Environmental Flows Study

Prepared by

AECOM USA Group, Inc.
Kellogg Brown & Root Services, Inc.
LBG-Guyton Associates
Ekistics Corporation

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Region H Water Planning Group
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for

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Prepared by
AECOM USA Group, Inc.
TBPE Reg. No. F-3082

Jason D. Afinowicz, PE
Project Manager

David L. Parkhill, PE
Vice President

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Acronyms and Abbreviations

B&E	Bay and Estuary
BRA	Brazos River Authority
CFS	Channel Flow Status
COH	City of Houston
CWA	Coastal Water Authority
FTA	frequency of target attainment
GBFIG	Galveston Bay Freshwater Inflows Group
GCWA	Gulf Coast Water Authority
GIS	geographic information systems
IBT	interbasin transfer
LROCR	Little River Off-Channel Reservoir
MGD	millions of gallons per day
NHCRWA	North Harris County Regional Water Authority
RWP	Regional Water Plan
SJRA	San Jacinto River Authority
TCEQ	Texas Commission on Environmental Quality
TRA	Trinity River Authority
TWDB	Texas Water Development Board
USGS	United States Geological Survey
WAM	Water Availability Model
WMS	water management strategy
WRAP	Water Rights Analysis Package
WUG	water user group
WWTP	wastewater treatment plant

Model Descriptions

A	Naturalized Flow
B	Existing Diversions with Full Return Flows
C	Full Authorized Diversions with Full Return Flows
D_0	Future 2060 Conditions with Existing Permits and Full Return Flows
D_3	D_0+ Freeport Seawater Desalination
D_4	D_0+ Expanded Use of Groundwater
D_7	D_0+ BRA System Operations Permit
D_8	D_0+ Allens Creek Reservoir
D_9	D_0+ Little River Off-Channel Reservoir
D_{11}	D_0+ Wastewater Reuse for Industry
D_{12}	D_0+ TRA to Houston Contract
D_{13}	D_0+ TRA to SJRA Contract
D_{14}	D_0+ Houston to GCWA Transfer
D_{15}	D_0+ Houston Indirect Wastewater Reuse
D_{16}	D_0+ NHCRWA Indirect Wastewater Reuse
D_{17}	D_0+ Lake Houston Additional Yield
E	Future 2060 Conditions with Return Flows and All Recommended WMS
F	TCEQ Run 3 (Full Authorized Diversions with No Return Flows)

WRAP Cards

Identifier	Card Type	Function
CI	Constant Inflows and/or Outflows	A set of 12 monthly values of inflow (or outflow) applied at a specified location each year of the simulation
CP	Control Point Information	Establishes system connectivity and identifies methods for obtaining evaporation, precipitation, and drainage area
FY	Firm Yield and Yield Reliability	Activates yield-reliability analysis for a specified water right and generates an output table
RF	Monthly Multipliers for Return Flows	A set of 12 monthly multipliers used to distribute return flows from water right diversions
SV/SA	Storage Volume vs. Storage Area Table	Paired records establishing a storage volume vs. surface area relationship for a specified reservoir
TS	Target Series	Optional card associated with a water right diversion allowing the diversion target to be set through a number of methods
UC	Usage Coefficients	A set of 12 monthly multipliers used to distribute an annual water right diversion for the monthly time step
WR	Water Right	Establishes the location of a diversion with options for diversion amount, return flows, and other functions
WS	Reservoir Storage and/or Hydropower Data	Associates a water right diversion with storage in a specified reservoir as well as additional options

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ES – Executive Summary

The importance of environmental flows to the health of Galveston Bay has been considered by the Region H Water Planning Group throughout the regional water planning process. The Region H Regional Water Planning Group adopted Bay & Estuary (B&E) target flow recommendations developed by the Galveston Bay Freshwater Inflows Group (GBFIG) in both the 2001 and 2006 Region H Regional Water Plans. Most recently in the 2006 Region H Regional Water Plan (RWP) the impacts of implementing water management strategies (WMS) were determined for the year 2060 condition. This analysis demonstrated a decrease in freshwater inflows to Galveston Bay as current levels of water use are increased to full authorized diversion. However, models of the projected future conditions demonstrated that freshwater inflow targets were met at levels approaching or exceeding the recommendations of GBFIG for scenarios which included expected return flows. However, the 2006 study stopped short of identifying resulting impacts to Bay and Estuary (B&E) inflows from individual WMS.

Additionally, no analysis was completed in the 2006 study which examined impacts to environmental flows at specific stream segments. Instream flows were further assessed in a study by the Texas Water Development Board that was included in the 2007 State Water Plan (SWP) with participation by the Region H Planning Group. However, again no analysis was completed during this study which related individual WMS to impacts on environmental flows.

In order to address these issues, the Region H Planning Group authorized a study to evaluate a variety of flow conditions for the year 2060 and examine the impacts of individual WMS. The Water Rights Analysis Package (WRAP) was executed for five baseline conditions which did not include Region H strategies, plus 12 sets of strategy models that were intended to isolate the impacts of individual Region H WMS. Strategy models were developed from a base model representing Full Authorized Diversion conditions with expected return flows and no term permits. Additionally, a study was undertaken to assess methodologies for increasing the frequency at which B&E inflows targets were attained and assess the impacts such an approach would have upon existing and future water supplies.

ES.1 Development of Water Availability Models for Evaluating Management Strategies

Several model conditions were devised and executed for the Neches-Trinity, Trinity, Trinity-San Jacinto, San Jacinto, San Jacinto-Brazos, and Brazos Basins to determine the impacts of WMS on inflows to Galveston Bay as well as instream flows. Each model represented a particular condition that could be compared to other simulations to determine incremental impacts from individual strategies. The resulting flows were compared on a basis of frequency to identify any impacts from future strategies.

The following modeling scenarios were evaluated for this study:

- Scenario A: Naturalized Flow
- Scenario B: Existing Diversions With Full Return Flows
- Scenario C: Full Authorized Diversions With Full Return Flows
- Scenario D: Future 2060 Conditions With Existing Permits and Full Return Flows

- Scenario E: Future 2060 Conditions With Return Flows and All Recommended WMS
- Scenario F: Full Authorized Diversions With No Return Flows

This study selected 17 of the recommended WMS from the 2006 Region H Regional Water Plan as potential candidates for modeling. The WMS selected for study are summarized below. For additional details, see Chapter 4 of the 2006 Region H RWP. Estimated Year 2060 yields for the strategies are shown in *Table ES-1*.

Table ES-1. WMS Supply Volume for Selected Strategies

No.	Strategy	Volume[1] (ac-ft)
1	Municipal Conservation	101,000
2	Irrigation Conservation	77,900
3	Freeport Desalination	28,000
4	Expanded Groundwater	91,000
5	Expand/Increase Contracts	68,300
6	New Contracts	293,400
7	BRA System Operations	163,700
8	Allens Creek Reservoir	97,400
9	Little River Off-Channel Reservoir	32,100
10	Non-Municipal Contractual Transfers	21,000
11	Wastewater Reuse for Industry	67,200
12	Trinity River Authority (TRA) to Houston Contract	150,000
13	TRA to San Jacinto River Authority (SJRA) Contract	50,000
14	Houston to GCWA Contract	56,000
15	Houston Indirect Reuse	52,500
16	North Harris County Regional Water Authority (NHCRWA) Indirect Reuse	31,400
17	Lake Houston Additional Yield	[2]1,000

