TECHNICAL MEMORANDUM

Date: April 2, 2010

To: Mr. Danny Vance, Chair
Mr. John Bartos, Vice-Chair
Trinity and San Jacinto Rivers and Galveston Bay Basin and Bay Area Stakeholder Committee

From: Norman D. Johns, PhD., Water Resources Scientist
National Wildlife Federation

Re: Overview of National Wildlife Federation calculation of consolidated inflow criteria for mid-range inflows to Galveston Bay.

Mr. Vance, Mr. Bartos, and Members:

It was a pleasure to present our ideas to you on March 18th for a potential "consolidated" inflow criteria for Galveston Bay. I am providing this memorandum to you to recap the concepts embedded in this approach and to provide you with a few more details.

These potential inflows are based on a compilation of several recommendations forwarded to your group from the Bay and Basin Expert Science Team (BBEST). We recognize that there were differences of opinion among the BBEST regarding what an inflow criteria for Galveston Bay should look like. Our chief aim in this approach is to examine how the inflow criteria forwarded to you can be combined with methodological aspects of the instream flow criteria and reconciled to a reasonable degree. Another chief consideration in our effort is to propose values to address the unspecified monthly values in the approaches forwarded to you from the BBEST.

To this end, we have combined the inflow recommendations developed explicitly for Galveston Bay in Chapter 3 of the BBEST report with a methodological approach of the instream-based criteria presented in Chapter 2, Section 2. As these elements are consolidated, we examine if they are comparable and compatible with the GBFIG / Reg. H recommendations endorsed by many members of the BBEST in the "consolidated comments" section of the BBEST report. The following describes the major steps in developing a consolidated inflow criteria which we believe offers a potential path forward for your stakeholder group.

This memorandum only addresses inflow recommendation for more-or-less normal rainfall periods. As indicated by the Science Advisory Committee in its March 17, 2010 review memorandum, a "comprehensive range of inflow conditions (e.g. higher flows and inflow minimums)" needs to be addressed. Further input on that is coming

Background

As shown in Table 1 and 2 there were two inflow criteria types offered by the BBEST. These are a) the newly-developed "Salinity Zone" approach (Chap. 3) based on satisfying salinity requirements of several key species, and b) an endorsement, in the Consolidated Comments section of the report (Section 5.2.1, page 196), for an "Alternative Recommendation." This alternative recommendation is for the Texas Water Development Board's and Texas Parks and Wildlife Department's previously-derived inflow criteria (e.g. MaxH, MinQ) on an annual basis. These State-derived criteria, which originally had no attainment goals attached, were amended by the Galveston Bay Freshwater Inflow Group (GBFIG) with a set of future attainment goals as illustrated in Table 2. For the sake of conciseness, these latter criteria will be referred to as simply the "State Methodology".

In Table 1, we have arbitrarily placed the numerical values called for by the BBEST in the mid-season location. For instance the specification of 742,000 ac-ft/month of inflow in the Spring from the Trinity basin could occur in any of the three months of that season. Similarly, the summer requirements are called for in any two of three months. Tables 34 through 37 of the BBEST report summarize the seasonal specifications for these criteria.

Key Species Salinity Zone Analysis (Chap. 3)

Seas. / Month		Trinity	San Jacinto	Coastal	Total
Winter	Dec				
	Jan	253,260	131,320	84,420	469,000
	Feb				
Spring	Mar				
	Apr	742,000	302,000	455,000	1,500,000
	May				
Summer	Jun				
	Jul	205,000	257,000	196,000	659,000
	Aug	205,000	257,000	196,000	659,000
Fall	Sep				
	Oct	141,000	250,000	244,000	635,000
	Nov	141,000			
	Total	1,687,260	1,197,320	1,175,420	3,922,000

Table 1 – The Galveston Bay inflow recommendation based on the Salinity-Zone approach of Chapter 3 (units are ac-ft/month).

Table 4
Alternative Recommendation for Freshwater Inflows for the Galveston Bay System

Inflow Scenario	Quantity Needed (acre-feet/year)	Historical Frequency	Target Frequency
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%

Table 2 – Excerpted Table 4 of the "Consolidated Comments, Section 5.2.1" of the BBEST report: the Alternative Recommendation of the State's Methodology results further modified by GBFIG with attainment goals.

Deriving a Consolidated Inflow Approach

In order to facilitate the development of a consolidated inflow approach it is first useful to remember that the State's Methodology is essentially a set of monthly or bi-monthly numbers which sum to the annual totals shown in Table 2. Figure 1 shows the monthly distribution of the various levels of the State Method results.

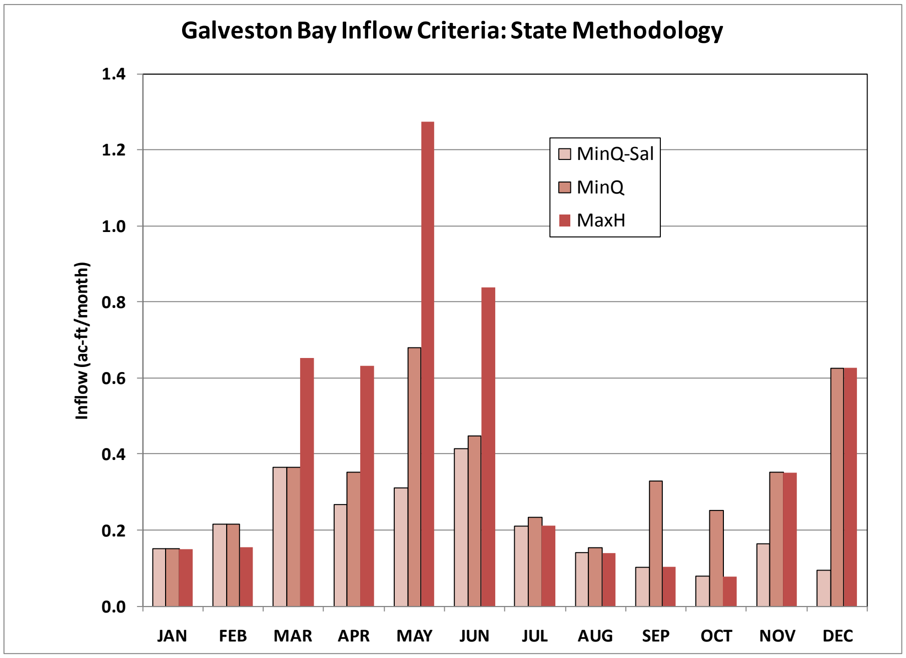


Figure 1 – The monthly distribution of the State's Methodology results.

