complexities have produced surprising responses to well-intended flow regime changes in other systems.[20] "Habitat suitability estimates for various fish species are an important component of any instream flow determination and generally include factors such as depth, velocity, substrate, and cover types. Detailed quantitative measures of habitat associations are lacking for many of the approximately 180 native freshwater fishes found in Texas."[21,22] Data for specific habitats, such as the predominantly sandy bottom habitat found in the Sabine and Neches basins, is even scarcer. Many studies in Texas have focused on streams and rivers with higher elevation gradients (stream slope) and different substrates (such as rock and cobble) from those typical in the Sabine and Neches Basins (primarily sand, clay, and large woody debris). Academic

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[19] http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/mtr/swqm_procedures.html (accessed 11/8/2010)

[20] Geoffrey E. Petts, Instream Flow Science for Sustainable River Management, FLOW 2008: State of the Art – Science, http://rushingrivers.org/webtestimony/exhibit5.pdf (accessed 11/8/2010)

[21] Texas Fish Habitat Survey, http://rsi-db.its.txstate.edu/fishhabitatsurvey/ (accessed 11/8/2010)

[22] http://www1.wrd.state.or.us/pdfs/04_14_10_Presentation_Materials.pdf (accessed 11/16/2010)

research is needed to answer critical questions about habitat requirements of local flow-sensitive species. For example: What local species do not readily adapt to flow modifications, what habitats are most critical in their life cycle, and what flow needs do they have?

Surveys of Potentially Limiting Habitat Available habitat types associated with flow standards measurement points should be surveyed. Identify priority substrate and habitat types (based on habitat needs for focal species), measure availability of these habitats and hydrologically relevant parameters (stream width, bank slope, bank height, bed slope) using geo-referenced transects.[23]

Mussel Surveys Mussel data is lacking and may not be available for each monitoring point. Existing information on mussel populations is based on sparse data with limited water quality and/or flow data associated with the collection event. Habitat and distribution data is limited and host fish species for mussels whose glochidia (young) disperse by attachment to fish gills are not documented for most species.[24] Ongoing FERC studies indicate predominantly sandy substrates place a natural limitation on mussel colonization in the lower Sabine River. Tributary studies are currently being designed to further evaluate mussel populations. Results from these studies and possibly others will be needed to evaluate current habitats and mussel populations. Future collections should include the full range of parameters including water quality, flow, and habitat measures. Historic habitat conditions should also be considered in data interpretation.

[23] TCEQ SWQM Surface Water Quality Monitoring Procedures, Volume 2
[24] Howells, R. G., Neck, R. W., Murray, H. D., & Texas. (1996). Freshwater mussels of Texas. Learn about Texas. Austin, Tex: Texas Parks and Wildlife Dept., Inland Fisheries Division.

Geomorphology As part of the SB 2 process, Dr. Johnathan Phillips has published several papers[25,26,27,28] with measurements and observations from the Sabine and Neches rivers at limited locations, primarily focused on lower reaches of each river. Very little geomorphic characterization on a broad-scale or detailed-scaled basis exists on other areas of the Sabine and Neches River Basins. Additional data is needed to understand natural processes and how changes in flows may affect them. Physical sediment characterization studies will include sediment coring, grain size measurements, and sediment transport measures.

5.3.2.2 Esturine

The Sabine-Neches Estuary includes many natural and man-made characteristics which have co-existed since around 1876 (over a 130 year time period) when the "Bonanza" timber industry began in East Texas and western Louisiana. During the early part of this time period, the first navigation canals were dredged to deepen the shallow connection that existed between Sabine Lake (primarily a freshwater lake at the time) and the Gulf of Mexico. Since that time, a number of changes have been made directly to the Sabine Lake Estuary and indirectly through its watershed, each with an incremental effect on its ecology. Some direct changes include digging the Ship Canal in several stages to its current depth of 40ft, the Intracoastal Waterway, and oil and gas well access canals into the marshes, land subsidence from mineral extraction, relative sea level rise, timber harvest which resulted in "drag scars" in surrounding swamps, dredging and navigation access maintenance activities, and restorative activities which include zig-zag terracing and replanting open areas in the

[25] Phillips, J. D. (2009), Avulsion regimes in southeast Texas rivers. Earth Surface Processes and Landforms, 34: 75–87. doi: 10.1002/esp.1692

[26] Phillips, J. D. (2003), Toledo Bend reservoir and geomorphic response in the lower Sabine River. River Research and Applications, 19: 137–159. doi: 10.1002/rra.702

[27] Phillips, Jonathan D., 2008. Geomorphic units of the Lower Sabine River, Tobacco Road Research Team, Department of Geography, University of Kentucky