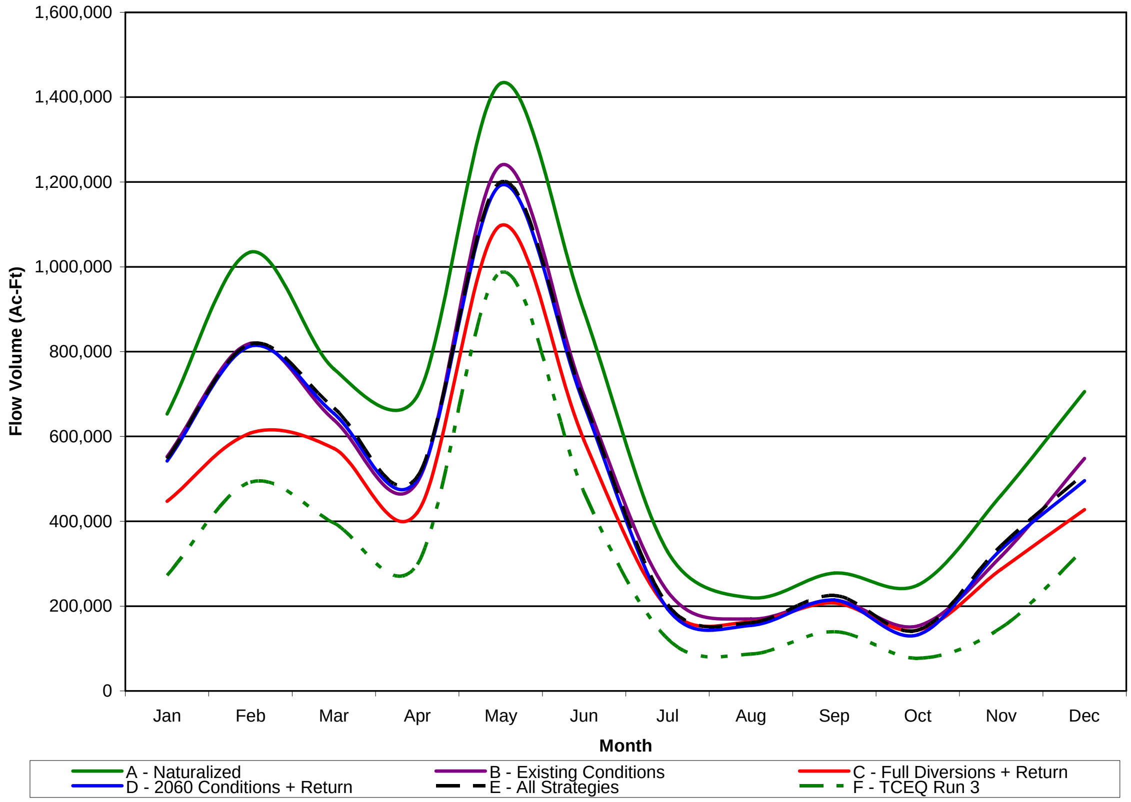
1. Rounded to nearest 100 ac-ft.
2. Modeled at full unallocated volume of 32,500 ac-ft.

ES.2 Impacts to Bay and Estuary Inflows

ES.2.1 B&E Inflow Targets and Attainment Frequency

WRAP strategy model output was used to determine effects of WMS implementation on B&E flows into Galveston Bay for the Year 2060 condition. Monthly median B&E flows were determined for A, B, C, D_0, E, and F. The strategy models (D_X) represent a Full Authorized Diversion scenario with the inclusion of expected return flows and strategies from upstream regions. A comparison of monthly medians is given in *Figure ES-1* below.

Figure ES-1. WRAP Model Median Monthly Bay and Estuary Inflows



As shown in *Figure ES-1*, median flows for the D_0 and E models are lower than the naturalized flows but higher than the TCEQ Run 3 (full diversions with limited return flows) model. This is partially due to the inclusion of expected return flows (see the C model curve) and partially due to the inclusion of WMS. Median flows for the E model were also found to be slightly lower than current conditions for the majority of the year, but exceed current conditions for March, April, September, and November. B&E flows for the E model were also evaluated with reference to B&E inflow targets recommended by the TWDB and Texas Parks and Wildlife Department. There are three sets of targets designed for maintaining fisheries. These are:

- Max H – sequence of monthly inflows for maximum B&E fisheries harvest
- Min Q – sequence of monthly inflows that minimizes the annual volume needed to maintain the B&E fisheries harvest
- Min Q-Sal – sequence of monthly inflows that maintains B&E salinity constraint

Monthly values for all three annual targets for the Galveston Bay system are given in *Table ES-2* below. In general, Max H represents a target condition for ultimate production while Min Q-Sal represents a base condition that must be maintained on a more reliable basis.

Table ES-2. Monthly Galveston Bay Inflow Targets

Month	Max H	Min Q	Min Q-Sal
1	150,500	150,500	150,490
2	155,200	216,700	216,700
3	652,800	363,900	363,900
4	632,500	352,600	267,270
5	1,273,700	679,700	309,970
6	839,700	448,100	413,560
7	211,500	232,700	211,500
8	140,000	154,000	140,000
9	103,000	330,200	102,960
10	78,600	251,900	78,600
11	351,500	351,500	164,390
12	626,800	626,800	93,870
TOTAL	**5,215,800**	**4,158,600**	**2,513,210**

Region H formally adopted GBFIG-proposed frequencies for meeting TWDB flow targets during the 2001 cycle of Regional Water Planning. GBFIG proposed a 50 percent frequency of attainment for Max H, 60 percent for Min Q, and 75 percent for Min Q-Sal (2006 Region H RWP). GBFIG-proposed frequencies were presented to the Region H Planning Group during the 2001 Regional Water Planning cycle and were adopted by the Region H Planning Group for the 2001 RWP. For additional information and documentation, please see the 2001 and 2006 Region H RWPs. However, the GBFIG recommendations do not explicitly address how to measure frequency of attaining these targets, nor do they define a desired frequency for the seasonality (i.e., monthly distribution) of freshwater inflows. For this study, the recommended annual frequency was used as a placeholder for the evaluation of seasonal variations (i.e., monthly distribution). Targets were assumed to be attained for a time period in which the flow met or exceeded the target. The frequency of meeting target flows (frequency of target attainment [FTA]) on an annual basis is given in *Table ES-3*.

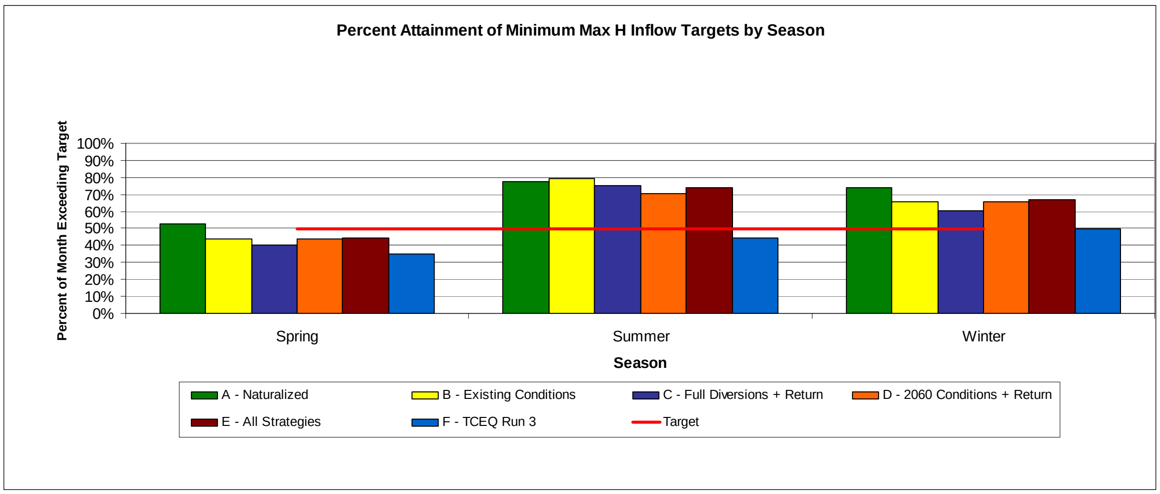
Table ES-3. Frequency of Target Attainment

