REPORT OF THE TRINITY – SAN JACINTO – TRINITY BAY AND BASIN STAKEHOLDERS COMMITTEE

FOR SUBMITTAL TO THE ENVIRONMENTAL FLOWS ADVISORY GROUP AND THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

MAY 31, 2010

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Introduction

Senate Bill 3, passed in 2007 by the 80th Texas Legislature, established a stakeholder-based process for including consideration of environmental flow needs in new water rights permits. The process includes an Environmental Flows Advisory Group (EFAG) whose membership is mandated in the legislation. The EFAG appointed a Trinity and San Jacinto Rivers and Galveston Bay Basin and Bay Stakeholder's Committee (BBASC) which then appointed a Basin and Bay Expert Science Team (BBEST). The BBEST has compiled a report of their best effort at creating a science-based flow regime which will maintain a *sound ecological environment*. The charge of the BBASC is to develop consensus-based recommendations of environmental flow standards based on the BBEST report while considering competing water needs such as the present and future water requirements as developed by the statewide water planning process[1].

Timeline

The functional timeline for achieving the goals of Senate Bill 3 is included below:

Environmental Flows Advisory Group formed
Stakeholders appointed—August 2008
BBEST appointed—December 2008
BBEST report submitted to Stakeholders—December 2009
BBASC report submitted to TCEQ—June 2010

BBASC Members

BBASC members as well as the category represented by each are listed below:

• Danny Vance, Chair	River Authorities
• John Bartos, Vice Chair	Environmental
• Scott Alford	Soil and Water Conservation Districts
• Terry Anderson	Public Interest Groups
• Lloyd Behm	Groundwater Conservation Districts
• James K. Brite, Jr.	Ag, Free-range Livestock
• Glenda L. Callaway	Environmental
• Jun Chang, P.E.	Municipalities
• William Goldston	Recreational Water Users
• Jace Houston	River Authorities
• Kathy Turner Jones	Groundwater Conservation Districts
• James W. "Jim" Kachtick, P.E.	Industry - Chemical

[1] Texas Water Code §11.02362

- Ken Kramer — Environmental
- Glynna Leiper — Industry - Refining
- Ted Long — Electric Generation
- Thomas A. "Tom" Michel — Groundwater Conservation Districts
- Paul Nelson — Regional Water Planning Groups
- James M. "Jim" Oliver — River Authorities
- James M. "Jim" Parks — Regional Water Planning Groups
- Denis Qualls — Municipalities
- Adam Sinclair — Industry - Mining
- Lori Traweek — Recreational Water Users
- George A. "Pudge" Willcox — Ag Irrigation
- Tracy Woody — Commercial Fisherman

Description of the Trinity and San Jacinto Watersheds

Galveston Bay and its entire watershed is made up of approximately 24,000 square miles. As evidenced in Figure 1, it extends from North Central Texas near Oklahoma to the Gulf of Mexico, a straight distance of 360 miles. Relief consists of various prairies and low rolling hills. Natural vegetative cover includes grasslands at the coast and in the upper watershed, separated by woodlands.

Climate, Population, and Economy in the Watersheds

Precipitation: In the northern part of the watershed, average annual precipitation increases west to east from slightly more than 30 inches per year in western counties to more than 44 inches per year in the eastern counties. The southern part of the watershed receives approximately 55 inches of rain per year. The rainfall is notoriously erratic including floods at times and drought at other times. A typical year has much of the rain and streamflow in the late spring followed by very hot, dry weather in the summer. Population growth and economic activity in the Trinity basin has necessitated extensive development of water supplies to get through the dry periods.

Evaporation: Water supply planning includes the effects of evaporation from the surface of a reservoir. The rate of evaporation from a reservoir surface exceeds rainfall throughout the Region C planning area but the margin is much greater in the western part of the region than in the eastern part as can be seen in Figure 2. This trend also holds true in the San Jacinto and lower Trinity River basins.

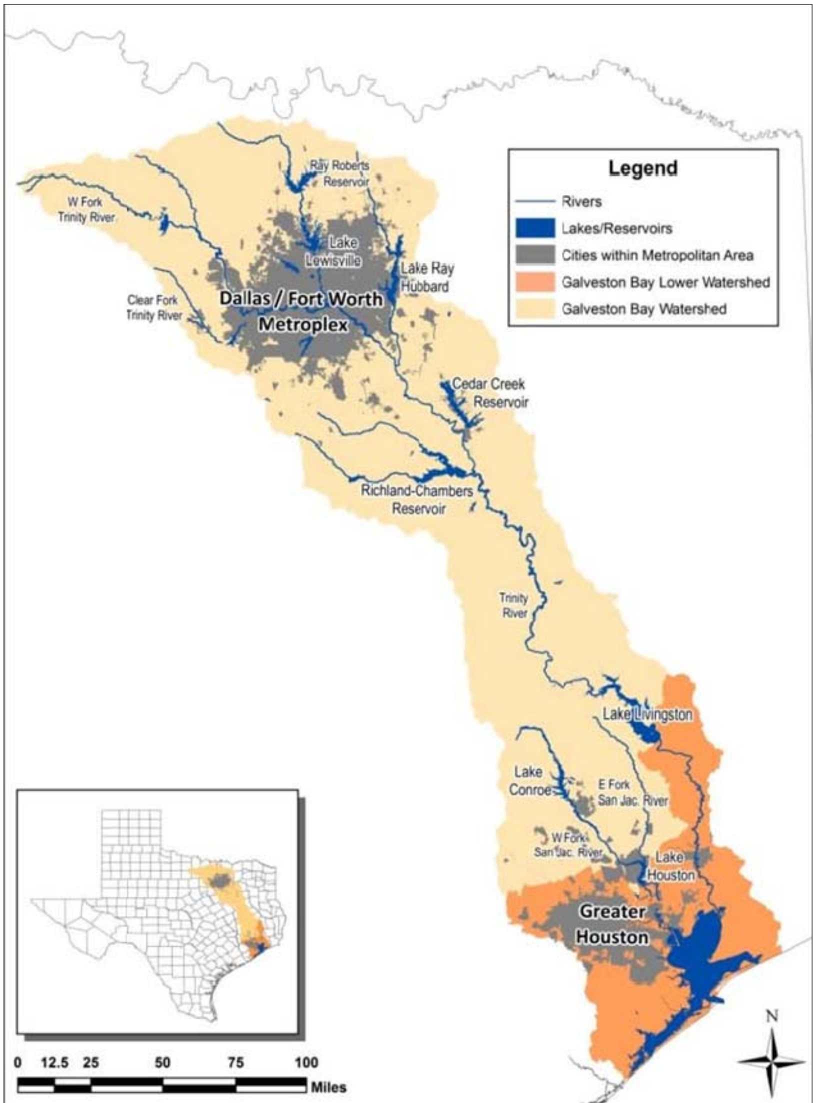

Figure 1. Trinity-San Jacinto Basins.

Streamflow: Figures 3, 4, and 5 show the variation in annual streamflow for three U.S. Geological Survey streamflow gages in Region C. The first two gages are on tributaries that have watersheds with limited development and show the natural variation of streamflows in this region. The Trinity River near Rosser gage is on the main stem of the Trinity River downstream of the Dallas-Fort Worth area. At this location, natural flow patterns have been substantially altered by reservoir development and by return flows of treated wastewater.

Population: The watersheds include the two largest metropolitan areas in Texas, Houston near the coast and the Dallas-Fort Worth area in the north. The total combined population of these areas is over 12 million totaling over half of the state's residents. The population of the area is expected to double by 2060[2] (the state's water planning horizon). Surface water is the primary source of water for this thriving area.

Economy: According to the Region C Water Plan, the leading industries in the northern part of the watershed include service, trade, and manufacturing, as well as government. North Texas accounts for one-third (1/3) of the gross domestic product of Texas and is a major driver in the state's economic engine. The estimated year 2006 payroll totaled $115 billion with 2.6 million

[2] Region C Initially Prepared Plan. 2010

people employed. According to the Region H Water Plan, the southern part of the Trinity-San Jacinto Basin is more industrial in nature. Two thirds of all U.S. petrochemical production and almost a third of the nation's petroleum industries are located in Region H. The Port of Houston is the sixth busiest port in the world. The service, manufacturing, medical, and transportation industries are also important economic sectors in the southern area of the basin.

<u>Climate, Ecology, and Economy of the Bay Area</u>

Climate and Ecology: Marshes and estuaries are an integral part of the Galveston-Trinity Bay ecosystem. The Bay itself is composed of 600 square miles with an average depth of 7 feet. Salinities in the Bay vary between freshwater inflows that approach 0 psu and open Gulf water at about 35 psu. Salinity is affected by many factors including the rate of freshwater inflows, tides, winds, and tropical storms. For example, Hurricane Ike dumped a phenomenal amount of rain on the bay as well as exceptional tidal activity and excessive winds. One tropical storm with 12 inches of rain over 6,000 square miles equates to 3.84 million acre feet of water over the bay watershed. During the last 50 years (since 1960) there were 20 Tropical Storms or Hurricanes that hit within 10 miles of Galveston County.

Economy: Fishing, both commercial and sport, within Galveston Bay and other major bodies of surface water within the Basins are major contributors to the local economic base. One third of the state's commercial fishing income and one half of the state's expenditures for recreational fishing come from Galveston Bay. Oysters, shrimp and finfish are important commercial species in the bay as well.

<u>A Sound Ecological Environment</u>

It is important to note that the Trinity-San Jacinto (T-SJ) BBEST could not reach a consensus agreement on a specific regime that would support a sound ecological environment, but the scientific group did agree that the current status of the systems under analysis within this effort are

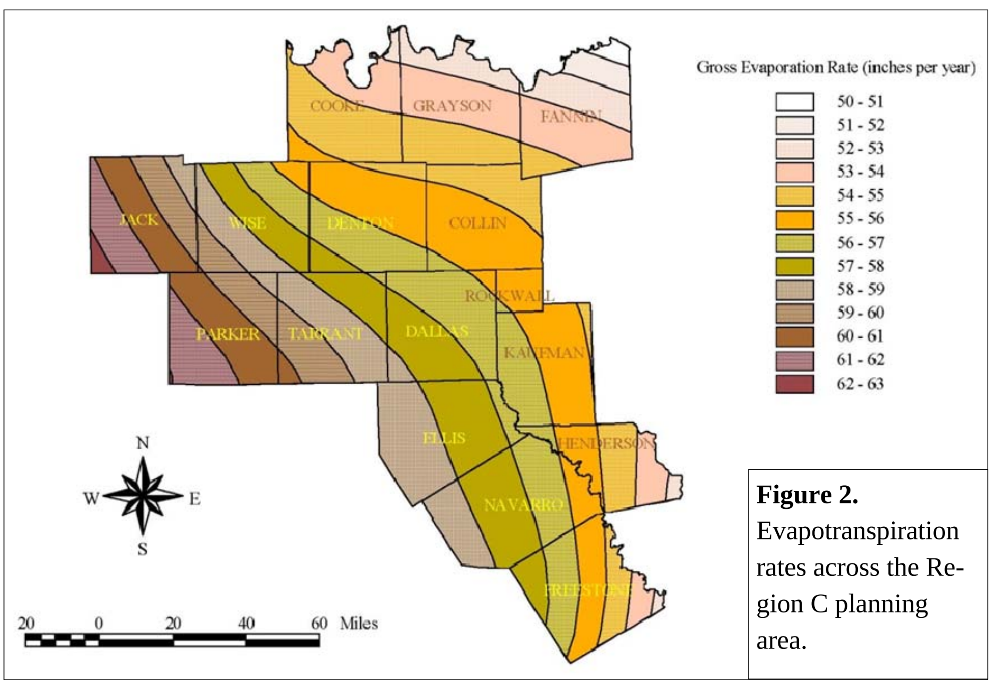

Figure 2. Evapotranspiration rates across the Region C planning area.