As illustrated in Figure 2, the results of the Salinity Zone approach can be arranged more deliberately within their respective seasons in order to evaluate the potential alignment with the State Method. In this case we have placed the combined seasonal values of the Salinity Zone approach for each of the three drainages into a single monthly total for illustrative purposes. For example the blue bar of 1.5 million ac-ft/month (MAFM) in May on Figure 2 is the sum of the three individual recommendations of 742,000,302,000 and 455,000 ac-ft/month for the Trinity, San Jacinto, and Coastal drainages, respectively for the Spring season (see Table 1). While this summation is used for comparison purposes here, the BBEST-proposed criteria are actually much more flexible in that they can fall anywhere within a three month window and do not have to be synchronous among the basins (e.g. the Trinity inflow can occur in March while the San Jacinto inflow can occur in May). By the way of comparison though, if summed, the Salinity Zone approach values align well with the State Method's MaxH level of inflow for December, May, June and October and align fairly well in November. The biggest departure is in the summer season in which the Salinity Zone approach recommends two months of 659,000 ac-ft which is reasonably close to the June Max H value, but neither of the Max H values for July or August is close to this.

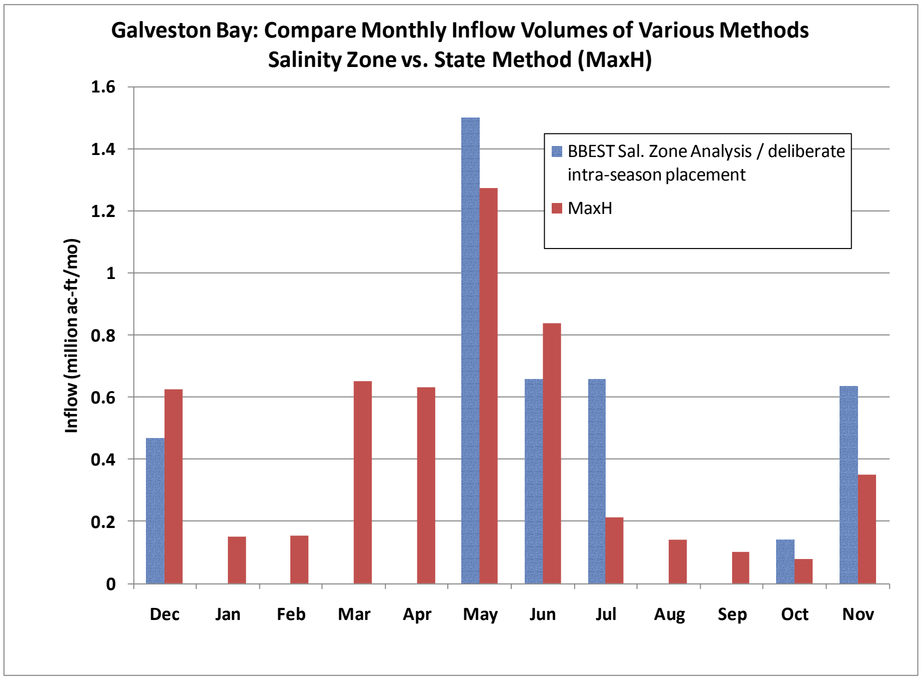


Figure 2 – Comparing the results of the Salinity Zone approach with the monthly distribution of the Max H level of the State Methodology results.

One of the most obvious needs for completing a consolidated criteria is identifying a scientific basis for filling in the "missing months" of the Salinity Zone approach. For this we will turn to another portion of the BBEST efforts to develop environmental flow regimes, namely, the use of the Hydrology-Based Environmental Flow Regime Methodology, or HEFR, consistent with guidance from the Texas Environmental Flows Science Advisory Committee (SAC). (see SAC 2009a). As discussed in the SAC's guidance document on methods for developing as estuarine inflow regime, one option is to use the HEFR program applied at an extreme downstream location for each of the drainages to the estuary (see SAC 2009b, Section 4.3.1). This procedure was tested for the Guadalupe estuary and gave reasonable alignment with the State Method for that estuary (see TPWD & TWDB presentation to SAC on Feb. 4th, 2009). We will use this approach to "fill in" the missing months of the Salinity Zone approach and compare these results to the monthly pattern and yearly totals of the State Method.

The HEFR method can be applied at any point for which there exist a reasonably long record (20+ years) of daily flow or inflow data. One option for the current effort would be to simply utilize the HEFR-derived flow values developed by the BBEST at the most downstream gauge of the various drainages (e.g. Romayor on the Trinity River). Figure 3 shows that the BBEST applied HEFR at many such points (Romayor, East and West Forks of the San Jacinto River, Buffalo Bayou, Spring Creek, Brays Bayou). However, there are a couple of principal shortcomings with using these lowermost gauges. First, is the fact that the gauge locations do not record all of the flow in the basin that goes to Galveston Bay. As a result, there is the potential for a difference in flow characteristics between the most downstream gauging locations and the total inflow to the bay due to the additional drainage area below those points (e.g. the portion of the Trinity River basin below Romayor). For example, Figure 4 illustrates the difference in flows at Romayor compared to the river mouth. In this particular example year of 2003, the pattern is remarkably similar overall, but with some differentiation in flow peaks, especially in the summer and fall due to storms in the lowermost portion of the basin.