Scenario	Max H (%)	Min Q (%)	Min Q-Sal (%)
GBFIG Recommendation	50	60	75
A - Naturalized	68	67	83
B – Current Conditions	63	58	79
C – Full Diversion	59	53	75
D – 2060 Conditions	60	56	74
E – All Strategies	62	59	77
F – TCEQ Run 3	43	43	56

As shown in the table, the E model meets the recommended GBFIG annual B&E targets at the desired frequency for both the Max H and Min Q-Sal flow. The frequency of attainment for Min Q for the E model is 59 percent, just one percent less than the recommended 60 percent proposed by GBFIG. FTA can also be viewed from a seasonal and monthly perspective, as shown in

Figures ES-2 and *ES-3* for Max H and Min Q-Sal. On a monthly basis, FTA was assumed to reach its goal for a particular month if the count of that month during the period of record exceeded the frequency goal. For example, if 50 percent or more of the Januarys in the period of record reached the Max H flow target, the desired Max H FTA for January was considered to be met. For the purpose of this study, three seasons were developed based on the observed flow regime. The spring season was assumed to consist of the months from March through June, while summer was represented as July through October, and the winter season represented as November through February. Dividing the months into seasons required careful consideration of flow patterns. As shown in *Figure ES-1*, there is a clear three-season pattern to the median monthly bay and estuary (B&E) flows. To avoid complicating analysis and creating a biased weighting of certain months, the seasons were divided into three periods of equal four-month length. As shown in the figure, there is a very distinct low-flow regime from July through October. Defining the summer season around this low-flow period resulted in November being the beginning of the winter category and March being at the start of spring. Seasonal FTA was calculated as an average of the frequency of attainment for the component months for the season. Similarly, annual FTA was calculated as an average of the FTA values for all 12 months of the year.

Figure ES-2. Seasonal Frequency of Target Attainment



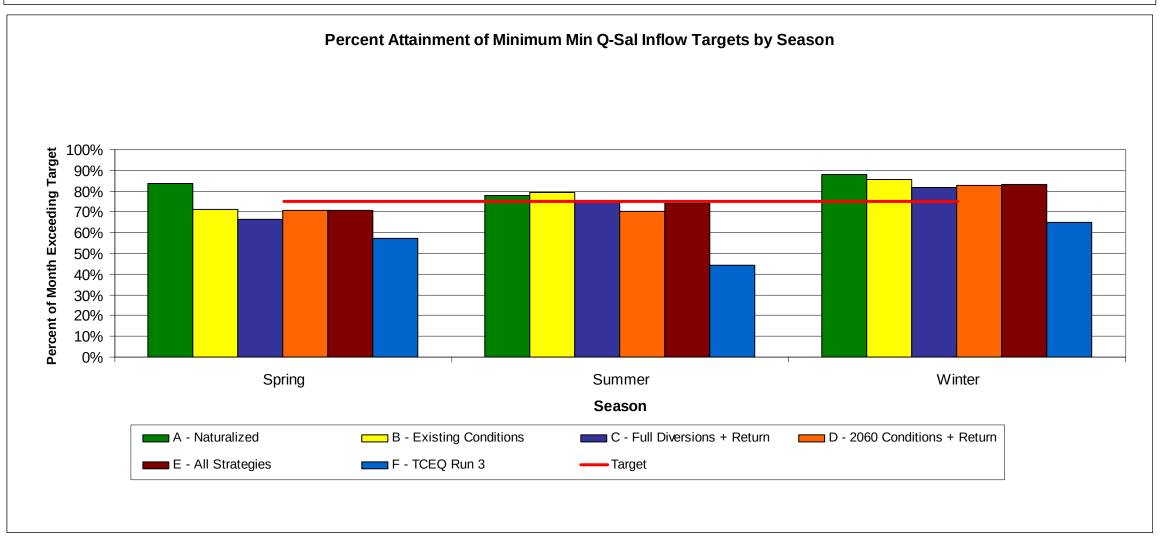
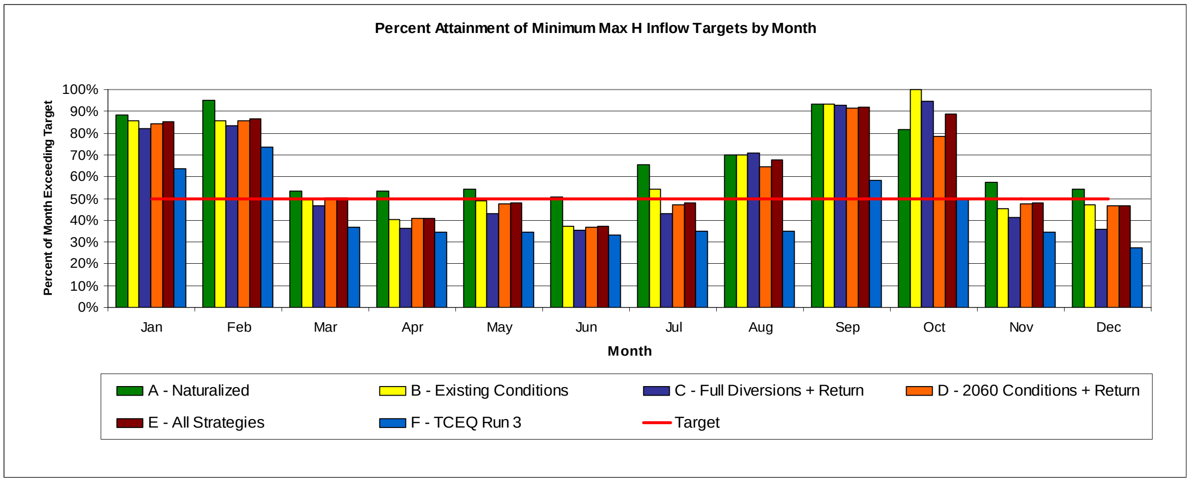
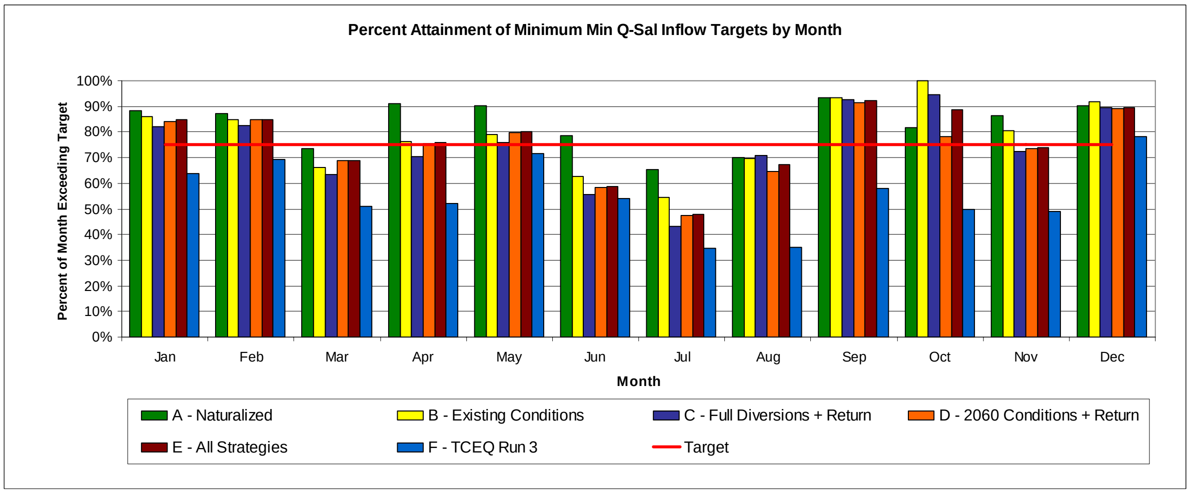