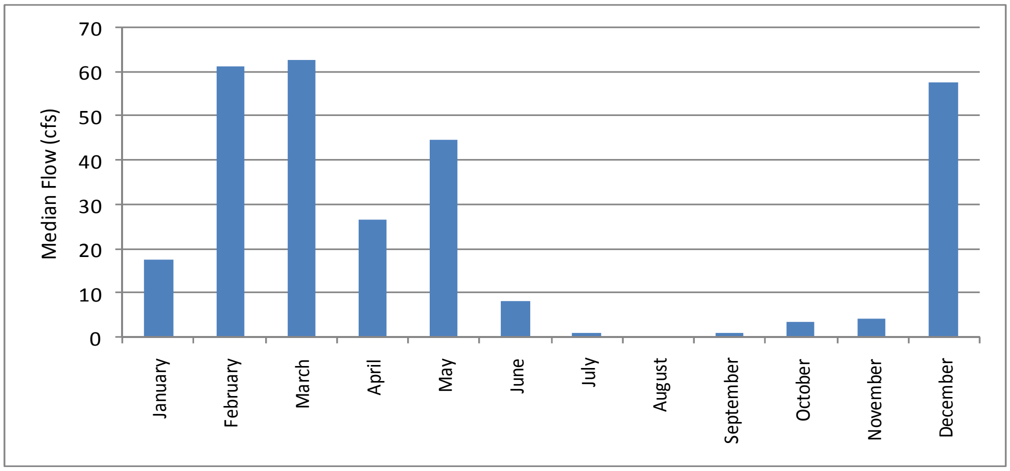

Figure 3. Median values of monthly average flow volumes in Tehuacana Creek near Streetman from 1968 through 2009. Source: USGS

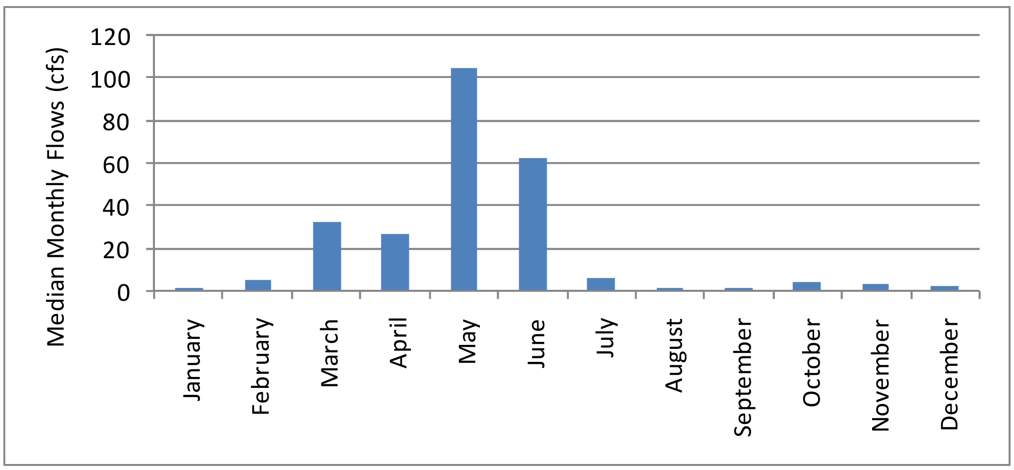

Figure 4. Median values of monthly average flow volumes in the West Fork, Trinity River near Jacksboro from 1974 through 2009. Source: USGS

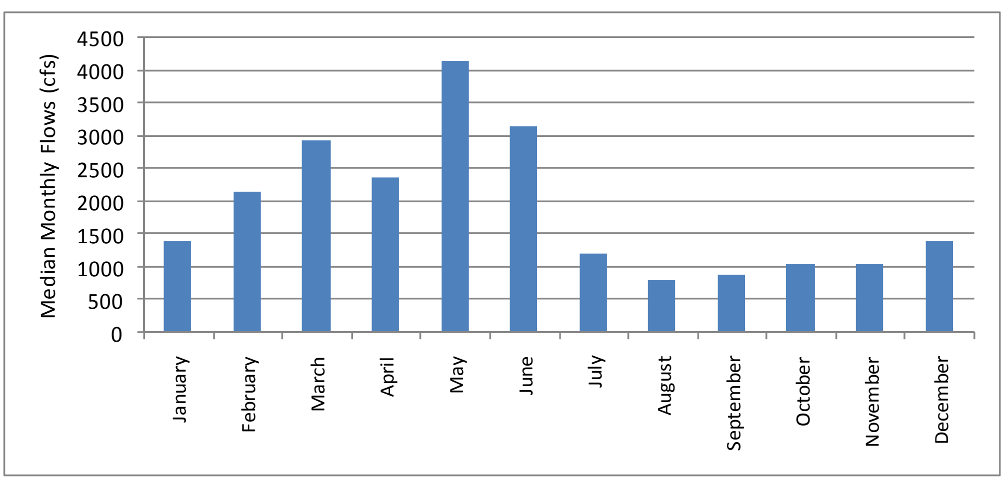

Figure 5. Median values of monthly average flow volumes in the Main Stem, Trinity River near Rosser from 1924 through 2009. Source: USGS

healthy and sound ecological environments. As defined in the Texas Instream Flow Program Technical Overview document, a sound ecological environment can be described as “a resilient, functioning ecosystem characterized by intact, natural processes, and a balanced, integrated, and adaptive community of organisms comparable to that of the natural habitat of a region.[3]”

BBEST Report Summary

The BBEST, recognizing that there is insufficient data to derive a sound relationship between biological metrics and flow, defaulted to using historical flows. This was done because historical flows are known to support the existing ecology of the Trinity and San Jacinto Rivers. **The recommendations of the BBEST, which used Hydrology-based Environmental Flow Regime (HEFR—a desktop statistical hydrology model developed by the Texas Parks and wildlife Department approximately two years ago) to derive a flow regime based upon historical flows, thus resulted not in the identification of a flow regime “adequate” to maintain the health of the bay and river ecology, but a flow regime that describes only, through the lens and filter of HEFR, what has historically occurred.**

1. Science-Based Conditional Phased Approach (Conditional Recommendation)

Paramount to the recommendation of this section is the acknowledgement of the level of uncertainty surrounding the available ecological science supporting potential recommended flow amounts. The “Conditional Recommendation” includes a limited number of monitoring stations, limited flow regime values, and identification of additional conditional monitoring stations and flow regime values to be considered as more science is developed. The recommendation put forth was for seasonal base flows and seasonal subsistence flows at four monitoring stations listed in Table 1.

Table 1. Science Based Conditional Phased Approach for Instream Flows

	Winter	Spring	Summer	Fall
Oakwood Base Flows	265(91%)*	322(95%)	186(85%)	162(82%)
Oakwood Subsistence Flows	98 (100%)	80(100%)	75 (97%)	85 (96%)
Romayor Base Flows	744 (91%)	923(93%)	510(83%)	515(74%)
Romayor Subsistence Flows	295(100%)	290(100%)	223(97%)	240(95%)
Cleveland Base Flows	27(86%)	28 (90%)	16 (69%)	16 (66%)
Cleveland Subsistence Flows	10 (100%)	10 (100%)	9 (91%)	9 (89%)
Conroe Base Flows	38 (90%)	47 (90%)	17 (81%)	16 (77%)
Conroe Subsistence Flows	10 (100%)	12 (100%)	10 (95%)	10 (92%)

*cfs with frequency of attainment over period of record in parenthesis

2. Science-Based Environmental Flow Regime (Regime Recommendation)

The “Regime Recommendation” was a very prescriptive, detailed regime that included over 700

[3] Texas Instream Flow Program Technical Overview. Report 369. May 2008.

specific target for the two river basins. The flow regime for eleven recommended stations is summarized on the following pages.

West Fork Trinity River at Grand Prairie

Base flow, Winter, Subsistence Condition: 24 cfs with attainment frequency of 96% of the time
Base flow, Winter, Dry Condition: 52 cfs with attainment frequency of 82% of the time
Base flow, Winter, Average Condition: 84 cfs with attainment frequency of 66% of the time
Base flow, Winter, Wet Condition: 118 cfs with attainment frequency of 50% of the time
Pulse flow, Winter, 1,380 cfs, 1 per season, volume of 16,418 ac-ft, and duration of 9 days
Pulse flow, Winter, 392 cfs, 2 per season, volume of 3,830 ac-ft, and duration of 4 days
Base flow, Spring, Subsistence Condition: 28 cfs with attainment frequency of 95% of the time
Base flow, Spring, Dry Condition: 53 cfs with attainment frequency of 87% of the time
Base flow, Spring, Average Condition: 84 cfs with attainment frequency of 76% of the time
Base flow, Spring, Wet Condition: 138 cfs with attainment frequency of 63% of the time
Pulse flow, Spring, 3,540 cfs, 1 per season, volume of 35,438 ac-ft, and duration of 15 days
Pulse flow, Spring, 1,280 cfs, 2 per season, volume of 8,345 ac-ft, and duration of 8 days
Base flow, Summer, Subsistence Condition: 15 cfs with attainment frequency of 96% of the time
Base flow, Summer, Dry Condition: 40 cfs with attainment frequency of 74% of the time
Base flow, Summer, Average Condition: 55 cfs with attainment frequency of 60% of the time
Base flow, Summer, Wet Condition: 82 cfs with attainment frequency of 46% of the time
Pulse flow, Summer, 535 cfs, 1 per season, volume of 5,749 ac-ft, and duration of 5 days
Pulse flow, Summer, 293 cfs, 2 per season, volume of 1,899 ac-ft, and duration of 3 days
Base flow, Fall, Subsistence Condition: 16 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 39 cfs with attainment frequency of 76% of the time
Base flow, Fall, Average Condition: 54 cfs with attainment frequency of 61% of the time
Base flow, Fall, Wet Condition: 79 cfs with attainment frequency of 46% of the time
Pulse flow, Fall, 338 cfs, 1 per season, volume of 3,475 ac-ft, and duration of 3 days
High pulse flow, 3,580 cfs, 2 per *year*, volume of 41,739 ac-ft, and duration of 17 days
Overbank flows, 10,700 cfs, 1 per 5 *years*, volume of 202,575 ac-ft, and duration of 37 days

Elm Fork Trinity River near Carrollton

Base flow, Winter, Subsistence Condition: 24 cfs with attainment frequency of 78% of the time
Base flow, Winter, Dry Condition: 61 cfs with attainment frequency of 73% of the time
Base flow, Winter, Average Condition: 102 cfs with attainment frequency of 60% of the time
Base flow, Winter, Wet Condition: 165 cfs with attainment frequency of 46% of the time
Pulse flow, Winter, 2,380 cfs, 1 per season, volume of 29,629 ac-ft, and duration of 9 days
Pulse flow, Winter, 418 cfs, 2 per season, volume of 2,218 ac-ft, and duration of 3 days
Base flow, Spring, Subsistence Condition: 28 cfs with attainment frequency of 87% of the time
Base flow, Spring, Dry Condition: 65 cfs with attainment frequency of 81% of the time
Base flow, Spring, Average Condition: 112 cfs with attainment frequency of 70% of the time
Base flow, Spring, Wet Condition: 185 cfs with attainment frequency of 58% of the time
Pulse flow, Spring, 6,560 cfs, 1 per season, volume of 87,056 ac-ft, and duration of 14 days
Pulse flow, Spring, 2,980 cfs, 2 per season, volume of 34,860 ac-ft, and duration of 9 days
Base flow, Summer, Subsistence Condition: 15 cfs with attainment frequency of 75% of the time
Base flow, Summer, Dry Condition: 42 cfs with attainment frequency of 68% of the time
Base flow, Summer, Average Condition: 106 cfs with attainment frequency of 52% of the time
Base flow, Summer, Wet Condition: 210 cfs with attainment frequency of 35% of the time
Pulse flow, Summer, 1,270 cfs, 1 per season, volume of 7,160 ac-ft, and duration of 5 days
Pulse flow, Summer, 361 cfs, 2 per season, volume of 1,975 ac-ft, and duration of 2 days
Base flow, Fall, Subsistence Condition: 16 cfs with attainment frequency of 77% of the time
Base flow, Fall, Dry Condition: 60 cfs with attainment frequency of 68% of the time
Base flow, Fall, Average Condition: 101 cfs with attainment frequency of 55% of the time
Base flow, Fall, Wet Condition: 161 cfs with attainment frequency of 40% of the time
Pulse flow, Fall, 830 cfs, 1 per season volume 5,485 ac-ft, and duration of 5 days
High flow pulse, 6,900 cfs, 2 per year, volume of 94,502 ac-ft, and duration of 14 days
Overbank flows, 11,000 cfs, 1 per 2 years, volume of 154,505 ac-ft, and duration of 18 days