[28] Jonathan D. Phillips, Lisa Park, Forest blowdown impacts of Hurricane Rita on fluvial systems, Earth Surface Processes and Landforms, 2009, 34, 8

marshes, rock-facing erodible banks of the Intracoastal Waterway and the Sabine Lake shoreline, and beneficial use of dredge spoils to fill in eroded areas. Tidewater control structures have been built in some of the major canals into the marshes to retard saltwater intrusion into the marshes and slow freshwater movement from the marshes back into Sabine Lake. Indirect changes to the Sabine Lake watershed include construction of reservoirs in the Sabine and Neches river watersheds and construction of recreation (fishing and duck hunting) reservoirs in the marshes to the east and west of Sabine Lake, and a host of other watershed land-use changes, both potentially harmful and potentially restorative. Without construction of ship locks within the Ship Canal connecting Sabine Lake and the Gulf of Mexico, Sabine Lake will never return to a freshwater lake, but physical restoration measures will protect marsh habitat from changes which have occurred in and around the Sabine Lake estuary during the past 130 years. Monitoring is needed before, during, and after restorative measures in order to evaluate incremental changes of future modifications to the estuary as well as evaluate the effectiveness of restorative measures.

5.3.2.3 Reservoirs

Although reservoirs in the Sabine and Neches basins are man-made, they are an integral part of today's riverine ecosystems. In addition to providing a more reliable supply of fresh water supply for man, reservoirs are a significant and valuable habitat for reservoir and riverine fish species, aquatic and semi-aquatic plants, and waterfowl. Some fish species use both reservoir and riverine habitats during their life cycle. Paddlefish and white bass are examples. "Under the Statewide Freshwater Fisheries Monitoring and Management Program, Texas Parks and Wildlife biologists conduct periodic surveys of freshwater fisheries and provide detailed reports on their findings. The program is supported by the Federal Aid in Sport Fish Restoration Act."[29] Large public reservoirs are surveyed every four years and selected smaller reservoirs are also surveyed. The TPWD produces a "Performance Report" for these surveys which includes measures of health for species significant to the recreational fishery. Some

[29] http://www.tpwd.state.tx.us/publications/pwdpubs/lake_survey/ (accessed 11/15/2010)

baitfish such as threadfin shad are also included in these surveys, but little or no data is collected or reported for other ecologically beneficial fish species. This type of data is needed for reservoir habitats. Littoral (shallow) habitat is a very productive habitat in reservoirs and should be included in the focus of reservoir studies for basin-wide ecological health assessment. Productivity of reservoirs may be evaluated in terms of areas of shoreline length (riparian zone) as an index of habitat quality.[30] In addition to the reservoir fishery and upstream fisheries, reservoirs typically make voluntary or required freshwater releases to protect downstream habitat or meet other downstream water needs. Minimum flow releases preserve instream flows and fish habitat even during extreme droughts. Reservoirs and downstream tailrace fisheries have ecologically and economically beneficial value which should be recognized along with values of riverine and estuarine habitats.

5.3.3 Data Collection Protocol and Quality Assurance

Data quality objectives should be established early in the study design process. All data should be collected and verified using accepted methods and protocols[31] and stored in digital, geo-referenced format. Data collection goals will be re-evaluated and prioritized periodically. Prior to the collection of data for the purposes of any of the disciplines included in this work plan, the data quality objectives must be clearly defined to ensure that the data are scientifically credible by documenting that the collection procedures adhere to proven scientific practices utilizing established quality assurance/quality control measures.

Data acquired from other sources or historical data collected prior to this work plan must be reviewed and qualified to assure the data was collected with defined quality objectives and those objectives were satisfied. Data not meeting those requirements should not be included with any analyses or used to determine flow requirements. However, this historical data may

[30] Arscott et al., 2002 and Stanford, 2002, (a reference within: Riparia: ecology, conservation, and management of streamside communities (Robert J. Naiman, Henri Décamps, Michael E. McClain))

[31] http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/mtr/swqm_procedures.html (accessed 10/13/2010)

have overall value in defining data gaps and needs for further study. Finally, validated and approved data should be stored in digital, geo-referenced format (see also Section 5.2.1, page 12).

6 Schedules for Continuing Validation and Refinement

SB3 requires a schedule for "continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards." In its Work Plan Guidance, the SAC suggested this process would "confirm or refute that the recommended standards are protective of a sound ecological environment." By extension of the BBASC's responsibility to consider man's needs, validation and refinement should also consider if data is sufficient to defend the flow regime defined by standards as being required for a sound ecological environment. It is anticipated that new information may be evaluated for adaptive management as it becomes available. As stated in the SAC Work Plan Guidance, an evaluation of the standards and implementation strategies is anticipated to be a continuing process.

Like the Periodic Review (Section 4, page 10), the schedule for continuing validation and refinement should be aligned with the SB 1 five-year regional planning process.