Figure ES-3. Monthly Frequency of Target Attainment



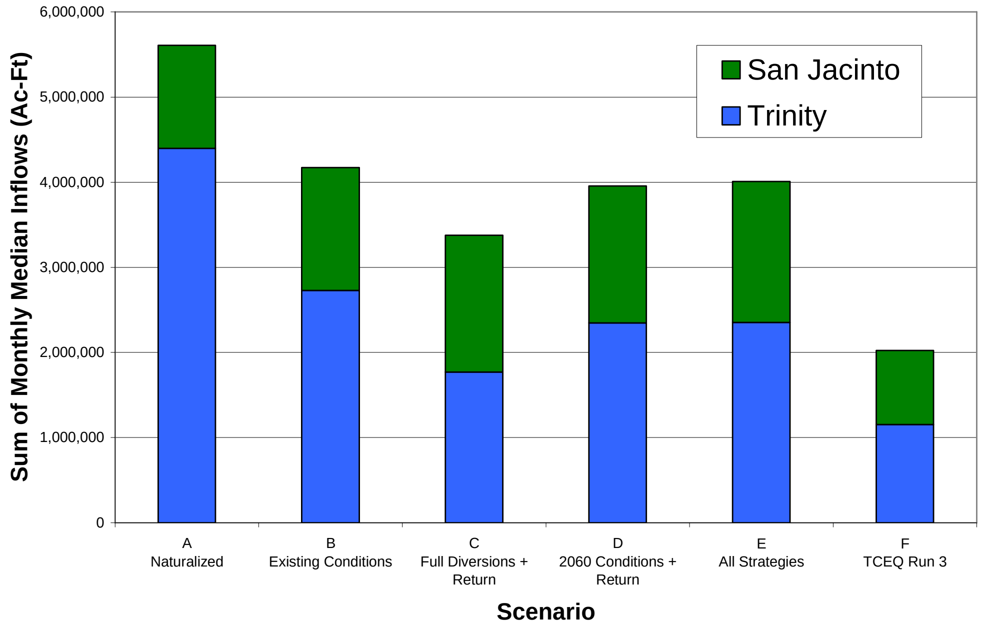


In addition to the E model, all strategies were modeled separately to determine their individual impacts. The impacts of each strategy contributed only minor variation in frequency of B&E target attainment to the base model; the majority of months showed no change, with the few months altered typically varying from the base model by ± 2 percent frequency or less.

ES.2.2 Location of B&E Inflows

Implementation of WMS will impact not only the FTA but also the proportion of inflow supplied by each basin. This is especially important given that several strategies proposed involve IBTs of water in the Trinity and San Jacinto Basins, which are the primary contributors to B&E flow. B&E inflows for the San Jacinto and Trinity Basins for several model runs are shown in *Figure ES-4*.

Figure ES-4. B&E Contributions of the San Jacinto and Trinity Basins



As shown in the figure, for naturalized conditions as well as the current conditions model, B&E inflows are dominated by the Trinity Basin. The proportion of flow provided by the Trinity is lower for the remaining models, including the C model (Full Authorized Diversions + expected return flow). However, the implementation of upstream WMS shown for the D_0 model causes an increase in the relative contributions of the Trinity as compared to the C model. The proportion is slightly lower for the E model, demonstrating that the Region H strategies slightly increase the proportion of water coming from the San Jacinto Basin. This is largely due to the IBT of water into the San Jacinto system.

ES.3 Evaluation of Alternatives for Meeting GBFIG Targets

ES.3.1 Concept and Target Conditions

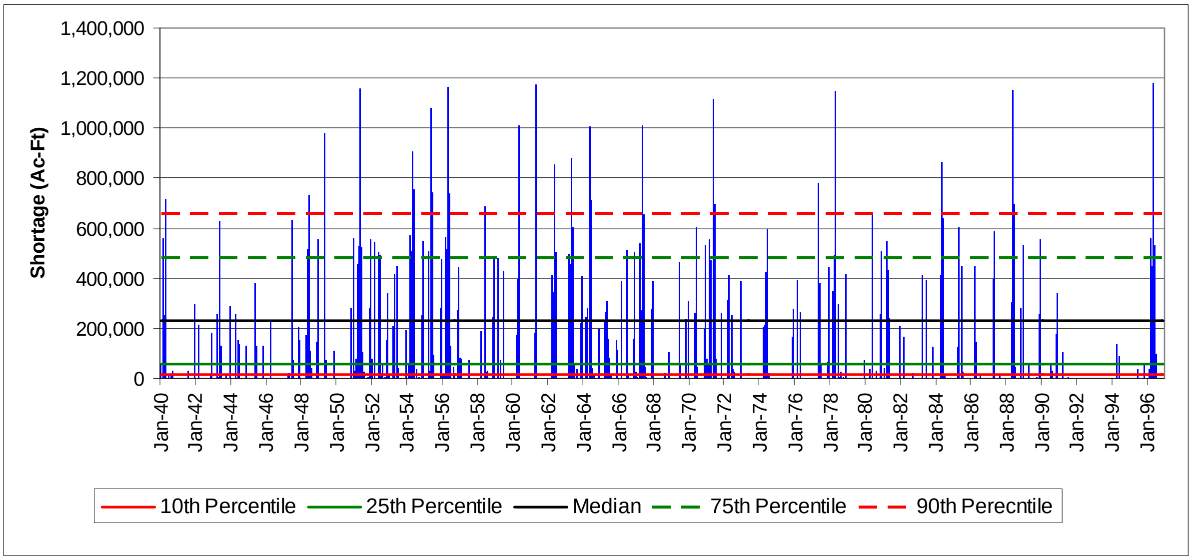
As part of the scope of services for the environmental flows investigation, alternatives were considered to allow the WMS (E) models to meet B&E flow targets at the desired frequency for Year 2060 conditions. The goal of the modeling process was to assess if a methodology could be developed to achieve a desired target B&E inflow frequency while also maintaining current and future water supplies (without reducing firm yields). Modified WMS models were developed for Max H and Min Q-Sal. Models are based on a Year 2060 full diversion scenario with expected return flows and all modeled WMS strategies (E model base).

ES.3.2 Methodology

It was assumed that B&E inflow targets are achieved by any flow that equals or exceeds the target flow. FTA is increased by increasing the number of months meeting the volume target, but not by uniformly increasing volumes. The most efficient way to achieve this is to target the months with the smallest shortages and increase the B&E flows for those months to target levels.

The option for increasing monthly B&E flows that is least likely to interfere directly with the priority system is the discrete release of water from reservoir storage. From a reservoir operations standpoint, this is equivalent to managing releases when shortages for a particular month are less than some specified level. Such an operating scenario in which reservoir releases would be made to address only the smallest B&E target flow shortages would minimize the volume of reservoir releases needed to meet frequency goals and in turn decreases the possibility of reducing the firm yield of existing and future water rights. The range of Max H shortages is shown in *Figure ES-5*.

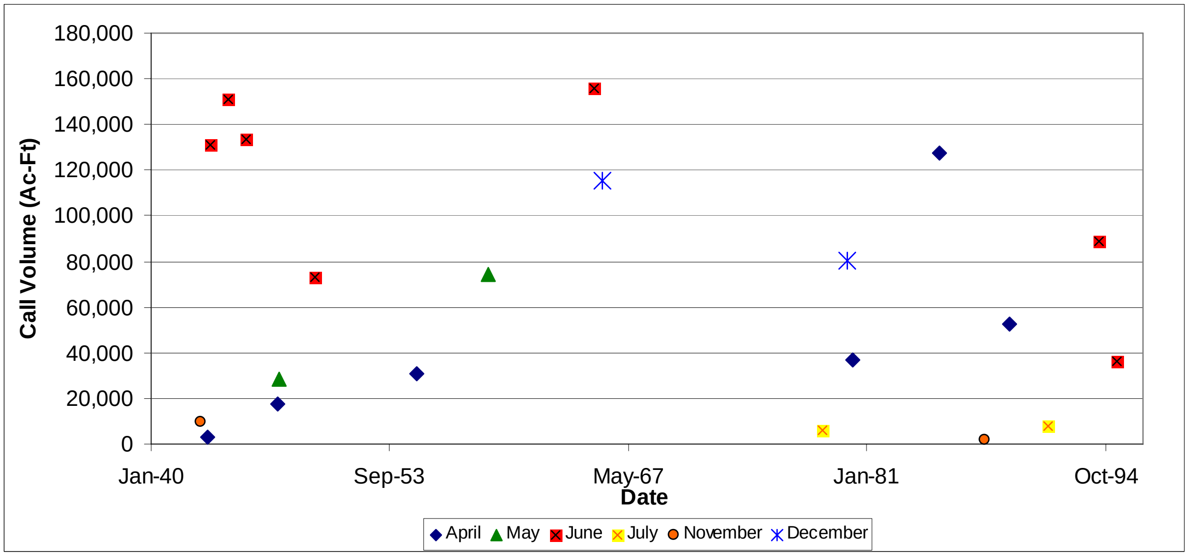
Figure ES-5. Monthly Target Shortages for Max H



While there are a large number of months with shortages and a median shortage value of 230,000 acre-feet, only a limited number of the smallest shortages must be corrected to achieve the desired frequency goals (50 percent for Max H and 75 percent for Min Q-Sal).