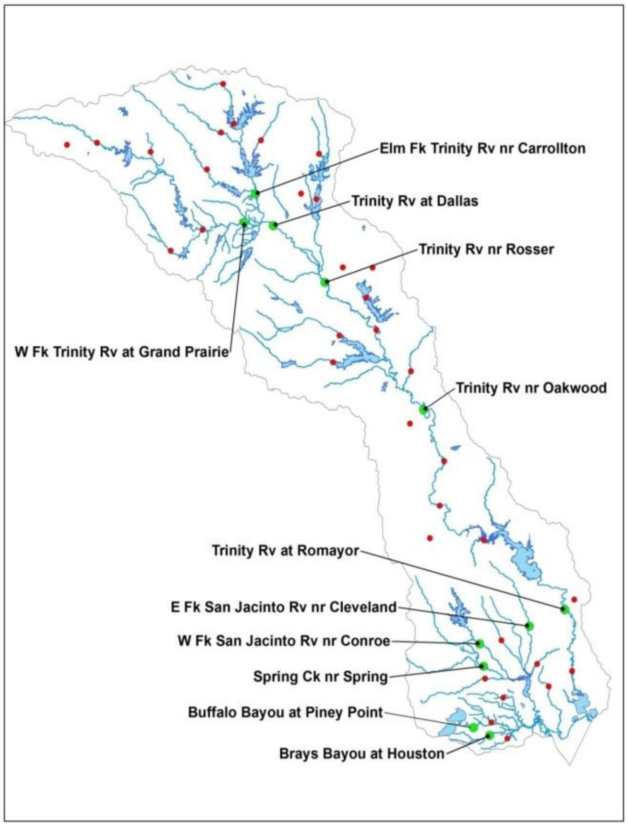


Figure 3 – Excerpted Figure 12 of the BBEST report showing locations at which the HEFR program was applied (green dots).

An additional concern with strictly using the BBEST HEFR results already derived is that there are many contributing coastal drainages that were not explicitly addressed by the BBEST, such as Cedar Bayou, Double Bayou, Oyster Creek, and Clear Creek. In addition, the seasonal alignments differ between the BBEST instream flow recommendations and estuary inflow recommendations. For example, the Spring season is specified as March through June for instream flow recommendations and as March through May for freshwater inflow recommendations. This causes differences in alignments for other seasons. For our calculations here, we used the seasonal alignment proposed for the freshwater inflow recommendations.

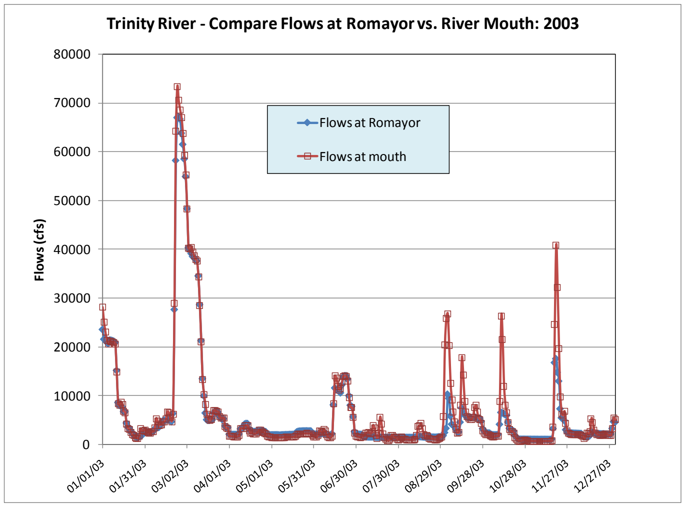


Figure 4 – Comparison of flows at the Trinity River Romayor gauge versus the total Trinity River basin inflows.

Fortunately, the Texas Water Development Board has estimates of daily inflow for all the contributing drainage basins to Galveston Bay dating from 1977 and extending through 2005 at the time of the BBEST work. These data represent "total" inflows in that they include the runoff contributions below the lowermost gauges or from totally ungauged coastal areas as well as corrections for diversions and return flows below the gauges. These are the same inflow data used by the BBEST to develop the salinity patterns that underlie the Salinity Zone approach recommendations of Table 1.

For the current effort we have applied the HEFR program by using the TWDB-derived total inflow values at 3 locations (see Figure 5) representing: a) the total drainage of the Trinity River basin into the estuary; b) the total drainage of the San Jacinto River basin, including Buffalo Bayou and its tributaries; c) most of the remaining coastal basins summed (Cedar Bayou, Double Bayou, Dickinson Bayou, Chocolate Bayou, and Clear Creek). Table 3 illustrates one of the resulting HEFR –derived inflow "matrices", in this case for the whole Trinity River basin. Comparable results for the other drainages are shown in the Additional Tables section at the end of this memo. This approach is analogous to the HEFR-based approach used by some members of the BBEST for instream flow recommendation except that here it is applied to the full watershed.

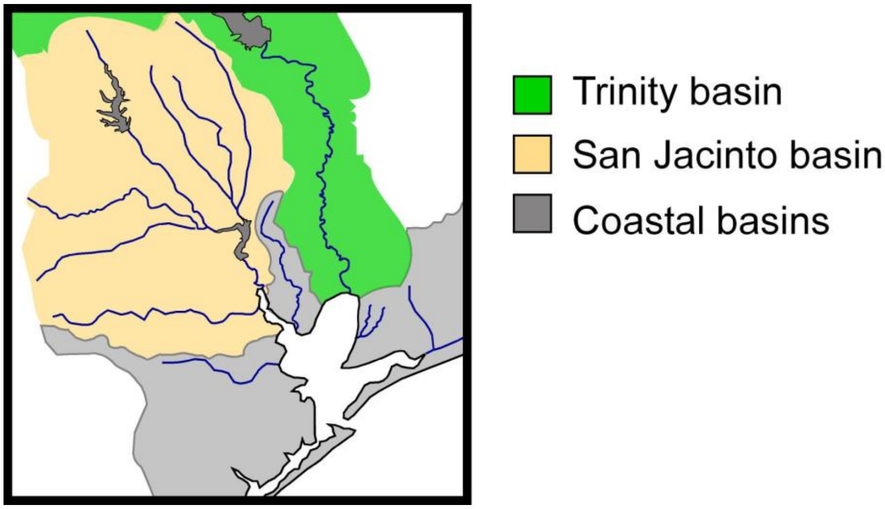


Figure 5 – The HEFR program was applied for the three indicated drainages to Galveston Bay.

		Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sep, Oct, Nov)
Overbank Flows		**Q: 66,150 cfs with Frequency 1 per 2 years Volume is 2,399,592 Duration is 34**			
High Flow Pulses		**Q: 35,290 cfs with Frequency 2 per year Volume is 935,130 Duration is 19**			
		Q: 24,400 cfs with Frequency 1 per season Volume is 564,924 Duration is 14	**Q: 24,810 cfs with Frequency 1 per season Volume is 745,299 Duration is 17**	**Q: 9,593 cfs with Frequency 1 per season Volume is 144,730 Duration is 6**	**Q: 17,940 cfs with Frequency 1 per season Volume is 227,898 Duration is 7**
		Q: 12,660 cfs with Frequency 2 per season Volume is 205,319 Duration is 7	**Q: 9,180 cfs with Frequency 2 per season Volume is 87,869 Duration is 6**	**Q: 3,892 cfs with Frequency 2 per season Volume is 18,794 Duration is 3**	**Q: 6,935 cfs with Frequency 2 per season Volume is 44,533 Duration is 3**
Base Flows (cfs)	**Wet**	**3782(62.9%)**	**3784(67.1%)**	**2351(48.1%)**	**1970(37.6%)**
	Avg.	**2091(73.7%)**	**2077(78.5%)**	**1638(64.0%)**	**1318(49.3%)**
	Dry	**1370(82.5%)**	**1457(87.8%)**	**1166(79.8%)**	**852(61.0%)**
Subsistence Flows (cfs)		**533**	**993**	**661**	**191**

Table 3 – Example of resulting HEFR-derived flow matrix for the total Trinity River basin inflows (Results for San Jacinto and coastal basins in the Additional Tables and Figures section below).

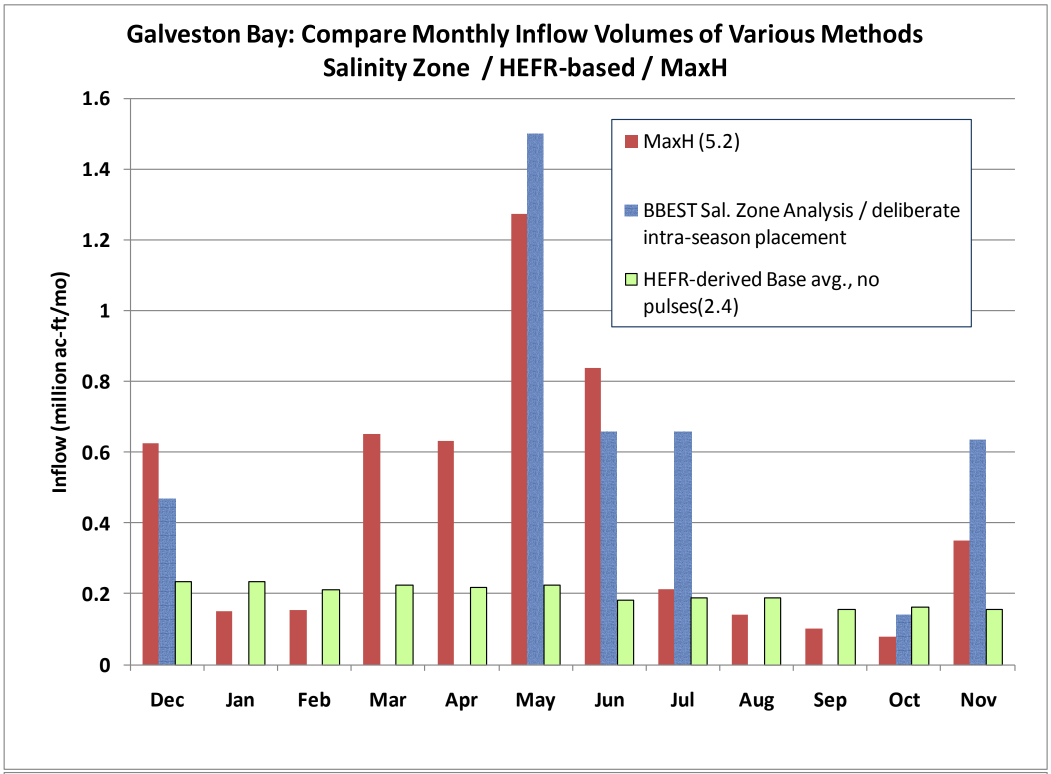
After deriving the HEFR-based tables for each of the three drainage areas of Figure 5, there are clearly many different levels of inflow recommendations (e.g.

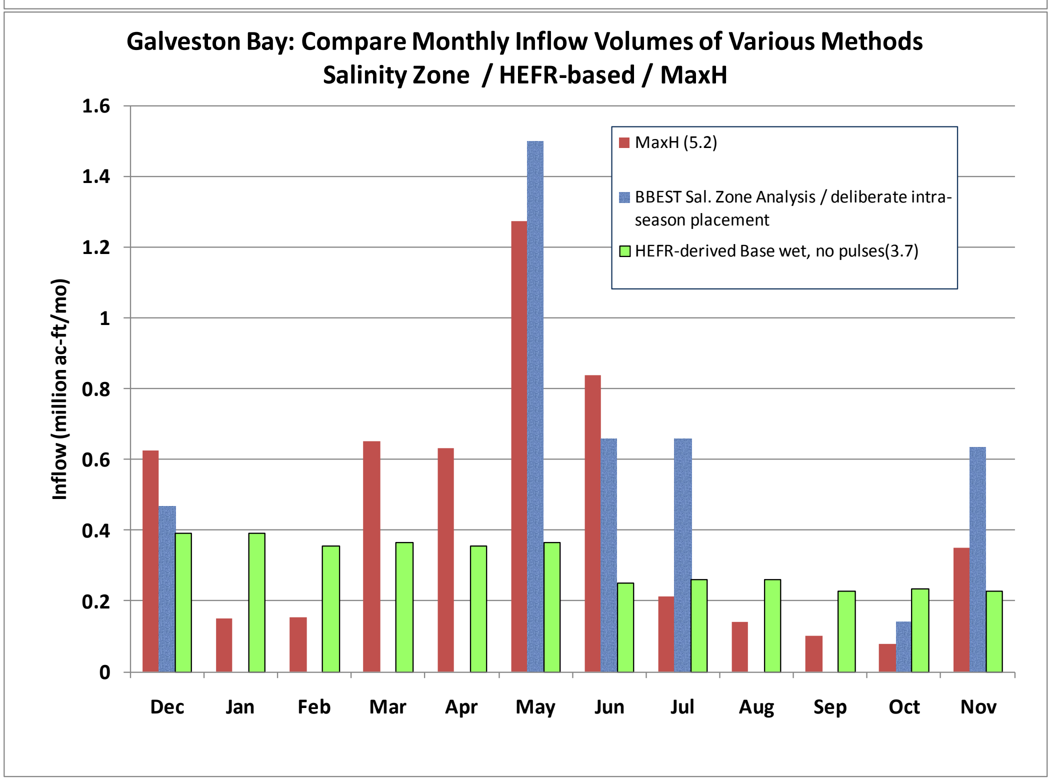
Base Average, 2 per season high-flow pulses) to be considered for complementing the Salinity Zone approach.