Trinity River at Dallas

Base flow, Winter, Subsistence Condition: 24 cfs with attainment frequency of 91% of the time
Base flow, Winter, Dry Condition: 51 cfs with attainment frequency of 81% of the time
Base flow, Winter, Average Condition: 132 cfs with attainment frequency of 65% of the time
Base flow, Winter, Wet Condition: 272 cfs with attainment frequency of 50% of the time
Pulse flow, Winter, 3,420 cfs, 1 per season, volume of 46,147 ac-ft, and duration of 9 days
Pulse flow, Winter, 758 cfs, 2 per season, volume of 3,968 ac-ft, and duration of 3 days
Base flow, Spring, Subsistence Condition: 28 cfs with attainment frequency of 92% of the time
Base flow, Spring, Dry Condition: 71 cfs with attainment frequency of 84% of the time
Base flow, Spring, Average Condition: 152 cfs with attainment frequency of 74% of the time
Base flow, Spring, Wet Condition: 304 cfs with attainment frequency of 63% of the time
Pulse flow, Spring, 8,800 cfs, 1 per season, volume of 105,155 ac-ft, and duration of 15 days
Pulse flow, Spring, 4,120 cfs, 2 per season, volume of 41,998 ac-ft, and duration of 9 days
Base flow, Summer, Subsistence Condition: 15 cfs with attainment frequency of 91% of the time
Base flow, Summer, Dry Condition: 44 cfs with attainment frequency of 76% of the time
Base flow, Summer, Average Condition: 104 cfs with attainment frequency of 60% of the time
Base flow, Summer, Wet Condition: 225 cfs with attainment frequency of 44% of the time
Pulse flow, Summer, 1,740 cfs, 1 per season, volume of 18,760 ac-ft, and duration of 6 days
Pulse flow, Summer, 660 cfs, 2 per season, volume of 685 ac-ft, and duration of 3 days
Base flow, Fall, Subsistence Condition: 16 cfs with attainment frequency of 91% of the time
Base flow, Fall, Dry Condition: 50 cfs with attainment frequency of 76% of the time
Base flow, Fall, Average Condition: 112 cfs with attainment frequency of 61% of the time
Base flow, Fall, Wet Condition: 198 cfs with attainment frequency of 45% of the time
Pulse flow, Fall, 1,100 cfs, 1 per season, volume of 8,524 ac-ft., and duration of 5 days
High flow pulse, 8,720 cfs, 2 per year, volume of 110,120 ac-ft, and duration of 15 days
Overbank flow, 11,100 cfs, 2 per year, volume of 145,167 ac-ft, and duration of 18 days

Trinity River near Rosser

Base flow, Winter, Subsistence Condition: 106 cfs with attainment frequency of 95% of the time
Base flow, Winter, Dry Condition: 248 cfs with attainment frequency of 77% of the time
Base flow, Winter, Average Condition: 466 cfs with attainment frequency of 64% of the time
Base flow, Winter, Wet Condition: 821 cfs with attainment frequency of 50% of the time
Pulse flow, Winter, 5,400 cfs, 1 per season, volume of 105,276 ac-ft, and duration of 10 days
Pulse flow, Winter, 2,650 cfs, 2 per season, volume of 30,078 ac-ft, and duration of 6 days
Base flow, Spring, Subsistence Condition: 212 cfs with attainment frequency of 95% of the time
Base flow, Spring, Dry Condition: 398 cfs with attainment frequency of 88% of the time
Base flow, Spring, Average Condition: 625 cfs with attainment frequency of 79% of the time
Base flow, Spring, Wet Condition: 1,078 cfs with attainment frequency of 67% of the time
Pulse flow, Spring, 13,600 cfs, 1 per season, volume of 159,551 ac-ft, and duration of 16 days
Pulse flow, Spring, 6,400 cfs, 2 per season, volume of 70,661 ac-ft, and duration of 9 days
Base flow, Summer, Subsistence Condition: 142 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 266 cfs with attainment frequency of 77% of the time
Base flow, Summer, Average Condition: 401 cfs with attainment frequency of 59% of the time
Base flow, Summer, Wet Condition: 574 cfs with attainment frequency of 41% of the time
Pulse flow, Summer, 2,660 cfs, 1 per season, volume of 19,745 ac-ft, and duration of 5 days
Pulse flow, Summer, 1,100 cfs, 2 per season, volume of 10,751 ac-ft, and duration of 3 days
Base flow, Fall, Subsistence Condition: 125 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 208 cfs with attainment frequency of 72% of the time
Base flow, Fall, Average Condition: 320 cfs with attainment frequency of 57% of the time
Base flow, Fall, Wet Condition: 626 cfs with attainment frequency of 41% of the time
Pulse flow, Fall, 2,210 cfs, 1 per season, volume of 22,748 ac-ft, and duration of 4 days
High flow pulse, 12,600 cfs, 2 per year, volume of 164,647 ac-ft, and duration of 16 days
Overbank flows, 26,000 cfs, 1 per 2 years, volume of 456,654 ac-ft, and duration of 27 days

Trinity River near Oakwood

Base flow, Winter, Subsistence Condition: 196 cfs with attainment frequency of 95% of the time
Base flow, Winter, Dry Condition: 340 cfs with attainment frequency of 85% of the time
Base flow, Winter, Average Condition: 623 cfs with attainment frequency of 72% of the time
Base flow, Winter, Wet Condition: 1,110 cfs with attainment frequency of 58% of the time
Pulse flow, Winter, 11,200 cfs, 1 per season, volume of 257,289 ac-ft, and duration of 14 days
Pulse flow, Winter, 3,200 cfs, 2 per season, volume of 18,931 ac-ft, and duration of 5 days
Base flow, Spring, Subsistence Condition: 280 cfs with attainment frequency of 95% of the time
Base flow, Spring, Dry Condition: 458 cfs with attainment frequency of 89% of the time
Base flow, Spring, Average Condition: 820 cfs with attainment frequency of 79% of the time
Base flow, Spring, Wet Condition: 1,398 cfs with attainment frequency of 66% of the time
Pulse flow, Spring, 15,700 cfs, 1 per season, volume of 362,910 ac-ft, and duration of 19 days
Pulse flow, Spring, 7,840 cfs, 2 per season, volume of 141,705 ac-ft, and duration of 11 days
Base flow, Summer, Subsistence Condition: 70 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 257 cfs with attainment frequency of 69% of the time
Base flow, Summer, Average Condition: 411 cfs with attainment frequency of 53% of the time
Base flow, Summer, Wet Condition: 682 cfs with attainment frequency of 36% of the time
Pulse flow, Summer, 2,930 cfs, 1 per season, volume of 26,246 ac-ft, and duration of 5 days
Pulse flow, Summer, 1,180 cfs, 2 per season, volume of 4,866 ac-ft, and duration of 2 days
Base flow, Fall, Subsistence Condition: 101 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 265 cfs with attainment frequency of 73% of the time
Base flow, Fall, Average Condition: 439 cfs with attainment frequency of 57% of the time
Base flow, Fall, Wet Condition: 819 cfs with attainment frequency of 41% of the time
Pulse flow, Fall, 3,050 cfs, 1 per season, volume of 39,239 ac-ft, and duration of 5 days
High flow pulse, 15,000 cfs, 2 per year, volume of 326,119 ac-ft, and duration of 18 days
Overbank flows, 24,600 cfs, 1 per 2 years, volume of 626,471 ac-ft, and duration of 26 days

Trinity River at Romayor

Base flow, Winter, Subsistence Condition: 542 cfs with attainment frequency of 95% of the time
Base flow, Winter, Dry Condition: 875 cfs with attainment frequency of 86% of the time
Base flow, Winter, Average Condition: 1,500 cfs with attainment frequency of 74% of the time
Base flow, Winter, Wet Condition: 2,590 cfs with attainment frequency of 61% of the time
Pulse flow, Winter, 19,600 cfs, 1 per season, volume of 316,434 ac-ft, and duration of 16 days
Pulse flow, Winter, 8,860 cfs, 2 per season, volume of 85,975 ac-ft, and duration of 7 days
Base flow, Spring, Subsistence Condition: 720 cfs with attainment frequency of 95% of the time
Base flow, Spring, Dry Condition: 1,160 cfs with attainment frequency of 89% of the time
Base flow, Spring, Average Condition: 1,860 cfs with attainment frequency of 78% of the time
Base flow, Spring, Wet Condition: 3,033 cfs with attainment frequency of 65% of the time
Pulse flow, Spring, 20,400 cfs, 1 per season, volume of 473,174 ac-ft, and duration of 17 days
Pulse flow, Spring, 11,300 cfs, 2 per season, volume of 172,144 ac-ft, and duration of 9 days
Base flow, Summer, Subsistence Condition: 210 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 580 cfs with attainment frequency of 68% of the time
Base flow, Summer, Average Condition: 915 cfs with attainment frequency of 52% of the time
Base flow, Summer, Wet Condition: 1,550 cfs with attainment frequency of 34% of the time
Pulse flow, Summer, 4,430 cfs, 1 per season, volume of 65,285 ac-ft, and duration of 5 days
Base flow, Fall, Subsistence Condition: 250 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 630 cfs with attainment frequency of 71% of the time
Base flow, Fall, Average Condition: 1,000 cfs with attainment frequency of 55% of the time
Base flow, Fall, Wet Condition: 1,720 cfs with attainment frequency of 39% of the time
Pulse flow, Fall, 5,420 cfs, 1 per season, volume of 119,525 ac-ft, and duration of 5 days
High flow pulse, 22,700 cfs, 2 per year, volume of 499,009 ac-ft, and duration of 18 days
Overbank flows, 44,600 cfs, 1 per 2 years, volume of 1,875,722 ac-ft, and duration of 34 days