For the Max H condition, frequency of attainment of monthly B&E targets for the E model, described earlier, was compared to the target frequency of attainment. Note that the target frequency of attainment for each B&E condition (Max H, Min Q, and Min Q-Sal) are the frequency goals as defined by GBFIG and evaluated in this study. For months with frequencies less than 50 percent, the frequency shortage was defined as the difference between 50 percent and the simulated frequency of attainment. Months with shortages below the targets were identified and ranked in size. Months with the smallest shortages were selected for adjustment by pulling adequate supply out of reservoir storage to meet the Max H target. The target months selected for modification are illustrated in *Figure ES-6*.

Figure ES-6. Frequency and Volume of Reservoir Releases for Max H Attainment



A similar process was carried out for the Min Q-Sal targets, with the goal for frequency of attainment set to 75 percent.

ES.4 Impacts to Future Water Supply

The impacts to future water supply as a result of the methodology used to address B&E target flow shortages can be demonstrated as a function of future firm yield and future reservoir storage. The release of stored water from Lake Houston and Lake Livingston will result in a reduction of water supply available for diversion for both of these reservoirs as well as potential upstream supply reductions. Supply impacts can be quantified as a reduction in future firm yield and/or a reduction in future reservoir storage.

ES.4.1 Water Right Yield

Firm yields were calculated for the E and revised models for key rights, including supplies identified in the 2006 RWP as well as potentially impacted WMS. Results from the revised models were compared to the E model to determine any change in minimum annual diversion. The results, shown in *Table ES-4* below, demonstrate that, in spite of the significant effects on reservoir levels, the altered reservoir operations used to meet FTA goals do not alter the firm yields of the Trinity or San Jacinto Basins. This is because the reservoirs do not empty at any time during the study and monthly diversions continue to be met from a combination of reservoir inflow and stored water.

Table ES-4. Minimum Annual Diversions for Max H and Min Q-Sal Reservoir Operation

Basin	Description	Permit (ac-ft)	Model Minimum Annual Diversion (ac-ft)		
			E	Revised Max H	Revised Min Q-Sal
San Jacinto	Lake Houston	168,000	168,000	168,000	168,000
San Jacinto	Lake Conroe	100,000	82,266	82,266	82,266
Trinity	COH Livingston	940,800	940,800	940,800	940,800
Trinity	*SJRA/Devers ROR	58,500	58,285	58,285	58,285
Trinity	*COH/Dayton	38,000	34,084	34,084	34,084
Trinity	CLCND - Lake Anahuac	39,613	9,317	9,317	9,317
Trinity	*CLCND Fixed Right - CWA	73,334	73,334	73,334	73,334
Trinity	*SJRA - CLCND Fixed Right - CWA	30,000	30,000	30,000	30,000
Trinity	Livingston - TRA	403,200	403,200	403,200	403,200

'*Established through fixed right agreements.

The above results, indicating no impact to firm yield supply due to reservoir releases, is a result primarily of the inclusion of expected return flows in the E model. The import of water coupled with the inclusion of expected return flows in the E model creates significant volumes of water in the lower Trinity and San Jacinto basins made available for firm yield diversions and B&E flow releases. These return flows, however, are not currently permitted for use in the lower basins and it is noted that without the inclusion of these return flows, the impact to future firm yield for the supplies listed in *Table ES-4* would be significantly more pronounced. *Table ES-5* provides the projected firm yield of the water supplies for the E model without the inclusion of return flows.

Table ES-5. Minimum Annual Diversions With and Without Upper Basin Return Flow

Basin	Description	Permit	E Model		E Model without RF	
			MAD (ac-ft)	Min. Date	MAD (ac-ft)	Min. Date
Trinity	COH Livingston	940,800	940,800	NA	536,303	1956
Trinity	*SJRA/Devers ROR	58,500	58,285	1950	33,718	1956
Trinity	*COH/Dayton	38,000	34,084	1956	15,846	1956
Trinity	CLCND - Lake Anahuac	39,613	9,317	1956	9,317	1956
Trinity	*CLCND Fixed Right - CWA	73,334	73,334	NA	43,207	1956
Trinity	*SJRA - CLCND Fixed Right - CWA	30,000	30,000	NA	17,322	1963
Trinity	Livingston - TRA	403,200	403,200	NA	264,408	1956

ES.4.2 Reservoir Levels

Impacts to reservoir volumes in the revised E model for Max H and Min Q-Sal targets are shown in *Figures ES-7* and *ES-8*. For Lake Houston, managing releases to meet the Max H and Min Q-Sal frequency goals resulted in extended periods of reduced reservoir volume. Lake Houston does not completely refill after 1942 for Max H and 1951 for Min Q-Sal. While Lake Houston averages 98 percent of full for the unaltered E model during the period of record, the revised Max H and Min Q-Sal models average 90 and 87 percent, respectively. The effects of revised reservoir operations are greater for Lake Livingston, which averaged 95 percent of full volume for the E model, 81 percent for Max H revisions, and 78 percent for Min Q-Sal revisions. As with Lake Houston, Lake Livingston did not refill after 1943 for Max H and 1951 for Min Q-Sal.