Tables 34-37 of the BBEST report indicate that the most of the recommended Salinity Zone approach inflow levels of Table 1 above are also recommended to occur fairly commonly at 1 in 2 years with some being less frequent. According to the BBEST, these recommendations are based on how often these respective seasonal inflows were met or exceeded historically. Thus, we are treating these BBEST inflow values as more-or-less average condition inflows. For filling in the missing months therefore we have chosen the Base Average flows as a starting point. Other components of the HEFR results, namely high-flow pulses will be discussed below.

Figures 6a and 6b illustrate the results of utilizing the HEFR-derived values for the three contributing drainage points (of Tables 3, 7 and 8) summed together. The results shown here are for just base flows with no pulses added in. Figure 6a is for the medium level of base flows, called Base Average and Figure 6b is for the highest level of base flows called Base Wet. While either of these levels of base flows provide reasonable approximations of the MaxH values for some months (e.g. Jan., Feb., Aug. – Oct.), even this highest level of base flow can not approach the inflow values called for either in the State Method or the Salinity Zone approach in the months of May, June, July and Sept. Furthermore, Base Average inflows fall far short of the other methodologies in Nov. and Dec. Inflows reflecting only HEFR-derived base flow values alone would also be a good deal short of reaching the MaxH level for March and April. The conclusion is that HEFR-derived base flows alone are not sufficient to meet key months of either the Salinity Zone approach or State Method recommendations. But, of course, the HEFR-derived flows also include pulses.

As was shown above in Table 3, there are several tiers of high-flow pulses of the historic record which are calculated from the HEFR program, differentiated by their frequency of occurrence in the historical record (e.g. 2 per year, 1 per season, 2 per season). The larger the pulse event, the less frequently it occurred during the historic period and, accordingly, the less frequently it is called for in the resulting recommendations. For the sake of convenience we will simply refer to these high-flow pulses as “High”, “Medium,” and “Low,” corresponding to the 2 per year, 1 per season, 2 per season events of Table 3 and the analogous results for the other drainage areas (results for the other 2 are shown in the Additional Tables section at end of this memo). Figure 7 illustrates the approximate relative size, duration, and peak flow value of the three tiers of high-flow pulses for the Trinity River basin total inflows, from Table 3, with units in ac-ft/day, the more common measure of estuary inflows.





Figures 6a (upper) and 6b (lower) – Comparison of inflow values: MaxH of State Method, the results of the BBEST Salinity Zone approach, and two levels of HEFR-derived base flows for all contributing drainages summed.

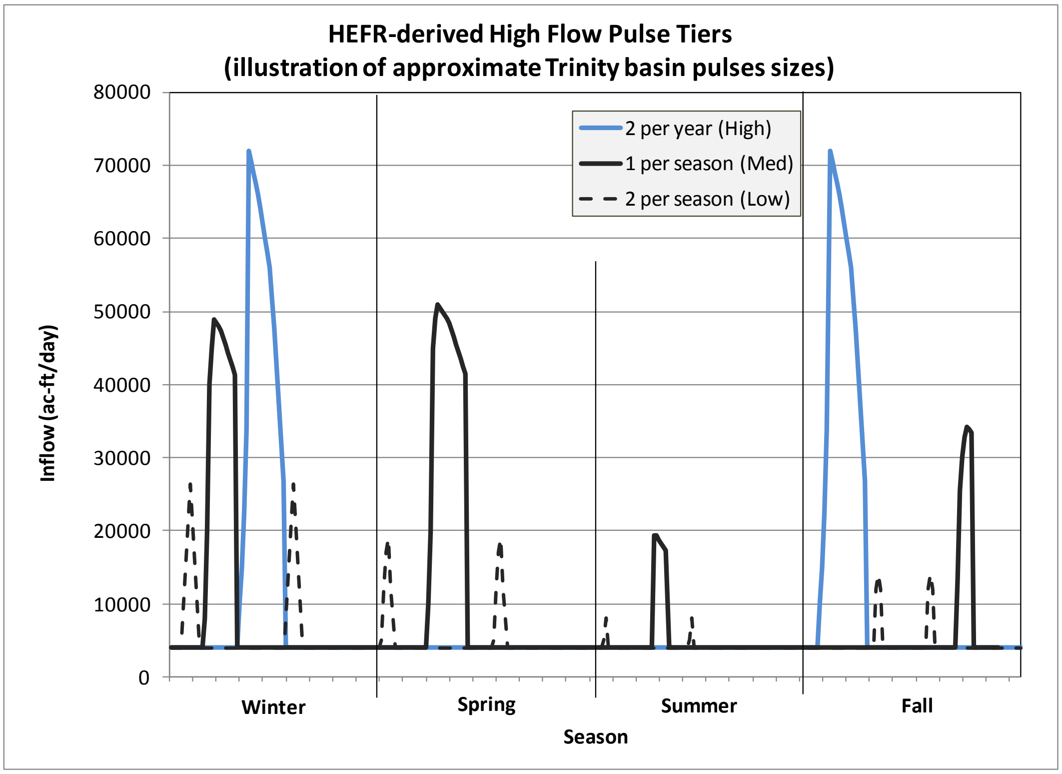


Figure 7 – Comparison of approximate high-flow pulse magnitudes and durations resulting from the HEFR method applied to total Trinity River basin inflows for the 1977-2005 period [as added to the base flow, approximated at 3967 ac-ft/day (2000 cfs)].

Clearly, there are a multitude of combinations of high-flow pulses that are possible. For the current effort we will concentrate on the lower two tiers: "low" (2 per season) and "medium" (1 per season). Figure 8 illustrates the resulting total inflow volumes that result from utilizing the Base Average inflows and both the "medium" and two "low" tier high-flow pulses from all three contributing drainages (whole Trinity basin, whole San Jacinto basin, and the coastal drainages shown on Figure 5). Here we have purposefully placed the "medium" tier high-flow pulse in the monthly position (e.g. May) that provides the greatest alignment with the State Method. This base flow and high-flow pulses combination would represent a total annual inflow volume of 6.5 million ac-ft/year (MAFY) compared to the State Method MaxH level of 5.2 MAFY. This combination of Base Average inflows and high-flow pulses leads to an inflow sequence that would largely satisfy the Salinity Zone approach (except for July) and comes close to satisfying the State Method even in March and April. While this annual volume is a good bit higher than the State Method, the inflow levels in March and April do match fairly well.