West Fork San Jacinto River near Conroe

Base flow, Winter, Subsistence Condition: 23 cfs with attainment frequency of 95% of the time
Base flow, Winter, Dry Condition: 36 cfs with attainment frequency of 89% of the time
Base flow, Winter, Average Condition: 58 cfs with attainment frequency of 77% of the time
Base flow, Winter, Wet Condition: 111 cfs with attainment frequency of 61% of the time
Pulse flow, Winter, 1,820 cfs, 1 per season, volume of 33,557 ac-ft, and duration of 15 days
Pulse flow, Winter, 420 cfs, 2 per season, volume of 3,679 ac-ft, and duration of 7 days
Base flow, Spring, Subsistence Condition: 24 cfs with attainment frequency of 96% of the time
Base flow, Spring, Dry Condition: 37 cfs with attainment frequency of 87% of the time
Base flow, Spring, Average Condition: 56 cfs with attainment frequency of 74% of the time
Base flow, Spring, Wet Condition: 88 cfs with attainment frequency of 59% of the time
Pulse flow, Spring, 3,430 cfs, 1 per season, volume of 44,140 ac-ft, and duration of 17 days
Pulse flow, Spring, 1,100 cfs, 2 per season, volume of 12,377 ac-ft, and duration of 9 days
Base flow, Summer, Subsistence Condition: 9 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 18 cfs with attainment frequency of 67% of the time
Base flow, Summer, Average Condition: 26 cfs with attainment frequency of 49% of the time
Base flow, Summer, Wet Condition: 38 cfs with attainment frequency of 32% of the time
Pulse flow, Summer, 193 cfs, 1 per season, volume of 1,301 ac-ft, and duration of 3 days
Pulse flow, Summer, 74 cfs, 2 per season, volume of 380 ac-ft, and duration of 2 days
Base flow, Fall, Subsistence Condition: 9 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 22 cfs with attainment frequency of 71% of the time
Base flow, Fall, Average Condition: 29 cfs with attainment frequency of 57% of the time
Base flow, Fall, Wet Condition: 47 cfs with attainment frequency of 42% of the time
Pulse flow, Fall, 345 cfs, 1 per season, volume of 2,833 ac-ft, and duration of 5 days
High flow pulse, 3,600 cfs, 2 per year, volume of 44,771 ac-ft, and duration of 18 days
Overbank flows, 16,800 cfs, 1 per 5 years, volume of 158,831 ac-ft, and duration of 43 days

Spring Creek near Spring

Base flow, Winter, Subsistence Condition: 14 cfs with attainment frequency of 96% of the time
Base flow, Winter, Dry Condition: 22 cfs with attainment frequency of 86% of the time
Base flow, Winter, Average Condition: 36 cfs with attainment frequency of 74% of the time
Base flow, Winter, Wet Condition: 59 cfs with attainment frequency of 60% of the time
Pulse flow, Winter, 1,410 cfs, 1 per season, volume of 18,911 ac-ft, and duration of 15 days
Pulse flow, Winter, 359 cfs, 2 per season, volume of 2,711 ac-ft, and duration of 7 days
Base flow, Spring, Subsistence Condition: 14 cfs with attainment frequency of 96% of the time
Base flow, Spring, Dry Condition: 24 cfs with attainment frequency of 86% of the time
Base flow, Spring, Average Condition: 36 cfs with attainment frequency of 72% of the time
Base flow, Spring, Wet Condition: 52 cfs with attainment frequency of 57% of the time
Pulse flow, Spring, 2,440 cfs, 1 per season, volume of 23,987 ac-ft, and duration of 15 days
Pulse flow, Spring, 628 cfs, 2 per season, volume of 5,852 ac-ft, and duration of 8 days
Base flow, Summer, Subsistence Condition: 6 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 17 cfs with attainment frequency of 71% of the time
Base flow, Summer, Average Condition: 24 cfs with attainment frequency of 56% of the time
Base flow, Summer, Wet Condition: 35 cfs with attainment frequency of 39% of the time
Pulse flow, Summer, 367 cfs, 1 per season, volume of 2,595 ac-ft, and duration of 5 days
Pulse flow, Summer, 137 cfs, 2 per season, volume of 898 ac-ft, and duration of 3 days
Base flow, Fall, Subsistence Condition: 6 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 17 cfs with attainment frequency of 75% of the time
Base flow, Fall, Average Condition: 24 cfs with attainment frequency of 61% of the time
Base flow, Fall, Wet Condition: 37 cfs with attainment frequency of 45% of the time
Pulse flow, Fall, 304 cfs, 1 per season, volume of 2,019 ac-ft, and duration of 5 days
Pulse flow, Fall, 74 cfs, 2 per season, volume of 664 ac-ft, and duration of 2 days
High flow pulse, 2,670 cfs, 2 per year, volume of 29,045 ac-ft, and duration of 17 days
Overbank flows, 5,000 cfs, 1 per 2 years, volume of 51,766 ac-ft, and duration of 24 days

East Fork San Jacinto River near Cleveland

Base flow, Winter, Subsistence Condition: 22 cfs with attainment frequency of 95% of the time
Base flow, Winter, Dry Condition: 30 cfs with attainment frequency of 88% of the time
Base flow, Winter, Average Condition: 43 cfs with attainment frequency of 77% of the time
Base flow, Winter, Wet Condition: 80 cfs with attainment frequency of 62% of the time
Pulse flow, Winter, 1,400 cfs, 1 per season, volume of 16,483 ac-ft, and duration of 15 days
Pulse flow, Winter, 475 cfs, 2 per season, volume of 5,055 ac-ft, and duration of 8 days
Base flow, Spring, Subsistence Condition: 18 cfs with attainment frequency of 96% of the time
Base flow, Spring, Dry Condition: 28 cfs with attainment frequency of 86% of the time
Base flow, Spring, Average Condition: 42 cfs with attainment frequency of 72% of the time
Base flow, Spring, Wet Condition: 64 cfs with attainment frequency of 56% of the time
Pulse flow, Spring, 1,700 cfs, 1 per season, volume of 17,889 ac-ft, and duration of 13 days
Pulse flow, Spring, 687 cfs, 2 per season, volume of 6,769 ac-ft, and duration of 8 days
Base flow, Summer, Subsistence Condition: 8 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 18 cfs with attainment frequency of 68% of the time
Base flow, Summer, Average Condition: 24 cfs with attainment frequency of 52% of the time
Base flow, Summer, Wet Condition: 34 cfs with attainment frequency of 33% of the time
Pulse flow, Summer, 223 cfs, 1 per season, volume of 1,454 ac-ft, and duration of 4 days
Pulse flow, Summer, 94 cfs, 2 per season, volume of 288 ac-ft, and duration of 2 days
Base flow, Fall, Subsistence Condition: 10 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 19 cfs with attainment frequency of 75% of the time
Base flow, Fall, Average Condition: 27 cfs with attainment frequency of 57% of the time
Base flow, Fall, Wet Condition: 38 cfs with attainment frequency of 41% of the time
Pulse flow, Fall, 249 cfs, 1 per season, volume of 1,417 ac-ft, and duration of 4 days
Pulse flow, Fall, 56 cfs, 2 per season, volume of 188 ac-ft, and duration of 2 days
High flow pulse, 2.030 cfs, 2 per year, volume of 23,386 ac-ft, and duration of 16 days
Overbank flows, 4,000 cfs, 1 per 2 years, volume of 43,908 ac-ft, and duration of 23 days

Buffalo Bayou at Piney Point

Base flow, Winter, Subsistence Condition: 11 cfs with attainment frequency of 96% of the time
Base flow, Winter, Dry Condition: 25 cfs with attainment frequency of 80% of the time
Base flow, Winter, Average Condition: 38 cfs with attainment frequency of 68% of the time
Base flow, Winter, Wet Condition: 58 cfs with attainment frequency of 55% of the time
Pulse flow, Winter, 783 cfs, 1 per season, volume of 12,220 ac-ft, and duration of 10 days
Pulse flow, Winter, 521 cfs, 2 per season, volume of 6,301 ac-ft, and duration of 7 days
Base flow, Spring, Subsistence Condition: 13 cfs with attainment frequency of 95% of the time
Base flow, Spring, Dry Condition: 26 cfs with attainment frequency of 81% of the time
Base flow, Spring, Average Condition: 37 cfs with attainment frequency of 67% of the time
Base flow, Spring, Wet Condition: 51 cfs with attainment frequency of 54% of the time
Pulse flow, Spring, 1,080 cfs, 1 per season, volume of 19,364 ac-ft, and duration of 12 days
Pulse flow, Spring, 569 cfs, 2 per season, volume of 7,316 ac-ft, and duration of 6 days
Base flow, Summer, Subsistence Condition: 26 cfs with attainment frequency of 95% of the time
Base flow, Summer, Dry Condition: 45 cfs with attainment frequency of 87% of the time
Base flow, Summer, Average Condition: 66 cfs with attainment frequency of 74% of the time
Base flow, Summer, Wet Condition: 96 cfs with attainment frequency of 60% of the time
Pulse flow, Summer, 799 cfs, 1 per season, volume of 14,321 ac-ft, and duration of 13 days
Pulse flow, Summer, 395 cfs, 2 per season, volume of 4,734 ac-ft, and duration of 7 days
Base flow, Fall, Subsistence Condition: 13 cfs with attainment frequency of 96% of the time
Base flow, Fall, Dry Condition: 33 cfs with attainment frequency of 81% of the time
Base flow, Fall, Average Condition: 49 cfs with attainment frequency of 69% of the time
Base flow, Fall, Wet Condition: 75 cfs with attainment frequency of 56% of the time
Pulse flow, Fall, 423 cfs, 1 per season, volume of 4,730 ac-ft, and duration of 6 days
Pulse flow, Fall, 231 cfs, 2 per season, volume of 325 ac-ft, and duration of 3 days
High flow pulse, 1,170 cfs, 2 per year, volume of 23,569 ac-ft, and duration of 15 days

Base flow, Winter, Subsistence Condition: 3 cfs with attainment frequency of 95% of the time
Base flow, Winter, Dry Condition: 6 cfs with attainment frequency of 84% of the time
Base flow, Winter, Average Condition: 9 cfs with attainment frequency of 72% of the time
Base flow, Winter, Wet Condition: 10 cfs with attainment frequency of 67% of the time
Pulse flow, Winter, 735 cfs, 1 per season, volume of 5,167 ac-ft, and duration of 14 days
Pulse flow, Winter, 239 cfs, 2 per season, volume of 1,444 ac-ft, and duration of 7 days
Base flow, Spring, Subsistence Condition: 1 cfs with attainment frequency of 97% of the time
Base flow, Spring, Dry Condition: 5 cfs with attainment frequency of 79% of the time
Base flow, Spring, Average Condition: 8 cfs with attainment frequency of 60% of the time
Base flow, Spring, Wet Condition: 10 cfs with attainment frequency of 50% of the time
Pulse flow, Spring, 707 cfs, 1 per season, volume of 4,222 ac-ft, and duration of 10 days
Pulse flow, Spring, 263 cfs, 2 per season, volume of 1,367 ac-ft, and duration of 6 days
Base flow, Summer, Subsistence Condition: 1 cfs with attainment frequency of 97% of the time
Base flow, Summer, Dry Condition: 5 cfs with attainment frequency of 72% of the time
Base flow, Summer, Average Condition: 8 cfs with attainment frequency of 57% of the time
Base flow, Summer, Wet Condition: 10 cfs with attainment frequency of 47% of the time
Pulse flow, Summer, 197 cfs, 1 per season, volume of 1, 032 ac-ft, and duration of 6 days
Pulse flow, Summer, 69 cfs, 2 per season, volume of 385 ac-ft, and duration of 3 days
Base flow, Fall, Subsistence Condition: 1 cfs with attainment frequency of 95% of the time
Base flow, Fall, Dry Condition: 5 cfs with attainment frequency of 71% of the time
Base flow, Fall, Average Condition: 7 cfs with attainment frequency of 58% of the time
Base flow, Fall, Wet Condition: 9 cfs with attainment frequency of 48% of the time
Pulse flow, Fall, 246 cfs, 1 per season, volume of 1,505 ac-ft, and duration of 6 days
Pulse flow, Fall, 26 cfs, 2 per season, volume of 90 ac-ft, and duration of 2 days
High flow pulse, 1,440 cfs, 2 per year, volume of 10,972 ac-ft, and duration of 16 days
Overbank flows, 3,700 cfs, 1 per 2 years, volume of 26,603 ac-ft, and duration of 26 days

3. Regime Recommendation for Freshwater Inflows for Galveston Bay

Table 2. Freshwater Inflow Recommendations for Galveston Bay

Trinity flow recommendations:

	Spring	Summer	Fall	Winter
Criterion	696,000	193,000	133,000	HEFR Table
Periodicity	1 of 3 months	2 of 3 months	2 of 3 months	
Recommended Annual Frequency	1 in 2 years	1 in 2 years	1 in 3 years	

San Jacinto flow recommendations:

Season	Spring	Summer	Fall	Winter
Flow	302,000	257,000	250,000	
Periodicity	1 of 3 months	2 of 3	1 of 3	
Annual Occurrence	15 of 23 years	5 of 23	13 of 23	
Recommended Annual Frequency	1 in 2 years	1 in 5 years	1 in 2 years	

Coastal streams flow recommendation:

Season	Spring	Summer	Fall	Winter
Flow	455,000	196,000	244,000	
Periodicity	1 of 3 months	2 of 3	1 of 3	
Annual Occurrence	17 of 23	7 of 23	6 of 23	
Recommended Annual Frequency	1 in 2	1 in 4	1 in 4	

4. "Conditional Recommendation" for Freshwater Inflows for the Galveston Bay System

Table 3. "Conditional Recommendation" for Freshwater Inflows for the Galveston Bay System

Inflow Scenario	Quantity Needed (acre-feet/year)	Historical Frequency	Target Frequency (annual basis)
Max H	5.2 million	66%	50%
Min Q	4.2 million	70%	60%
Min Q-Sal	2.5 million	82%	75%
Min Historic	1.8 million	98%	90%

Max H: Modeled inflows recommended for maximum bay and estuary fisheries harvest by Texas Parks & Wildlife Department.
Min Q: Minimum modeled inflow recommended to maintain the bay and estuary fisheries harvest.
Min Q-Sal: Estimated minimum acceptable inflow recommended to maintain the salinity needed for bay and estuary fisheries viability.
Min Historic: Minimum annual inflow calculated for Galveston Bay over the period of record (1941-1990).

This recommendation matched the studies and recommendations of the Region H Water Planning Group which conducted a specific study to examine Galveston Bay inflows and impacts on the Region H water supplies. As noted by Region H, the health and productivity of Galveston Bay must consider the quantity, quality, seasonality (monthly inflows), and location of inflows. It is anticipated that the inflow needs projections will continue to be refined over time. As has been noted by the SAC[4], there are significant weaknesses to the State Methodology (a flow regime recommended in 1998) in regards to its application in a Senate Bill 3 process, particularly in its identification of an optimum flow regime. While there is a significant amount of uncertainty that 5.2 million acre feet per year would produce the maximum productivity within the system, it is recom-

[4] SAC Report, June 5, 2009. Methodologies for Establishing a Freshwater Inflow Regime for Texas Estuaries.

mended that these flow amounts be met at the noted frequencies over future years on an annual basis. It is anticipated that more science will be developed and applied to refine the identification of flows that can be shown to be necessary to support a sound ecological environment for the entirety of the Galveston Bay ecosystem.

Comparison of the Instream Recommendations

It can easily be seen that the "Conditional Recommendation" is much less complex than the "Regime Recommendation". This "Conditional Recommendation" matrix was intentionally simplified in recognition of the limited science available and the level of uncertainty in specifying a flow regime that provides flows which are *adequate* to support a sound ecological environment. **According to the language of Senate Bill 3, the science must be available to *predict* the response of an ecosystem to these particular recommended flows[5]. The HEFR methodology, which is based on historic hydrology, does not predict the response of an ecosystem but instead was chosen as a tool to develop a flow matrix based solely on hydrology. The shortcomings of this model must be recognized.** First, the HEFR model is in the early stages of development, and second, as SAC guidance indicated, the wet, dry, and average flow conditions are defined post facto by quartile points and "have no physical or ecological significance[6]." Third, as further pointed out by the SAC, a hydrological record will produce a matrix that is "based on little or no consideration of the actual flow requirements for specific aquatic organisms." These factors were key in the "Conditional Recommendation" being a simplified version of a matrix with an emphasis on adaptive management when more science is available specifically for the Trinity and San Jacinto Basins.

In addition, the methodology used to implement any flow matrix by the TCEQ would be unable to handle the specificity of the flow regime developed in the "Regime Recommendation" because the WAM uses a monthly time step as opposed to a daily time step which is spelled out in the regime matrix. As pointed out by the SAC, the "real issue is whether the recommended environmental flow components themselves reflect the proper magnitudes and frequencies to achieve their designated objectives, and this, of course, is the crux of the difficulties in identifying an *adequate* environmental flow regime as defined by SB 3[6]." The SAC goes on to add that using historical hydrological data to develop a recommended environmental flow regime will likely result in a flow regime more than adequate to support a sound ecological environment. **Therefore, the presumption is that some lesser quantities of flow or some lesser frequency of occurrence than were experienced historically may still be adequate to sustain a sound ecological environment.**

Comparison of Freshwater Inflow Recommendations

Just as in the above comparison of the two Instream Flow Requirements, a comparison of the Freshwater Inflow Requirements for Galveston Bay reveals that the "Regime Recommendation,

[5] Texas Water Code §11.002(15)
[6] SAC Discussion Paper: Moving from Instream Flow Regime matrix Development to Environmental Flow Standard Recommendations dated 2/16/10

Freshwater Inflow Recommendations for Galveston Bay," is not as straight-forward as the "Conditional Recommendation," the "Alternative Recommendation for Freshwater Inflows for the Galveston Bay System." As noted in the comments section of the BBEST Report, the salinity-zonation approach utilized in the "Regime Recommendation" has many limitations that unfortunately do not allow for the identification of freshwater inflow requirements that can be shown to be necessary to support a sound ecological environment for Galveston Bay in its entirety. First, a substantial difficulty with developing relations of freshwater inflow to estuarine health has been that what is good for one organism may not necessarily be good for another. It can be considered a fallacy to use one indicator organism, vallisneria, as representative of the Trinity River flows necessary to provide predictability of a sound ecological environment for Galveston Bay. This holds true for the use of rangia and oyster for the San Jacinto River as well.

Frequency of occurrence of inflows presented was addressed and studied by the Region H Water Planning Group in a report entitled "Region H Water Planning Group Environmental Flows Study." This report has been incorporated into the 2011 Region H Initially Prepared Plan. The report concludes that meeting the requirements of a monthly or seasonal flow regime has significant impacts on the storage of Lake Livingston, which represents 52% of the total water supply available in Region H.

> *"Although targets were met without reducing firm yield, a loss of modeled reservoir storage did result for both Lake Houston and Lake Livingston. For Max H, the median level for Lake Houston was reduced by eight percent (8,741 acre feet) and for Lake Livingston by 17 percent (284,603 acre feet). The storage loss was larger for the Min Q-Sal condition, with the median storage level reduced by 11 percent (12,069 acre feet) in Lake Houston and 24 percent (404,816 acre feet) in Lake Livingston."*

The loss of 284,603 acre feet in Lake Livingston represents a lowering of the conservation lake level from 131 msl to 127.36 msl, a loss of 3.6 ft in storage. This loss impairs the water supply capability of the lake and will impair the permitted yield of the lake in the event of a drought.

There are other powerful, uncorrelated factors that affect bay health besides bay inflows, including tides, temperature, wind, land modification, and water quality.

Analysis of Impacts on Regional Water Planning

Overview of Regional Water Planning

Senate Bill 1 was passed by the 75th legislature in 1997 with the purpose of creating a regional, bottom-up planning process to ensure that future Texans will have sufficient water resources. This is achieved by comparing estimated future municipal, manufacturing, agricultural, steam electric, and mining demands and supplies. Appropriate water management strategies are then selected to overcome any identified water shortages. In the process of selecting and developing supply strategies, the regional planning groups are required "to adjust strategies to provide for appropriate environmental water needs, including instream flows and bays and estuaries inflows[7]." Furthermore, each regional planning group is composed of individuals representing various groups and positions, including environmental interests[8].

1. Economic Significance

Of the sixteen regional groups created by SB1, the two major planning groups in the Trinity and San Jacinto river basins are Regions C and H (Figure 6). As of 2010, it was estimated that Region C population would exceed over 6.7 million Texans[9] with Region H representing an additional 6 million[10]. This not only represents over half of the US Census Bureau's estimated 2009 Texas population of 24.8 million residents[11], but also a very significant portion of the State's economic activity. According to the TWDB[12] the cost of failing to implement the regional plan in 2060 in Region C could cost the area $158 billion in lost sales, income, and taxes. In Region H the cost would be $42.7 billion[13].

Industry

According to the Region C Water Plan, the leading industries in the cities in the northern part of the watershed include service, trade, and manufacturing, as well as government. The estimated year 2006 payroll totaled $115 billion with 2.6 million people employed. According to the Region H Water Plan, the southern part of the Trinity-San Jacinto Basin is more industrial in nature. Two thirds of all U.S. petrochemical production and almost a third of the nation's petroleum industries are located in Region H. The Port of Houston is the sixth busiest port in the world. The service, manufacturing, medical, and transportation are also important economic sectors in the southern area of the basin.

Steam Electric Needs

Sufficient water must continue to be available for production of electricity. The need for electricity

[7]Texas Administrative Code §357.5(e)(1)
[8]Texas Water Code Ann §16.053(c)
[9]Region C Preliminary Implementation Plan. April, 2010.
[10]Region H Preliminary Implementation Plan. March, 2010.
[11]US Census Bureau. www.census.gov
[12]Norvell, Stuart and Kluge, Kevin. Socioeconomic Impacts of Unmet Water Needs in the Region C Water Planning Area. Texas Water Development Board, April 2005.
[13]Norvell, Stuart and Kluge, Kevin. Socioeconomic Impacts of Unmet Water Needs in the Region H Water Planning Area. Texas Water Development Board, May 2005.

exists throughout the Trinity and San Jacinto River basins as well as the Galveston Bay area. Currently, steam-electric water use is 3.8% of Region H's water demand and is expected to increase to 6.2% in 2060. Steam-electric demand is currently 2.3% in Region C and is expected to increase to 3.9% in 2060. Current technology requires cooling water as part of electricity production. It is anticipated that water for electrical uses would most likely be from industrial water rights or water supply contracts with water authorities and/or municipalities.

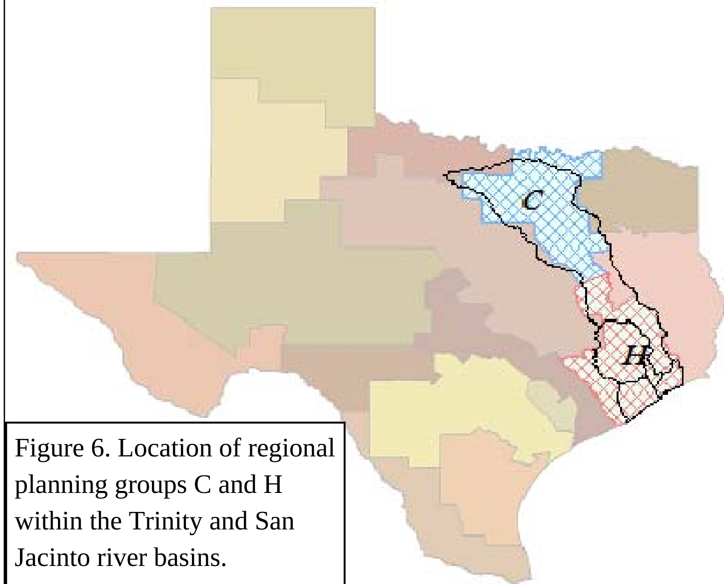

Figure 6. Location of regional planning groups C and H within the Trinity and San Jacinto river basins.