Figure ES-7. Lake Houston Storage Volume for Revised Reservoir Operation

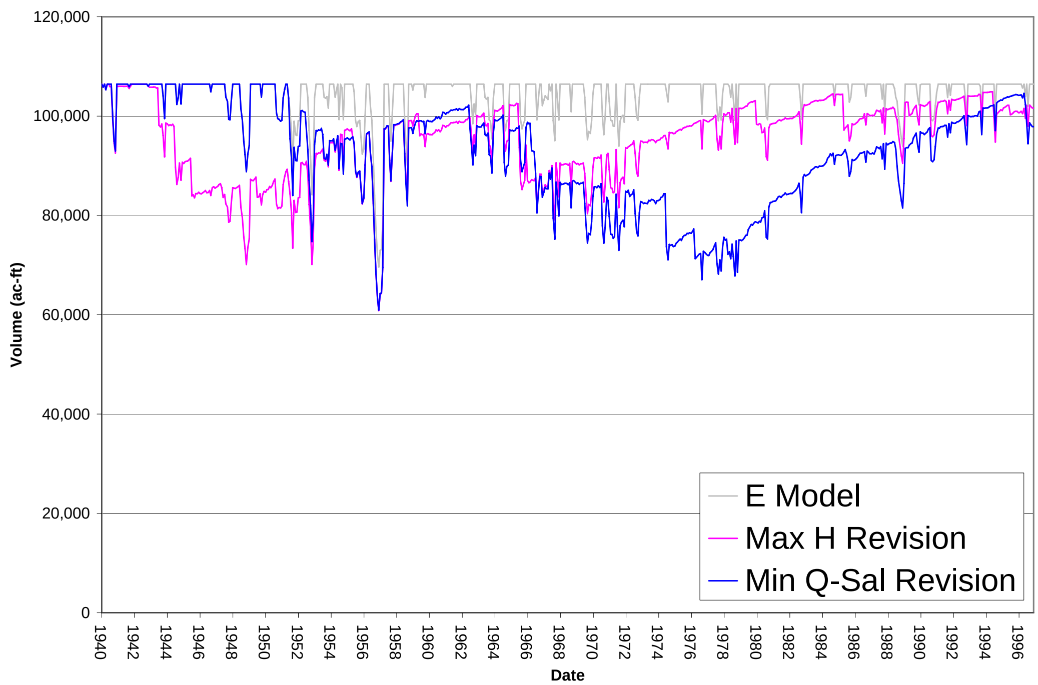
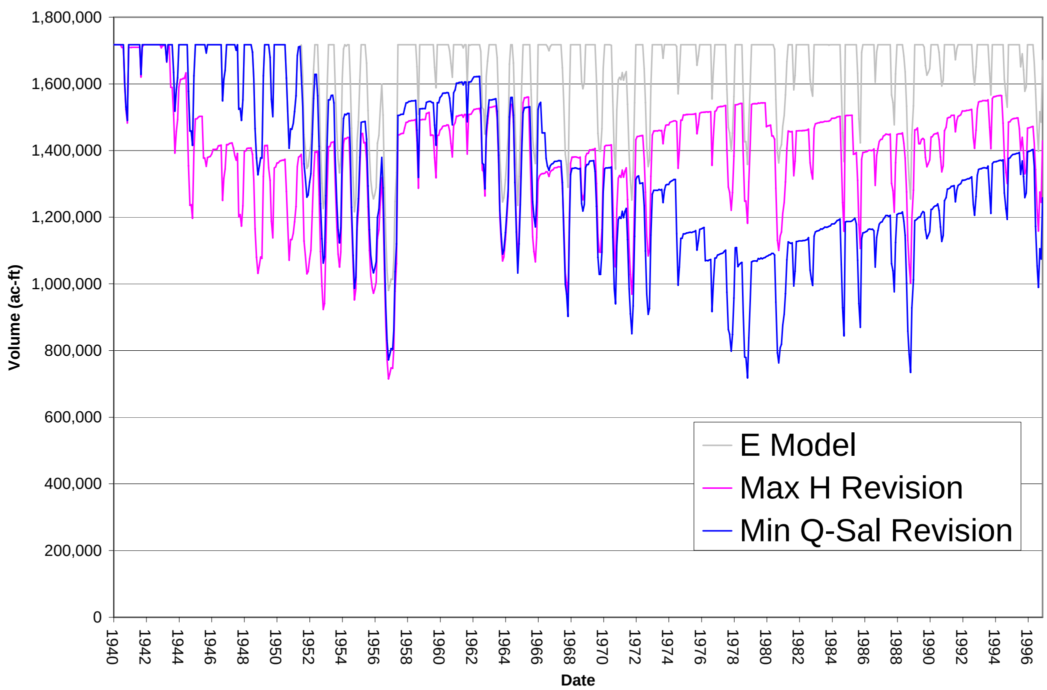


Figure ES-8. Lake Livingston Storage Volume for Revised Reservoir Operation



ES.5 Instream Flows

ES.5.1 Identification of Critical Segments

A list of 26 segments with the potential to be impacted by Region H WMS was developed from a compilation of segments studied in the TWDB Streamflow Assessment conducted for the 2007 SWP. Regulated flows at the segments were determined for the base (D_0) models as well as for all WMS models, including the composite E model. Based on monthly results for the model simulation period, 10th percentile flows were calculated to investigate low flow conditions. For each WMS, 10th percentile flows at each of the 26 segments were compared to the D_0 models. For each WMS, the stream segment with the greatest (absolute) percentage difference from the base model was considered to be the most critical segment for that strategy. For the 13 strategy models, six segments were identified in the Brazos and San Jacinto Basins as being particularly influenced by Region H WMS. Lyons flows, generally considered to represent a general low-flow condition adequate to maintain sound ecologic function, were calculated for the segments for comparison purposes. A summary of highly impacted segments is presented in *Table ES-6.*

Table ES-6. Impacts of WMS Implementation on Critical Stream Segments

WRAP Identifier	Basin	Strategy	10th Percentile Flows			Lyons Flow (ac-ft)
			D_0 (ac-ft)	Strategy (ac-ft)	Change (%)	
532801	Brazos	Freeport Desalination	41,101	40,776	-0.8	68,751
		BRA System Ops		39,246	-4.5	
		Allens Creek		40,027	-2.6	
BRRI70	Brazos	Little River	55,925	55,028	-1.6	78,697
		Houston to GCWA		55,324	-1.1	
SPSP	San Jacinto	TRA to Houston	1,461	4,223	189.1	1,607
		TRA to SJRA		2,736	87.3	
		All Strategies		5,522	278.0	
1004	San Jacinto	Expanded GW	2,082	2,937	41.1	2,444
A5191P	San Jacinto	Indust. WW Reuse	59,845	56,482	-5.6	39,041
		Houston Indir. Reuse		56,863	-5.0	
		NHCRWA Indir. Reuse		59,039	-1.3	
SRGB	San Jacinto	Lake Houston Yield	65,550	66,973	2.2	43,805

With the exception of the Freeport Desalination and the Houston to GCWA transfer strategies, WMS from increased inputs such as increased groundwater, IBTs, or additional permitted reservoir yield resulted in positive impacts to 10th percentile flows. These positive impacts tended to occur year round, but were greatest during the summer months with some indicating large increases in flow through early fall. The remaining strategies, which resulted in an overall negative impact (i.e., reduced flows) at the critical segments, fell into two distinct groups. The three wastewater reuse strategies (Houston, NHCRWA, and industrial), along with the Freeport Desalination strategy, caused fairly uniform reductions to 10th percentile flows throughout the year, with little or no seasonable variability. The remaining reduction-causing WMS were the three reservoir strategies (BRA System Operations, Allens Creek, and Little River) and the Houston to GCWA transfer. Unlike the reuse WMS, flow reductions were not uniformly distributed and tended to intensify during the spring and summer seasons.

The greatest positive impact for any critical segment was a result of the TRA to Houston Transfer, which created an overall increase in 10th percentile flow of 189 percent. The greatest reduction was -5.6 percent for industrial wastewater reuse. For the model representing full implementation of all strategies (E), the change at the critical segment was a positive increase of 278 percent.

As shown in *Table ES-6*, strategy flows in the San Jacinto Basin exceeded Lyons flow levels, while the Brazos Basin strategy flows were well below calculated Lyons flows; one should note that for the critical segments in the Brazos Basin, 10th percentile flows for D_0 were already lower than Lyons flows. The observation that a number of strategy flows in the San Jacinto Basin exceeded the Lyons flows, even when strategy impacts reduced flow, suggest that categorization of a segment as critical is not a clear indication of its ecological condition.

ES.5.2 Lyons Flows and Field Evaluations

The identification of critical segments described above was paired with a field study to enhance understanding and applicability of flow conditions at the identified segments. While points were labeled as critical, identification as being most impacted does not in of itself reveal whether low-flow or reduced-flow conditions represent an ecologically degraded state. For this reason, the second stage of the instream flow study involved calculating Lyons flows for relevant segments combined with field evaluation of instream flow conditions. Results were then used to examine possible environmental repercussions of WMS. Lyons flows were calculated based on regulated flow rates for the Current Conditions (Run 8) model; values were calculated as 60 percent of median flows for March through September and 40 percent of median flows for October through February.