Another possible approach would be to utilize the Base Average inflows with just the "medium" (1 per season) tier high-flow pulses. This approach is shown on Figure 9 with a total annual volume of 5.2 MAFY. While there is agreement in total annual volume with the State Method, there are unfortunately a few glaring discrepancies with the results of the Salinity Zone approach. Notably, the placement of the single 1-per season "medium" summer pulse can't satisfy the Salinity Zone approach recommendations for inflows in 2 of the 3 summer months (shown as June and July in the Figure). By contrast the "medium" tier high-flow pulse in the winter season exceeds both the Salinity Zone approach and the State Method values.

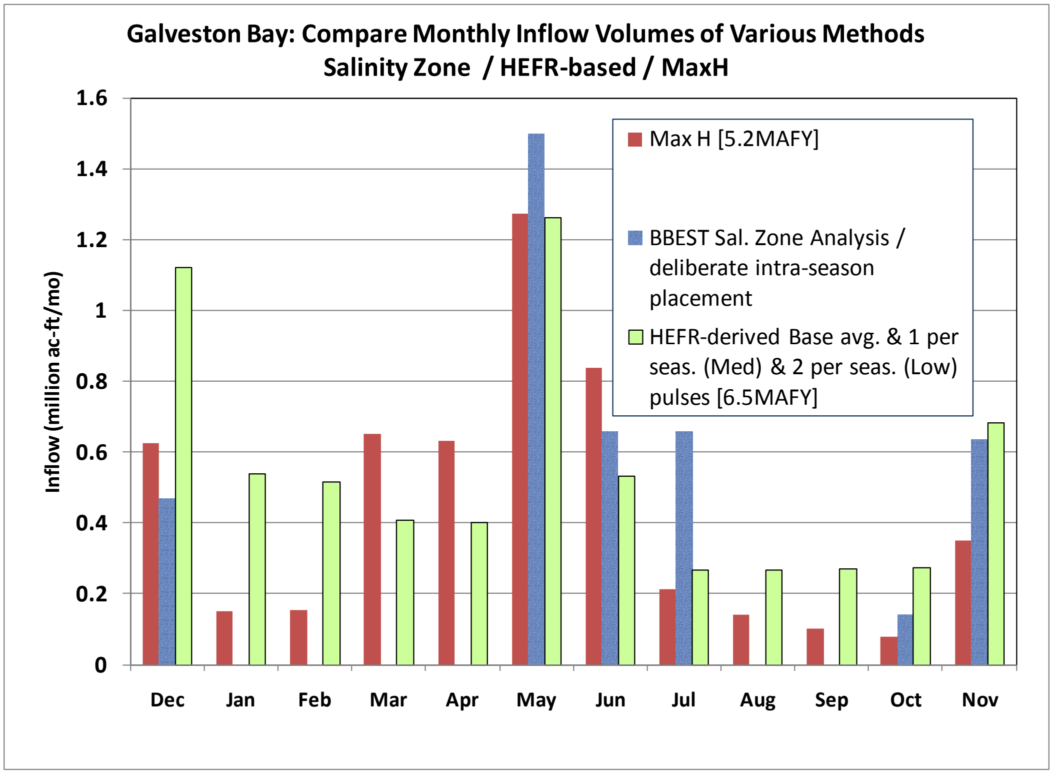


Figure 8 – Comparison of inflow values: MaxH of State Method, the results of the BBEST Salinity Zone approach, and HEFR-derived Base Average inflows with the "medium" (1-per season) and "low" (2-per season) high-flow pulses. The "medium" pulses are purposefully placed in months of high inflow recommendation by other methods.

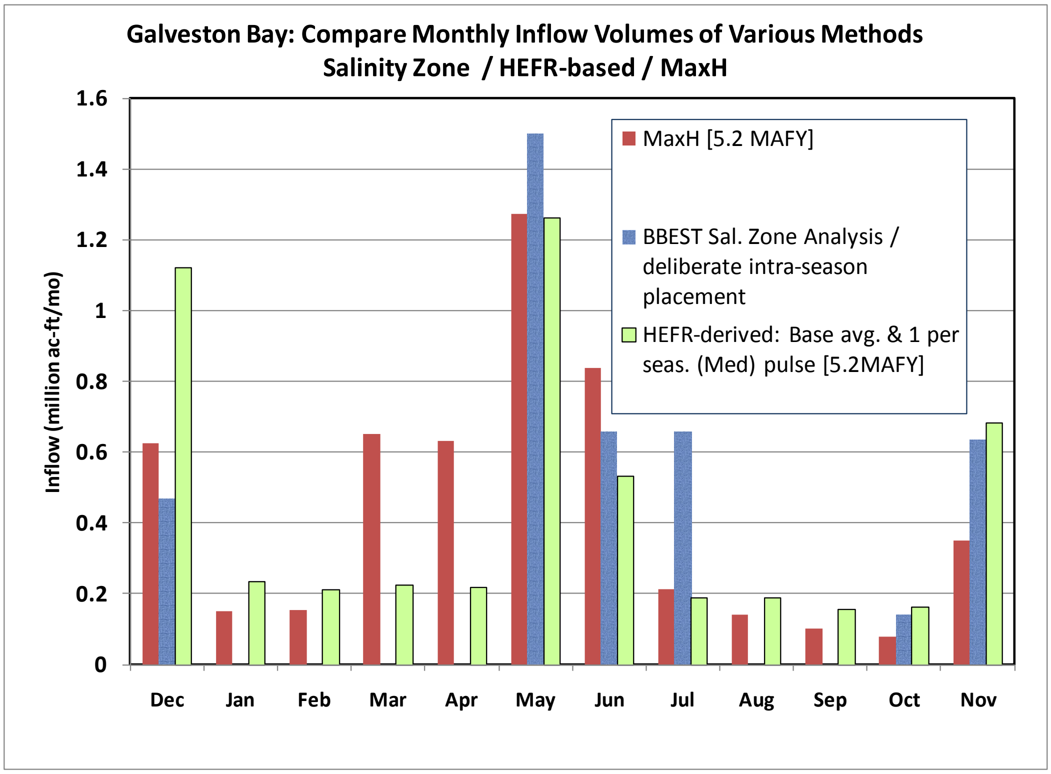


Figure 9 – Comparison of inflow values: MaxH of State Method, the results of the BBEST Salinity Zone approach, and HEFR-derived Base Average inflows with the "medium" (1-per season) high-flow pulses. The "medium" pulses are purposefully placed in months of high inflow recommendation by other methods.