2. Potential for Impacts from Environmental Flow Standards

The sixteen regional groups have met extensively over the previous thirteen years at considerable cost in both resources and time. The interjection of environmental flow regimes based upon desktop-statistical models such as HEFR (upon which the Trinity/San Jacinto "Regime Recommendation" is based), could undermine the fundamental assumptions upon which this planning has occurred by imposing an environmental water demand based upon existing/historical flows. HEFR was also employed by the Sabine/Neches BBEST in a manner very similar to that employed in the Trinity and San Jacinto basins. Because many of the water management strategies in the statewide water plan depend upon importing water from other basins, and because regions are often interdependent in an upstream-downstream relationship, the extent of the impacts from HEFR-based environmental standards and set asides will be felt statewide in cascade fashion. This may increase water shortages in those basins where additional supplies are most needed. Any attempt to assess the impacts of an environmental flow regime on regional planning must recognize that some water management strategies may not be developed as a result. For instance, the Region H water planning group has determined that full implementation of the (upstream) Region C Water Plan will actually ***increase***, not decrease, the amount of water available to the Region H planning area[14]. However if Region C is unable to implement their water management strategies, less water will be available to both regions, increasing pressures on existing supplies that could be impacted by environmental flow requirements.

3. Projected Regional Needs

The 2011 Preliminary Implementation Plans for Regions C[15] and H[16] respectively, predict a combined shortage of over 2.7 million acre feet per year (Tables 4 and 5).

[14]Region H Planning Group Environmental Flows Study. June, 2009.
[15]Region C Preliminary Implementation Plan. 2010.
[16]Region H Preliminary Implementation Plan. 2010.

Table 4: Region C Projected 2060 Water Supplies and Demands

Expected 2060 Demand:	3,273,461 acft
Expected 2060 Supply:	1,774,509 acft
Total 2060 Shortage:	1,497,952 acft

Table 5: Region H Projected 2060 Water Supplies and Demands

Expected 2060 Demand:	3,525,117 acft
Expected 2060 Supply*:	3,415,361 acft
Total 2060 Shortage:	1,236,532 acft

**Some suppliers will have surpluses that are not allocated to entities with projected shortages.*

4. Water Management Strategies

In order to meet these projected shortages, the regions have selected, through a rigorous process, various strategies. These water management strategies are designed to be developed over time as populations grow and needs increase. Due to a variety of reasons, the timeframe for implementing many of these strategies has become decadal. It is therefore imperative that the process of evaluating these strategies continue with a reasonable expectation that the underlying assumptions will not change so that they can be developed prior to points in time when demand will exceed supplies. Table 6 lists the major water management strategies for Region C, and Table 7 shows the same for Region H. Note the importance of interbasin transfers, new reservoirs and reuse for both of these regions.

Interbasin transfers result in a net increase in flows to the importing basin; however this may also result in a net loss from the basin of origin. Accordingly, new interbasin transfers can only occur from basins with adequate water supplies and/or existing interbasin transfer permits. According to Table 6, the Region C plan calls for importing 400,000 acre-ft per year from Toledo Bend Reservoir. In addition, the Region H plan calls for importing 200,000 acre-ft from Toledo Bend as an alternate strategy to Millican Reservoir. Although the yield of Toledo Bend represents an existing supply with senior water rights, there currently exists no permit to import that water into the Trinity or San Jacinto basins. Permit requests for new interbasin transfers after the passage of Senate Bill 3 will be subject to environmental flow standards in the basin of origin[17]. **According to the recommendation from the Sabine/Neches BBASC, if the BBEST recommended flow regime for those basins is implemented, the yield of Toledo Bend could be reduced by as much as 70%[18]. At best, this would reduce the amount of water available for import into regions C and H. At worst it would render the prospect unviable.** The Region H plan also calls for significant imports from both the Trinity and Brazos river basins. As a specific example regarding the Trinity, **the Region H Initially Prepared Plan calls for 200,000 acre feet of water per year to be exported from TRA's portion of Lake Livingston. A preliminary study, completed since the last Stakeholder meeting, suggests that this amount could be reduced by up to 20%**

[17]Hess, Myron and Mary, Kelly. Memo: National Environmental Flow Standards and Interbasin Transfers
[18]AECOM, 2010. Summary of the Evaluation of Environmental Flow Recommendations in the Sabine River Basin

Table 6. Major Water Supply Strategies for Region C

Strategy	Sponsor	Supply (Acre-ft)	Type
Toledo Bend Reservoir	NTMWD TRWD	200,000 200,000	Inter-basin Transfer
Marvin Nichols Reservoir	NTMWD TRWD UTRWD	174,840 280,000 35,000	New Reservoir
TRWD Integrated Pipeline *	TRWD	179,000	Existing Supply
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	New Reservoir
Oklahoma Water	NTMWD TRWD Irving UTRWD	50,000 50,000 25,000 15,000	Inter-state Transfer
Lake Palestine	DWU	107,347	Inter Basin Transfer
New Lake Texoma	NTMWD	113,000	Inter Basin Transfer
Wright Patman Lake- Raise Flood Pool	DWU	112,100	Unpermitted IBT
TRWD Wetlands	TRWD	105,500	Reuse
Tawakoni Pipeline	DWU	69,128	Inter Basin Transfer
Lake Ralph Hall and Reuse	UTRWD	52,437	New Reservoir
Main Stem Trinity River Pump Station	DWU and NTMWD	41,029	Reuse
	TOTAL	**1,753,381**	

*Major Water Management Strategies are those that provide greater than 60,000 acre-ft of water per year OR involve the construction of a reservoir. *Existing supply not included in total.*

(40,000 acre feet per year) in order to meet BBEST "Regime Recommendation" instream flow requirements,[19] perhaps reducing the viability of moving this water within Region H where the needs are.

Another important water management strategy that could be affected by environmental flows is new reservoir construction. As seen in Tables 6 and 7, reservoir construction is an important component of the regional water plans, accounting for a proposed, additional 665,277 and 260,144 acre feet of water for Regions C and H, respectively by 2060. Historically, Region C Water Planning has relied upon surface water supplies. The Region H area is in the process of converting from

[19] Espey Consultants, In. Technical Memorandum: Analysis of Potential Impacts from Implementation of Trinity-San Jacinto BBEST Environmental Flow Regime Recommendations

Table 7. Major Water Supply Strategies for Region H

Strategy	Sponsor	Supply (Ac-ft/yr)*	Type
Allens Creek Reservoir	BRA/Houston	99,650	New Reservoir/Interbasin Transfer
GCWA Off-Channel Reservoir	GCWA	39,500	New Reservoir/Interbasin
Millican Reservoir	BRA	120,994	New Reservoir/Interbasin Transfer
Expanded Use of Groundwater		91,400	Groundwater
Luce Bayou Transfer	Houston	450,000	Inter Basin Transfer
TRA to Houston	TRA/Houston	123,524	Inter Basin Transfer
TRA to SJRA	TRA/SJRA	76,476	Inter Basin Transfer
Houston Indirect Wastewater Reuse	Houston	128,801	Reuse
NHCRWA Indirect Wastewater Reuse	NHCRWA	16,300	Reuse
Wastewater Reclamation for Industry	Houston, Manufactur-	67,200	Reuse
Wastewater Reclamation of Municipal Irrigation	Local Authorities	36,388	Reuse
Brazoria Interruptible Supplies for Irri-gation	GCWA	104,977	Inter Basin Transfer
BRA System Permit	BRA	25,350	Inter Basin Transfer

**Represents the maximum amount to be provided between 2010 and 2060.*

groundwater supplies to surface water. However new reservoir construction has become increasingly challenging. Future reservoirs would be subject to environmental flow standards and set asides. **Using statistically-based models that base environmental flow regimes on current or historical flow patterns could render reservoir projects infeasible.** A preliminary study, completed since the last Stakeholder meeting, has been conducted to evaluate the potential impacts of HEFR-based "Regime-style" instream flow requirements on the proposed Marvin Nichols Reservoir. The impact on the firm yield of that as-of-yet unpermitted reservoir was estimated to be up to 23%[20]. It is unknown if it would be possible to obtain the necessary permits to construct the reservoir in light of a flow standard and or set aside based upon historical hydrologic conditions (i.e. modeled after the "Regime Recommendation" approach).

The third major source of new supplies envisioned by the regional water plans is reuse. Although direct reuse would not be affected, indirect reuse strategies require bed and banks permits that would call for return flows to be discharged into a receiving body of water and withdrawn some distance downstream. It is uncertain as to whether such a permit could be issued in the presence of

[20] Espey Consultants, In. Technical Memorandum: Analysis of Potential Impacts from Implementation of Trinity-San Jacinto BBEST Environmental Flow Regime Recommendations

a flow standard that requires more instream flows than occur under current conditions. Detailed in the section of this report entitled *shortage analysis*, the application of the HEFR-based "Regime Recommendation" criteria would create an existing water shortage for the Trinity River. According to the Region C 2011 IPP, reuse, including existing reuse supplies, will provide an estimated 623,000 acre feet of water per year to the region by 2060. Only 146,000 acre feet in reuse water management strategies are listed in Table 5 because few of the proposed reuse projects reach the 60,000 acre feet per year criterion required to be called a major water supply strategy. Nevertheless, the sum of the reuse projects add up to a considerable contribution towards meeting the projected regional water shortages.

Shortage Analysis

Although Senate Bill 3 excludes existing, permitted water rights, certain amendments could subject them to environmental flow standards[17]. Depending upon the environmental flow standard and/or set-aside, this could make it difficult for water suppliers to react to changes in needs and operating realities because of concerns that amending their permits may subject the existing permit to environmental flow standards. It is therefore important to understand the frequency and magnitude of potential flow shortages involved.

The regional planning process has identified, under expected future conditions, where shortages are likely to exist during a drought of record. The drought of record is used in water planning in order to assure that sufficient supplies will exist under realistic, worst case scenarios. This is necessary because these are precisely the times in which demands are greatest and supplies are under the most pressure, thus representing a critical period. If supplies are sufficient to meet demand under critical conditions, water shortages will only occur under rare circumstances.

As mentioned previously, the BBEST "Regime Recommendation" would significantly alter the assumptions under which regional planning has occurred. It is therefore instructive to evaluate the impact that the "Regime Recommendation" methodology might have on the identified regional plans. A shortage analysis was conducted by Espey Consultants, Inc and presented to the Stakeholders Committee on April 15, 2010. This analysis consists of comparing historical flows (1940-1996) to the dry and average criteria of the BBEST "Regime Recommendations" for each of the Trinity River gages. The Texas Commission on Environmental Quality's Water Availability Model (WAM) Runs 8 and 3 were used as the models to make the comparisons. The WAM Run 8 uses current demand conditions. It assumes existing water rights are being utilized through an approximation of current demand rates (maximum over a recent ten year period) and return flows discharged according to recent (minimum over a recent five year period) patterns. The WAM Run 3 is a full utilization model that assumes all water rights are being fully diverted and that return flows are being fully reused. TCEQ utilizes this model in its evaluation of new water permit applications and amendments.