Field examination of stream segments provided a visual assessment of ecological conditions of the segments. This was combined with quantitative measurement of stage and flow from the United States Geological Survey (USGS) gauges, which enabled qualitative analysis of stream condition to be related to calculated Lyons flows. Seven stream segments were identified in the Brazos, San Jacinto, San Jacinto-Trinity, and Trinity Basins from the TWDB Streamflow Assessment for inclusion in the field study. Selected segments were chosen based on accessibility, availability of streamflow measurement (proximity to reliable USGS gauges), and reliable flow output from WRAP. Sites were examined during a low-flow period in late July 2008 so that recorded flows would be representative of low flow conditions. Segments were primarily evaluated for Channel Flow Status (CFS) based on TCEQ Surface Water Quality Monitoring (SWQM) procedures (TCEQ 2003). Flow status was defined as high if less than five percent of channel substrate was exposed; moderate if five to 25 percent was exposed; and low if greater than 25 percent was exposed. Observations were also made of any potential wetlands or riparian corridor in observable range of the survey point. A summary of Lyons and observed flows is presented in *Table ES-7* below. None of the segments examined showed signs of ecological degradation caused by low flows. While some of the locations observed had only experienced low flows for a short duration, some of the sites had been below the Lyons flow for approximately two months. This suggests that there may be limitations on gauging stream health sing Lyons flows for this region.

Table ES-7. Lyons and Observed Flows for Field Study Points

WRAP ID	**Location**	**Lyons Flow** (cfs**)**	[1]**Obs. Flow** (cfs)	[2]**Low Flow Days**	[3]**CFS**	**Potential Wetland** (Y/N)	**Potential Riparian Corridor?** (Y/N)
8TRRO	Trinity River near Romayor	1,098	1,000	58	M	N	Y
802	Trinity River at Liberty	1,217	<1,217	NA	M	N	Y
9CBCR	Cedar Bayou near Crosby	4	0.6	6	L	N	N
A3979A	Luce Bayou near Huffman	12	0.2	64	L	Y	Y
1004	W Fork San Jacinto near Porter	40	23	20	M	Y	Y
1009	Cypress Creek near Westfield	40	30	1	H	N	N
532801	Brazos River near Rosharon	1,118	208	15	L	N	N

[1]For segment 802, a flow gauge reading was not available during the observation period. However, flow was estimated to be below the Lyons flow as the recorded stage during the observation period was below the stage associated with the Lyons flow.
[3]Number of days prior to observation with average daily flow below Lyons Flow
[3]L = Low, M = Moderate, H = High

ES.6 Considerations

There are a number of concerns related to the presented evaluation of alternatives for meeting FTA. The approach used to meet FTA is a “hard-wired” approach that couldn’t be realistically replicated as a reservoir operating rule.

Another predictive issue is related to reservoir operation and the maintenance of firm water supplies for both anticipated and unexpected conditions. If drought exceeds the known drought of record, simulated in this study, reservoir storage may be critical for maintaining firm yield. Although drops in reservoir level in this exercise never impacted yield, the maintenance of a reduced reservoir level reduces a water supply's protection against unforeseen drought conditions. Furthermore, it is noteworthy to observe that the reservoir levels at the end of the revised reservoir operation simulations never reach a full level. Even if one assumes that the period of record is representative of future conditions to come, successive cycles of the period of record would result in continually dwindling reservoir levels and, ultimately result in a loss of firm yield. Another concern with the approach taken is the validity of assuming that annual GBFIG targets are applicable on a seasonal or monthly basis. Whether FTA is more critical for some seasons or months than others has not yet been established. The application of the annual GBFIG FTA to monthly targets was made due to a lack of a more reasonable alternative and should be studied further.

Finally, while the purpose of this study is not to evaluate B&E needs or develop new flow targets or FTA, the underlying assumption that B&E flow needs are met if the desired FTA is achieved must be considered critically. One potential concern is that this approach does not consider a bracket of flows, but only if the flow equals or exceeds the desired B&E flow. This does not account for the possibility that, in some circumstances, excessive flows may also result in less than optimum conditions. It is important to remember that the State's Max H, Min Q, and Min Q-Sal flow regimes are not made up of individual flow targets but rather represent optimal harvest when all 12 months in a year are at or near the monthly target. Monthly flow patterns for the Max H and Min Q-Sal models are given in *Figures ES-9* and ES-10. As seen in the figures, the revised model median for Max H and 25th percentile for Min Q-Sal (corresponding to 50 and 75 percent FTA) are at or above the target values for all months of the year. While this means that the FTA requirement has been met using the definitions and assumptions for this study, the difference in distribution between the targets and revised models indicate flow conditions that do not meet optimum goals as provided by TWDB targets. Additionally, it is important to recognize that these are percentile distributions; even if the median or 25th percentile curve perfectly matched the targets, this does not guarantee that every month of a particular year was at or near target as required to meet TWDB's definition of optimal performance.

Figure ES-9. Distribution of Monthly B&E Inflows for Max H Revised Operation Model

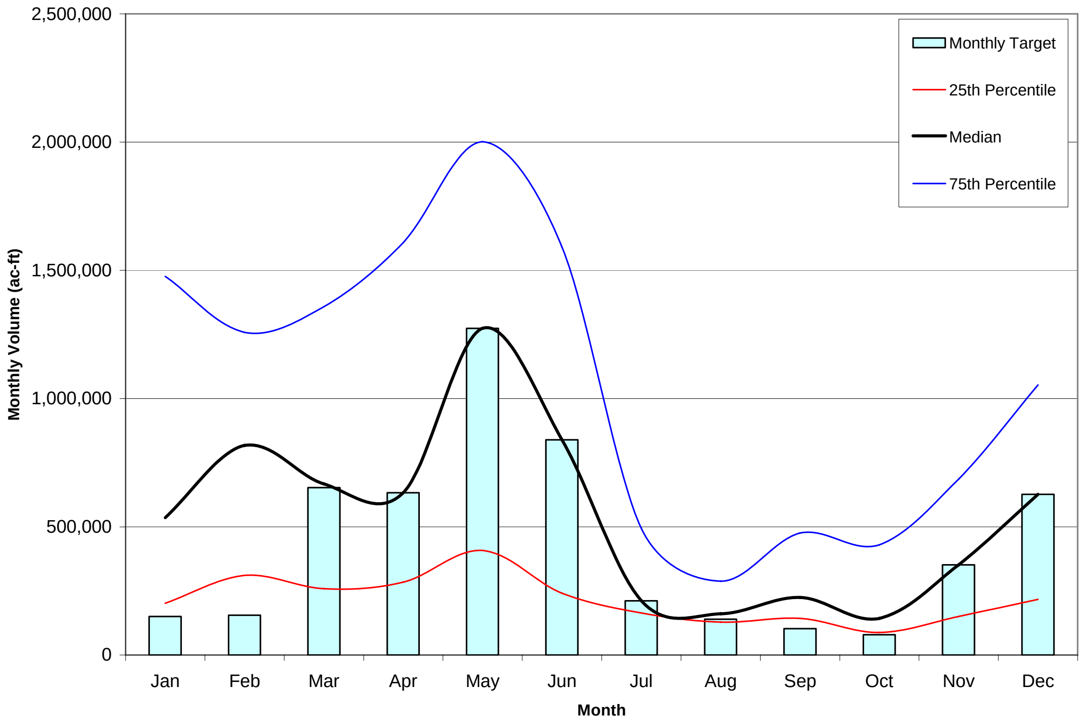
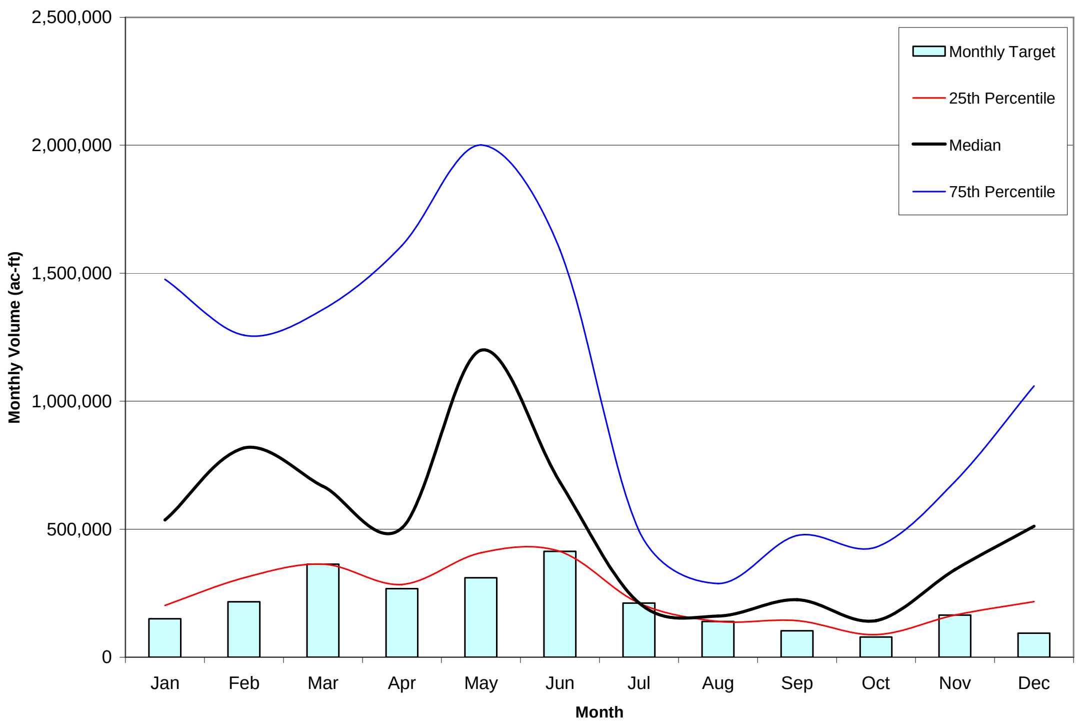