Thus we propose a possible consolidated approach to the inflow criteria for Galveston Bay as illustrated in Figure 10. First, this consolidated approach seeks to abide by the BBEST's Salinity Zone approach recommendations, so we have preserved those recommendations shown in blue bars. In terms of HEFR-derived values, we are essentially assuming that an inflow approximately equaling the "medium" tier (1-per season) high-flow pulse occurs in each season and roughly satisfies the BBEST Salinity Zone approach recommendations. Finally, we fill in the missing months with just Base Average inflow volumes from the three contributing drainages. The month of October is unique in that the BBEST's Salinity Zone approach recommended an inflow (141,000 ac-ft) for just the Trinity basin. In the consolidated approach we have preserved this and added to it just the Base Average inflows for the San Jacinto basin and coastal drainages. This leads to a total annual volume of 5.4 MAFY which is very comparable to the MaxH level of the State Method. For historic context, we can compare this total annual inflow volume to values that have occurred in the 1941-2005 period of record based on TWDB monthly estimates of total inflow volume. In that period of record, 5.4 MAFY is the 20th percentile level, meaning that it was equaled or exceeded in 80% of years in that period of record. Thus, that total annual volume is clearly in the low end of the range that has occurred historically.

Also as illustrated in Figure 10, this inflow sequence may comprise a reasonable approximation of the monthly pattern of Max H inflows if the BBEST recommended Salinity Zone approach inflows (blue bars) were to occur in certain select months. However, it is important to bear in mind that the blue bars of the Salinity Zone approach on Figure 10 are comprised of three individual basin inflows amounts (except for October): those tabulated in Table 1. We have only placed these in coincident positions within a season to examine the comparability to MaxH inflows. The monthly pattern within a season of the BBEST recommended inflows, and therefore the proposed consolidated approach, is much more flexible because the inflows can occur anytime within 3 month seasonal periods. In other words there are many monthly variations on the pattern illustrated in Figure 10 that could comprise an inflow criteria amount of 5.4 million ac-ft/year and satisfy the recommendation of the BBEST Salinity Zone approach.

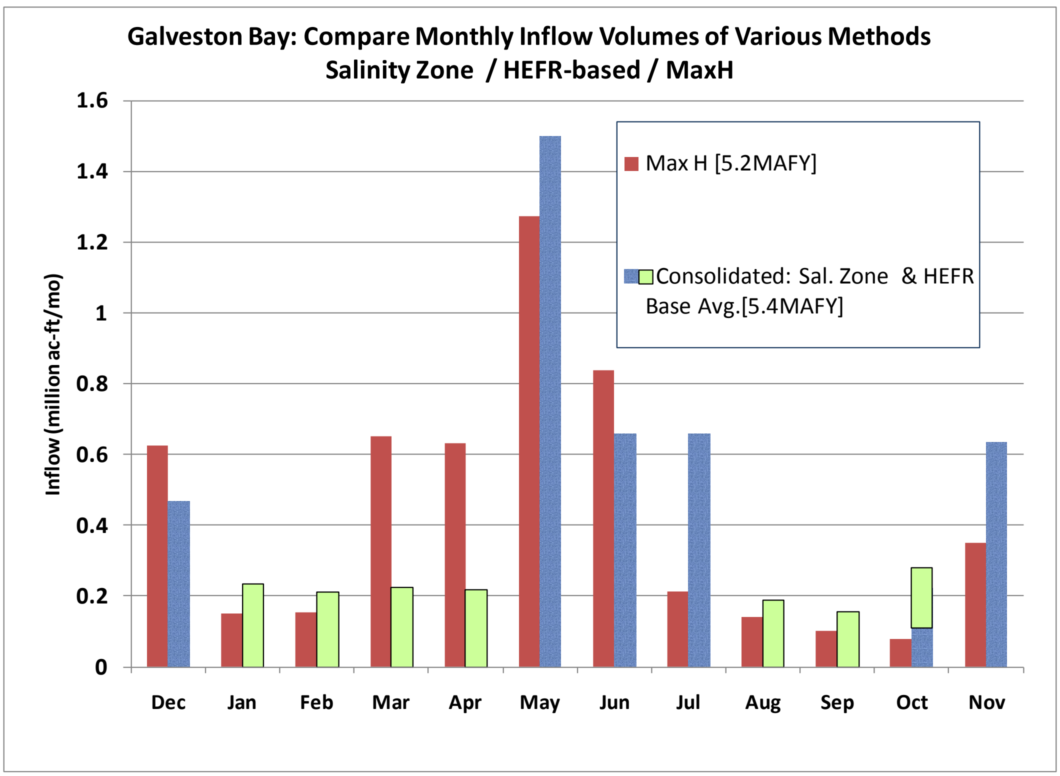


Figure 10 – A proposed Consolidated inflow criteria which fully recognizes the BBEST Salinity Zone approach recommendations and fills in missing months with HEFR-derived Base Average inflows (Oct. value is 141,000 ac-ft. from the Trinity Basin as called for by BBEST in Table 1, San Jacinto and Coastal drainages set to Base Average).

Consolidated Inflows by Major Drainage Basin

While Figure 10 shows that the consolidated approach inflows summed for all three drainages can approximate the MaxH inflows, it is necessary to move to the individual drainage perspective to specify these inflows in a format suitable for stating a potential inflow criteria.

Table 4 presents the results of the consolidated approach for the Trinity River basin as a whole. The Salinity Zone approach recommended inflows are in the top row of values and HEFR-derived "fill in" values below. As indicated, the BBEST inflow amounts and the "fill in" monthly values derived with HEFR can occur in a fairly flexible fashion through a combination of base flows and pulses within the seasonal windows.