The "Regime Recommendations" are then iteratively inserted into the WAM models as new instream flow criteria, making it possible to assess not only the frequency of achieving such criteria,

Table 8. Frequency of Attainment of BBEST "Regime Recommendation" Flows Under Present Conditions

	LOCATION	WINTER	SPRING	SUMMER	FALL	OVERALL
DRY	Trinity River at Grand Prairie	61%	70%	100%	100%	***52%***
	East Fork Trinity at Carrollton	11%	39%	5%	18%	***0%***
	Trinity River at Dallas	55%	58%	100%	100%	***41%***
	Trinity River at Rosser	48%	65%	100%	98%	***38%***
	Trinity River at Oak-wood	46%	65%	96%	77%	***29%***
	Trinity River at Ro-mayor	54%	67%	100%	49%	***18%***
AVERAGE	Trinity River at Grand Prairie	38%	43%	86%	86%	***23%***
	East Fork Trinity at Carrollton	4%	2%	0%	5%	***0%***
	Trinity River at Dallas	21%	20%	71%	86%	***13%***
	Trinity River at Rosser	13%	18%	84%	84%	***9%***
	Trinity River at Oak-wood	36%	27%	75%	54%	***13%***
	Trinity River at Ro-mayor	41%	34%	73%	32%	***13%***

but also the magnitude of potential shortages. For a more detailed discussion on the technical aspects of this analysis, see Appendix 1. Table 8 lists the frequency, by season, that each of the "Regime Recommendation" criteria are met under current conditions (WAM Run 8). The "Regime Recommendation" criteria, which include recommended frequencies, are not met at a single gage. Specifically, the "Regime Recommendation" gives attainment targets for base and subsistence flows in terms of percent of the time instream flows should meet or exceed those numbers while pulses are listed as separate targets that are to be met with the stated frequency (i.e. once per year, twice per season, etc.). Therefore, each season must contain the cumulative base and subsistence flows in addition to the requisite pulses for that season and flow condition (i.e. dry or average). In addition, the "Regime Recommendation", as written and submitted, specifies that each season must achieve the flow criteria 100% of the time (e.g. once per season, twice per season, etc). **As suggested above, these flows do not occur at a single gage under present demand conditions, modeled over 56 years of hydrologic conditions (1940-1996). Furthermore, an analysis by the Texas Water Development Board at the request of the T-SJ BBASC, has demonstrated that such frequencies have never been achieved historically, even over the periods of time upon which the "Regime Recommendations" were based.** Although some of the gages achieve annual, or overall targets in some years, none of them consistently achieve the BBEST "Regime Recommendation" criteria. Overall, the greatest attainment frequency occurred at the Trinity West Fork Gage where "dry" "Regime Recommendation" criteria have been found to occur under a present day scenario only 52% of the time. That is the only gage that demonstrates a percent achievement of greater than 50%. When evaluating "average" flow criteria, which have higher associated flow targets, the frequency declines even further, with the highest percent achievement at only 23% (Trinity River at Grand Prairie). The Trinity Elm Fork gage at Carrollton never achieves the "Regime Recommendation" criteria. Therefore, according to this analysis, if the BBEST "Regime Recommendation" criteria, as submitted, were to be adopted as a flow standard, ***most gages in the Trinity would experience shortages a majority of the time, even without future demands or drought conditions***. This agrees with analyses performed by the Texas Water Development Board, which compared the frequency of attaining "Regime Recommendation" targets under various scenarios.

1. Quantification of "Regime Recommendation" Shortages

Instream Flows

In order to understand the impact of these shortages, the maximum, monthly shortages were identified from the above analysis (WAM Run 8), as well as for a situation were existing water rights are being fully implemented (WAM Run 3). Monthly shortages have been determined by identifying times where flows in the historical record fail to meet or exceed the BBEST "Regime Recommendation" criteria. Of these, the maximum shortages have been identified and listed in Tables 9 and 10. Stated simply, these values represent the maximum volume by which monthly volumetric "Regime Recommendation" criteria are not met in a given month, thus creating a deficit between what is called for in the "Regime Recommendation" method and what would have been provided under historical hydrologic conditions (Table 9) and with full diversions and no return flows in place (Table 10). As can be seen, the deficits are significant, even under the current conditions model. Referring back to Table 5 gives an indication as to the frequency at which at least some deficit could be expected to occur. Although the values in Tables 9 and 10 represent worst case scenario, they are based on actual, historical hydrologic conditions. Planning to meet water demands under critical conditions is consistent with existing water planning methodologies and helps avoid future water shortages in all but the most extreme situations.

Bays and Estuaries

With respect to bay and estuary inflows, a similar analysis has been conducted for Galveston Bay and the three watersheds that contribute to it; the Trinity, San Jacinto and Coastal basins. Table 11 shows the results of this analysis, which also used output from WAM Run 8, the "current conditions" model, to evaluate how often the flow volumes called for in the "Regime Recommendation" approach might be met. Average shortages have been calculated for those periods of time when inflows do not meet or exceed the "Regime Recommendations." Note that unlike the instream-flow shortage-analysis, these values do not represent maximum shortages, and are therefore not worst case amounts. It should also be noted that a major difference between the BBEST "Regime Recommendation" bay inflow requirements and the instream flow requirements is that bay inflow requirements span multiple years. Targets are defined as needing to occur a specified number of times over a specified number of years; not within a single year or season.

Table 9. Shortage Volumes (ac-ft) of BBEST "Regime Recommendation" Dry and Average Criteria Using Current Demand Conditions (WAM Run 8)

		WINTER			SPRING		SUMMER			FALL	
	LOCATION	Annual Pulse	1/season	2/season	Annual Pulse and 1/season	2/season	Annual Pulse	1/season	2/season	Annual Pulse	1/season
DRY	Trinity River at Grand Prairie		10,322	0	24,233	0		0	0		0
	East Fork Trinity at Carrollton		30,377	7,743	86,639	0		6,977	8,654		6,431
	Trinity River at Dallas		26,397	0	77,718	0		0	0		0
	Trinity River at Rosser		78,560	17,858	114,649	0		0	0		2,593
	Trinity River at Oakwood		216,168	34,649	309,897	78,376		571	10,931		13,555
	Trinity River at Romayor		289,508	156,441	413,237	297,388		0	0		85,868
AVERAGE	Trinity River at Grand Prairie	33,567	13,684	909	57,451	5,711	32,868	1,572	0	30,523	0
	East Fork Trinity at Carrollton	94,929	33,699	11,683	183,655	75,503	94,775	10,718	9,306	94,339	8,580
	Trinity River at Dallas	90,847	33,178	0	166,794	56,451	88,757	2,158	0	84,511	0
	Trinity River at Rosser	134,391	109,810	34,921	249,198	110,586	130,920	8,057	1,713	116,311	7,076
	Trinity River at Oakwood	280,096	245,177	46,310	571,631	265,447	253,450	8,182	18,707	243,479	20,930
	Trinity River at Romayor	417,665	363,473	204,805	884,863	385,228	416,389	10,855	0	373,874	101,495

All values in ac-ft. The Regime Recommendation includes dry, average and wet conditions, however when these conditions exist or apply was not defined by the BBEST. Maximum annual pulse shortages are noted for each season. In comparing WAM outputs in any given year, only two annual pulses were identified, and, if failing to meet the annual pulse criteria, either one or both shortage were recorded. For more information on the methodology used in the shortage analysis, see appendix 1.

Table 10. Shortage Volumes (ac-ft) of BBEST Dry and Average "Regime Recommendation" Criteria Assuming Full Implementation of Existing Water Rights (WAM Run 3)

		WINTER			SPRING		SUMMER			FALL	
	LOCATION	Annual Pulse	1/season	2/season	Annual Pulse and 1/season	2/season	Annual Pulse	1/season	2/season	Annual Pulse	1/season
DRY	Trinity River at Grand Prairie		18,011	12,308	33,384	0		7,134	6,871		5,070
	East Fork Trinity at Carrollton		30,948	10,000	87,428	0		8,821	7,782		7,759
	Trinity River at Dallas		45,936	10,315	98,442	0		20,251	4,832		10,413
	Trinity River at Rosser		109,712	80,191	152,896	0		31,285	47,263		32,099
	Trinity River at Oakwood		253,252	63,206	347,529	156,411		35,820	32,148		50,000
	Trinity River at Romayor		297,948	235,927	415,921	306,482		0	55,291		136,690
AVERAGE	Trinity River at Grand Prairie	41,960	21,702	14,692	76,571	22,363	38,367	9,546	8,585	34,875	5,911
	East Fork Trinity at Carrollton	96,338	34,934	13,941	184,818	78,001	94,776	32,971	12,606	95,840	19,316
	Trinity River at Dallas	111,197	51,733	16,715	204,244	94,718	108,521	22,389	9,517	109,986	12,815
	Trinity River at Rosser	166,873	145,729	96,527	318,480	189,378	139,372	37,254	58,666	156,727	37,083
	Trinity River at Oakwood	317,374	279,566	86,456	618,593	331,618	269,234	43,405	47,960	268,689	57,804
	Trinity River at Romayor	501,215	374,392	247,152	904,305	393,588	418,874	103,869	0	457,949	156,412

All values in ac-ft. The Regime Recommendation includes dry, average and wet conditions, however when these conditions exist or apply was not defined by the BBEST. Maximum annual pulse shortages are noted for each season. In comparing WAM outputs in any given year, only two annual pulses were identified, and, if failing to meet the annual pulse criteria, either one or both shortage were recorded. For more information on the methodology used in the shortage analysis, see appendix 1.

2. Summary of Shortage Analysis

According to both the instream flow and the Galveston Bay inflow shortage analyses, the BBEST "Regime Recommendation" criteria create a water deficit under existing conditions. This contradicts the consensus finding by the BBEST that the Trinity and San Jacinto rivers and Galveston Bay represent sound ecological environments[21].

The significant water shortages created by the "Regime Recommendation" criteria would add to the predicted future deficit of the regional water plans. For example, the maximum shortage at the Trinity Carrolton gage under current conditions was found to be 183,655 acre feet per year with spring average flow criteria. Shortages increase farther downstream. At the Trinity Dallas gage, the maximum deficit under current demand conditions is 166,749 acre feet per year in the spring when evaluating the application of the "average" flow-condition criteria. At the Romayor gage below Livingston, the deficit reaches 884,863 acre feet per year with the same criteria (spring, with average flow condition criteria). When WAM Run 3 is used (maximum permitted diversions with no return flows), the values increase even further (Table 10). Note that these amounts represent only a single monthly failure of one set of criteria within a given season. It is possible, even likely, that under drought conditions, multiple targets would be missed within a season, further increasing the deficit amounts projected. A review of the historical, hydrologic record of the Trinity River indicates that this would have occurred in 1956 at the peak of the drought of record with multiple, maximum deficits occurring within and across several seasons.

Total bay shortages are equally significant (Table 11), reaching average annual shortages ranging from 99,000 to 408,000 acre feet. If the largest deficits from the three watersheds were to occur in the same year (a likely scenario in a severe drought), the shortage reaches almost 900,000 acre feet per year. The greatest magnitudes of average shortages occur in the Trinity and Coastal basins. There is a significant difference in shortage volumes between seasons.

Table 11. Shortage Analysis of BBEST "Regime Recommendation" Criteria for Trinity Bay

		WATERSHED								
		TRINITY			**SAN JACINTO**			**COASTAL**		
		Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Targets	Volume	74,200	205,000	141,000	302,000	257,000	250,000	455,000	196,000	244,000
	Periodicity	1 of 3 months	2 of 3 months	2 of 3 months	1 of 3 months	2 of 3 months	1 of 3 months	1 of 3 months	2 of 3 months	1 of 3 months
	Recommended Annual Frequency	1 in 2 years	1 in 2 years	1 in 3 years	1 in 2 years	1 in 5 years	1 in 2 years	1 in 2 years	1 in 4 years	1 in 4 years
	% Achievement	86%	45%	55%	75%	30%	54%	0%	0%	59%
	Average Shortage	408,000	143,000	99,000	154,000	144,000	143,000	327,000	115,000	141,000

While in some cases meeting either environmental instream requirements or bay inflow requirements would satisfy the other, there may be times when shortages for both occur but at different intervals, and are therefore additive. Further complicating a direct comparison of instream shortages to bay shortages is the fact that bay requirements stretch over multiple years with achievement frequencies varying between the three basins. Regardless, when considered across multiple seasons, the shortages are significant enough to rival the predicted 2060 water deficits of the regional water plans. **Furthermore, the existing deficit could be interpreted to mean that not only is there no unappropriated water remaining in the river for future supplies, but that the "Regime Recommendation" conflicts with existing supplies.** Therefore, any future increased withdrawals (permitted or not) could be argued to be degrading the river ecology. This could greatly complicate the three primary sources of water needed to overcome future shortages; reuse, interbasin transfers (as seen from the basin of origin), and reservoir construction. It could also complicate the full use of existing supplies.

Analysis of "Conditional Recommendation"

A frequency attainment analysis was performed for the "Conditional Recommendation." This analysis also used the WAM Run 8 current conditions model to determine how often the criteria proposed by this methodology would be met over the period of record for the WAM Run 8 model (1940-1996). The results are shown in Table 12. As can be seen, the target flows of the "Conditional Recommendation" are met by historical flows. This approach, therefore, would not create an existing water shortage and is much more in line with the SB 1 process.

Table 12. Frequency Attainment Analysis of Proposed "Conditional Recommendation" for Instream Flow Criteria

	Winter			Spring			Summer			Fall		
Gage	December	January	February	March	April	May	June	July	August	September	October	November
Romayor	96%	98%	100%	98%	98%	100%	100%	100%	100%	100%	100%	100%
Oakwood	100%	98%	100%	100%	98%	100%	100%	100%	100%	98%	100%	100%
Cleveland	93%	96%	98%	98%	98%	95%	96%	86%	79%	86%	82%	93%
Conroe	95%	96%	98%	98%	100%	100%	100%	96%	86%	82%	84%	91%

Summary and Recommendation

The Trinity-San Jacinto Basin and Bay Expert Science Team was unable to reach a consensus and submitted two sets of instream flow and bay inflow recommendations. The "Regime Recommendation" instream flow method uses HEFR to derive an environmental flow regime for 11 gages in the Trinity and San Jacinto basins over four seasons. When totaled, the requirements of the BBEST "Regime Recommendation" methodology comprise over 700 targets. In addition, these requirements are represented as daily, seasonal and annual targets with and without frequency attainment goals, that are themselves dependent upon flow conditions (wet, dry and average) that are never defined in terms of hydrology. The complexity of the "Regime Recommendation" criteria serve to confound any consideration as to how they could be implemented or considered in the permitting process. In addition, although based upon historical hydrology, the TWDB has determined that the "Regime Recommendation" criteria have never occurred. When compared to WAM runs, the "Regime Recommendation" criteria create an existing water deficit under existing conditions. The SAC has stated that it is appropriate to use historical hydrology as the basis for an environmental flow regime if one accepts that existing conditions represent a sound ecological environment. The basis for this, according to SAC[21], is that there currently exists insufficient data to derive a scientifically-based flow-regime, as called for by SB 3, which is predictive in nature. ***This logic, as manifest in the "Regime Recommendation," is self-defeating; it proposes a flow regime that has never occurred but demonstrates an existing water shortage. The weight of that conclusion alone is entirely sufficient to reject the "Regime Recommendation."*** However the reasons for so doing are even more compelling. By comparing the potential impacts of the "Regime Recommendation" on regional planning efforts, there is concern that this regime could undermine the Region C and H plans. By compounding projected water deficits in the State Water Plan, the "Regime Recommendation" method could conflict with the Senate Bill 1 process. Adding gravity to that conclusion is the fact that the SAC recognizes that a different flow regime with less onerous flow requirements may also be protective of the river and bay ecology[22].

As the Stakeholder Committee wrestled with all the information that has been provided by the Science Team and others who have made presentations related to hydrology and biology, the reality of a comment made by a member of the BBEST (when their report was presented) has been substantiated. The comment was that their report represented "***deadline science***." It was all they could do in the time allotted. And as the Stakeholder Committee debated the various flow regimes and sought to understand how these flow targets were determined, the application of the HEFR desktop statistical model came to focus. During debate on May 5, 2010, when it was stated that that the Science Advisory Committee had endorsed the HEFR model and, by extension, the "Regime Recommendation," a clarification was made by a member of SAC pointing out that the components of a flow regime were what they endorsed, ***not the numbers***.

1. Flow Regime Components

Specific subsistence and base flows are included in the "Conditional Recommendation" in order to address the conditions that are most limiting to water supplies and the environment. These are also the key conditions that are the focus of water rights and water law, and they are the conditions in which most available biological and other environmental data have been collected. These are flow levels at which it is most relevant and feasible to establish flows. ***Even these are not precisely tied to ecological functions because that data does not exist in these basins***, but what is proposed is consistent with the goals and requirements of SB3.

With regard to the pulse flows, there are only five major lakes below Dallas. Four of these lakes are on tributaries. Lake Livingston as the only main stem reservoir in the Trinity Basin. Advocates of the "Regime Recommendation" acknowledge that pulse flows should not come from storage in water supply lakes. If this is the case, then the ***only source of pulse flows below Dallas to Galveston Bay is rainfall*** that generates runoff from the streams and tributaries on which there are no lakes. There is no data that can tie specific flows in the San Jacinto and Trinity basins to particular ecological functions, plus the fact that pulses are transient and are determined almost entirely by rainfall. They occur as rainfall occurs and are not prevented by the entire Houston and Dallas/Fort Worth urban development and activity. While the "Conditional Recommendation" recognizes the

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[21] SAC Memo: Review Comments on Trinity/San Jacinto BBEST Reports.

[22] SAC Discussion Paper: Moving from Instream Flow Regime Matrix Development to Environmental Flow Standards. February 12, 2010..

importance of high-flow pulses, it also recognizes the paucity of data and subsequent inability of current science to correlate specific pulse volumes with ecological health. There is opportunity to pursue the development of pulse flow recommendations through adaptive management under SB3 as recommended for several sites in the “Conditional Recommendation”.

Overbank flows have important ecological functions, and flood levels identified by the National Weather Service have been identified. However, as noted and agreed by all participants in the basin science team and stakeholder group, ***overbank flows are not recommended*** as potential flow standards, due to flood damage implications and public safety issues.

The “Conditional Recommendation” is also based upon historical hydrology, although the advocates clearly recognize the lack of correlation between flow and ecological health. Realizing the limitations of available data and science, as well as the inherent uncertainty in comparing flows to biological responses, the complexity of the “Conditional Recommendation” has been minimized. In addition, the targets of the “Conditional Recommendation” are monthly, which comports with WAM outputs and serve to make this regime much more practical. Furthermore, this regime has occurred in the historical record, does not create water deficits under current conditions, and is therefore much less likely to conflict with the regional water planning process.

2. Implementation Strategies

SB3 requires the BBASC to consider strategies to achieve the recommended environmental flows. If the recommended flows are less than the currently unappropriated water, the strategy must focus on reconciling the recommended flows with future human uses. That is a very serious matter, but at least it is not immediate. If the recommended flows are greater than currently unappropriated water, then it presents an immediate conflict with existing water rights and supplies. In such case, a strategy to meet the recommendation must disregard the preservation of existing water rights stated elsewhere in SB3. If the conflict does not involve too much water, some adjustment in operating practices and similar measures may resolve it. However, if the amount of water recommended for environmental flows involves a large amount of water already permitted for water supply, any strategy inevitably involves a loss of existing water rights. That problem exists with the “Regime Recommendation”, which has been shown by several analyses to be unachievable with the hydrology of the San Jacinto and Trinity basins, with or without existing water rights. A strategy to pursue such a recommendation must involve a serious reduction in existing water rights, and may never be possible even then. The technical limitations in the development of the “Regime Recommendations” do not justify such recommendations or consequences.

The “Conditional Recommendation” makes it possible to develop achievable implementation strategies. The recommended subsistence and ‘dry’ base flows and estuary inflows are in the ranges that are most limiting for the environment and water supplies. They have also been most studied, and there is more experience in environmental studies, water supply planning and operations, and in water law, permitting, and regulation. There may be conflicts between the recommendations and existing water rights in some circumstances, but at least there is a base of knowledge and experience to deal with it. The “Conditional Recommendation” enables a focus on refining the recommendations for low flows and estuary inflows and achieving them. Finally, the “Conditional Recommendation” was an attempt to compromise between the two different positions represented by the members of the BBEST.

3. Adaptive Management

SB3 encourages the use of “adaptive management.” Ordinarily, that would mean implementing the recommended environmental flow regime, monitoring the results, and then modifying the regime. That would be possible if flows were under human control, but they are not. In the San Jacinto and Trinity basins, only the true base flows are strongly affected by human activity, specifically return flows from wastewater treatment plants. Higher flows, pulses, and overbank flows are determined by rainfall and runoff. Moreover, the “Regime Recommendation” flows are not fully achieved with or without human modification. Real flows match the regime only part of the time, and the rest of the time they do not. There are so many specific numbers for each site that it will not be possible to monitor them all or to isolate and associate environmental responses with them all.

The “Conditional Recommendation” provides a feasible and effective use of adaptive management. It recommends a limited number of subsistence and base flows and sites that can be feasibly monitored and are at flow levels that are somewhat under water management influence.

In addition to the recommended flows, the “Conditional Recommendation” specifies certain other flow components and sites to be analyzed as part of adaptive management. Necessary data can be collected at those sites and used to recommend additional flow levels in the future. The “Conditional Recommendation” includes clear, practical adaptive management.

Appendix 1

Shortage Analysis Process Explanation

In order to compare Regime criteria to WAM runs, Regime criteria have been converted to monthly criteria. The conversion of daily flow criteria from the HEFR-derived BBEST recommendations to monthly values produced by WAM runs is complex, requiring decisions to be made as to how to move from one time-unit to the other. In this case, flows called for by the Regime methodology have been summed for a given month, based on the season and flow conditions (i.e. dry or average conditions). Wet conditions have not been considered because the only additional requirement for wet flows is a semi-annual overbank flow, which the BBEST recognized would depend upon rainfall and runoff, and would not be artificially “manufactured” through the release of stored water or other water-management strategies.

In this fashion, a matrix of possible flow criteria has been derived for each month, including annual pulses, which must occur twice per year under “average” flow conditions, and seasonal high-flow pulses, which must occur under “average” or “dry” conditions a total of three times (one larger and two smaller) each winter, spring, and summer with fall flows calling for one high-flow pulse only. WAM monthly regulated flow outputs are then paired to the criteria, year by year over the period of record associated with each WAM run (*1940-1996*), starting with the greatest monthly flows and the greatest flow requirements. A required monthly-summed flow volume (i.e. Regime criteria) is derived from a summation of calculated volumes of high-flow pulses (delivered over a specified duration of days), a required percentage of base flow days, and a required percentage of subsistence flow days.

Assume 30 days in month.

Monthly Volumetric Criterion = P+ N(30)(B) – B(X) + R(30)(S) – S(X)

Monthly Volumetric Criterion = P+ N(30)(B) – B(X) + (1-N)(30)S

In this case, B would beDry base flow, and Subsistence is the next lower base flow criteria. If B was the Average Base Flow, then S would be the Dry base flow, not the Subsistence.

P = recommended Pulse Volume

X = recommended days of Pulse Flow duration

B = Magnitude of Base Flow recommendation

N = % recommended days of Base Flow

R = % recommended days of Subsistence Flow

S = Magnitude of Subsistence Flow recommendation

Comparisons start with the highest flow requirements and work down until each of the flow criteria are applied. For each year, both the Regime criterion and the month with which it had been paired are removed from further consideration so that a single monthly volume cannot be used to satisfy multiple criteria. When a flow criterion is not met, it is nevertheless paired with the next-highest monthly flow volume, and the shortage noted. The maximum shortage for each applied criterion is then determined across the POR and listed in Tables 9 and 10. For instance, the two largest monthly flows in a given year are automatically assigned to the two requisite annual high-flow pulses (under average conditions). These months are then removed from consideration for meeting further seasonal pulse requirements. The next highest flow in each season is then used to satisfy the seasonal single high-flow pulse requirement, etc. until all flow criteria have been paired with a monthly flow volumes from the respective WAM model