Season	Winter			Spring			Summer			Fall		
Month	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Consolidated Inflow Criteria	1 mon. @ 253260* 2 mon. @ 123000**			1 mon. @ 742000* 2 mon. @ 126000**			2 mon. @ 205000* 1 mon. @ 99000**			2 mon. @ 141000* 1 mon. @ 80000**		

note: *these are the BBEST recommended inflows from the Salinity Zone approach; **these inflow amounts for the fill in months are Base Average inflow times the number of days in the month, rounded and averaged.

Table 4 – The proposed inflow criteria of the consolidated approach for the Trinity River basin inflows.

Table 5 presents the results of the consolidated approach for the San Jacinto River basin as a whole. Again, the BBEST inflow amounts and hence the "fill in" monthly values derived with HEFR can occur in a fairly flexible fashion through a combination of base flows and pulses within the seasonal windows.

Season	Winter			Spring			Summer			Fall		
Month	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Consolidated Inflow Criteria	1 mon. @ 131320* 2 mon. @ 87000**			1 mon. @ 302000* 2 mon. @ 82000**			2 mon. @ 257000* 1 mon. @ 70000**			1 mon. @ 250000* 2 mon. @ 67000**		

note: *these are the BBEST recommended inflows from the Salinity Zone approach; ** these inflow amounts for the fill in months are Base Average inflow times the number of days in the month, rounded and averaged.

Table 5 – The proposed inflow criteria of the consolidated approach for the San Jacinto River basin inflows.

Table 6 presents similar results of the consolidated approach for the coastal drainages taken together as a whole. Again, the BBEST inflow amounts and hence the "fill in" monthly values derived with HEFR can occur in a fairly flexible fashion through a combination of base flows and pulses within the seasonal windows.

Season	Winter			Spring			Summer			Fall		
Month	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Consolidated Inflow Criteria	1 mon. @ 84420* 2 mon. @ 13000**			1 mon. @ 455000* 2 mon. @ 14000**			2 mon. @ 196000* 1 mon. @ 15000**			1 mon. @ 244000* 2 mon. @ 13000**		

note: *these are the BBEST recommended inflows from the Salinity Zone approach; ** these inflow amounts for the fill in months are Base Average inflow times the number of days in the month, rounded and averaged.

Table 6 – The proposed inflow criteria of the consolidated approach for the coastal drainages total inflows.

Conclusions

There are several conclusions to be drawn from the above.

1) The BBEST's salinity-zone inflow recommendations can be consolidated with HEFR-based inflows to arrive at inflows comparable in volume to the States' Methodology.

2) It is possible to achieve reasonable seasonal alignment between the State Methodology recommendations and a consolidated approach based on the BBEST's salinity-zone recommendations complemented with HEFR-based inflows.

3) Both base flow & high flow pulse components of the HEFR-based approach are necessary in order to arrive at volumes comparable to either the Salinity Zone approach or the State's Method.

4) The consolidated inflow criteria, set out in Tables 4 - 6, appear to represent a reasonable approach for incorporating the BBEST's salinity zone recommendations in order to establish inflow amounts during more-or-less normal conditions.

Additional Tables

		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Overbank Flows		Q: 56,390 cfs with Frequency 1 per 2 years Volume is 703,364 Duration is 31											
High Flow Pulses		Q: 28,290 cfs with Frequency 2 per year Volume is 379,726 Duration is 18											
High Flow Pulses		Q: 18,530 cfs with Frequency 1 per season Volume is 304,030 Duration is 15			Q: 21,610 cfs with Frequency 1 per season Volume is 275,997 Duration is 14			Q: 9,468 cfs with Frequency 1 per season Volume is 132,102 Duration is 8			Q: 16,930 cfs with Frequency 1 per season Volume is 157,616 Duration is 10		
High Flow Pulses		Q: 7,840 cfs with Frequency 2 per season Volume is 100,666 Duration is 7			Q: 7,811 cfs with Frequency 2 per season Volume is 90,406 Duration is 7			Q: 5,201 cfs with Frequency 2 per season Volume is 52,837 Duration is 5			Q: 6,428 cfs with Frequency 2 per season Volume is 58,010 Duration is 5		
Base Flows (cfs)	Wet	2332(61.1%)			1901(58.7%)			1596(52.5%)			1584(47.4%)		
Base Flows (cfs)	Avg.	1474(73.9%)			1353(71.5%)			1162(66.4%)			1101(58.4%)		
Base Flows (cfs)	Dry	1019(83.5%)			944(82.4%)			910(80.3%)			899(69.5%)		
Subsistence Flows (cfs)		750			775			773			649		
		Winter			Spring			Summer			Fall		

Table 7 – Resulting HEFR-derived flow matrix for the total San Jacinto River basin inflows.

Overbank Flows		Q: 47,300 cfs with Frequency 1 per 2 years Volume is 361,551 Duration is 18			
High Flow Pulses		Q: 27,180 cfs with Frequency 2 per year Volume is 217,190 Duration is 14			
		Q: 16,720 cfs with Frequency 1 per season Volume is 128,234 Duration is 12	Q: 16,410 cfs with Frequency 1 per season Volume is 128,908 Duration is 11	Q: 12,370 cfs with Frequency 1 per season Volume is 119,542 Duration is 12	Q: 23,590 cfs with Frequency 1 per season Volume is 185,572 Duration is 12
		Q: 7,140 cfs with Frequency 2 per season Volume is 52,043 Duration is 8	Q: 6,699 cfs with Frequency 2 per season Volume is 52,342 Duration is 7	Q: 3,722 cfs with Frequency 2 per season Volume is 31,322 Duration is 7	Q: 8,243 cfs with Frequency 2 per season Volume is 63,571 Duration is 8
Base Flows (cfs)	Wet	271(64.5%)	263(54.2%)	290(66.6%)	257(59.7%)
	Avg.	223(74.4%)	225(64.5%)	244(76.0%)	213(69.4%)
	Dry	192(84.4%)	181(74.5%)	197(85.8%)	185(79.3%)
Subsistence Flows (cfs)		152	136	159	140
		Dec Jan Feb	Mar Apr May	Jun Jul Aug	Sep Oct Nov
		Winter	Spring	Summer	Fall

Table 8 – Resulting HEFR-derived flow matrix for the total coastal basin inflows.

References

Trinity and San Jacinto River and Galveston Bay Basin and Bay Expert Science Team (BBEST). 2009. "Environmental flows Recommendations Report." Nov. 30, 2009.

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