Figure ES-10. Distribution of Monthly B&E Inflows for Min Q-Sal Revised Operation Model



ES.7 Conclusions

This study was intended to evaluate the impacts of individual management strategies on environmental flows including both B&E inflows and instream flows in channels. Furthermore, an evaluation of impacts to existing and future water supplies was performed for two scenarios aimed at increasing the frequency of attaining B&E inflow targets. The following observations were made through the course of the study:

B&E Inflow Volume, Location, and Target Attainment

- In general, the inclusion of strategies upstream of and within Region H generally leads to a net increase in B&E inflows due to the import of new water to the basin.
- Impacts of individual Region H WMS are relatively minor with the exception of the TRA to Houston transfer, which resulted in an increase in FTA of up to 10 percent for one month.
- Shortages in meeting Max H and Min Q-Sal targets occur generally in the spring. Shortages for Min Q generally occur during the summer months.
- B&E flows generally transition from originating in the Trinity River Basin to the San Jacinto River Basin as time passes and additional water is diverted to meet demands in the latter basin.
- Removal of return flows from Region C were found to result in a 20 percent reduction in B&E discharges from the Trinity River which represents a substantial impact to the total volume of B&E flows. Reductions in firm yield for six of seven key water rights were also caused by this elimination of upstream return flows.

Revised Models for Increasing FTA

- A methodology using the release of stored water was identified as the most effective means of increasing FTA while minimizing impacts to firm yield. Two separate models were developed to increase the occurrence of meeting monthly Max H and Min Q-Sal targets at the desired level.
- Although no reductions in firm yield were identified during the period of record, reductions in reservoir storage point to a reduced level of reliability in reservoir supply during unforeseen drought conditions and successive occurrences of the observed period of record.
- The developed methodology approaches recommended targets as “minimum criteria” to be met, rather than a pattern of flows for an optimal level of estuary production. Additional steps would be required to address target attainment from this perspective.

Instream Flows

- The predominant changes to instream flows are increases in flow due to new water sources such as IBTs and groundwater.
- Reservoir and operations projects in the Brazos River Basin resulted in reductions in stream flow.
- Field observations were made at a time when stream levels were at a rate near that of the calculated Lyons flows for each segment. Despite this flow condition, there were no indications of impaired stream health at the observed locations.

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Section 1 – Introduction

1.1 The Role of WRAP in Modeling Environmental Impacts

The Water Rights Analysis Package (WRAP [Wurbs 2007]) was developed as a tool for modeling water rights allocations and river and reservoir operations on a monthly time-step. In addition to this basic objective, the nature of the application allows for the modeling of various environmental conditions, especially the determination of instream flows and bay and estuary (B&E) flows as a result of operations within the basin. This process is made simpler by the constant maintenance of Water Availability Models (WAMs) for each basin in the State of Texas by the Texas Commission on Environmental Quality (TCEQ). These WAMs can then be modified as necessary and executed by WRAP to determine impacts from various changes. Please see *Appendix A* for an overview of the WRAP components discussed in this report. Currently, TCEQ maintains two versions of the WAMs for permitting purposes: 1) a full-diversion model with no return flows, known as the WAM Run 3, and 2) a current conditions model based on historical water use, known as the WAM Run 8. The period of record for both models contains the critical drought period for each basin.

A recent study by the Texas Water Development Board (TWDB) in the production of the 2007 State Water Plan (SWP) Appendix 6.2 – Streamflow Assessments (TWDB 2007) examined environmental flows as a result of water management strategies (WMS) recommended in the 16 individual Regional Water Plans (RWPs). The TWDB used the TCEQ Run 8 as a basis for evaluating future strategies. Diversions in each basin were increased according to the volume of use anticipated in the RWPs while code was also added to account for new strategies that were not yet permitted in the current WAMs. Median and 10th percentile instream flows were then compared between the unmodified Run 8 models and the future conditions models.

In Region H, the WAM has been used to characterize inflows to Galveston Bay for various conditions. In the 2006 Region H RWP Chapter 4, Section 5 (Region H Water Planning Group 2005), the consultant team modeled five flow conditions in the Neches-Trinity, Trinity, Trinity-San Jacinto, San Jacinto, and San Jacinto-Brazos Basins:

- Naturalized Flow
- Current Conditions (TCEQ Run 8)
- Full Permit With Return Flows
- Full Permit Without Return Flows (TCEQ Run 3)
- Full Permit With Return Flows and Strategies for Regions C and H

Changes in annual inflow were determined and a comparison was made between various percentiles of modeled inflows and the freshwater inflow targets for Galveston Bay as described by Max H, Min Q, and Min Q-Sal. The results of this study indicated that:

- The TCEQ WAM runs reveal a decrease in the freshwater inflows to Galveston Bay as existing water rights are used to their Full Authorized Diversion amounts.
- The Full Authorized Diversion scenario with no return flows results in a significant reduction in inflows to Galveston Bay, such that inflows are consistently lower than freshwater inflow targets.
- Sedimentation in reservoirs in the Trinity and San Jacinto Basins has a minimal impact on freshwater inflows.

- The Current Conditions, Full Authorized Diversions With Return Flows and Full Authorized Diversions plus Management Strategies represent models of increasing demand and return flows in Region H. These models show the portion of inflows to Galveston Bay from the San Jacinto Basin will increase while the portion from the Trinity Basin will decrease.

- Region C Management Strategies produce a net increase in flows to Galveston Bay as a result of large amounts of imported water producing return flows in the upper Trinity Basin.

- The incorporation of Management Strategies results in inflow patterns most similar to the Current Conditions.

- When aggregating the monthly statistics, freshwater inflow targets are met at levels approaching or exceeding the Galveston Bay Freshwater Inflows Group (GBFIG) frequency goals for all but the no return flow scenario.

- The individual monthly statistics for freshwater inflows reveal selected months which are not met at the target frequency, while in other months the target frequency is exceeded.

The 2006 study indicated several trends in B&E inflows. However, no effort was made at this point to determine the impact of individual strategies. As this study was completed during the course of the Regional Water Planning process, final strategies for upstream reaches of the Trinity Basin were not available for incorporation into the model as they were for the TWDB environmental flows study. Furthermore, this limited analysis did not approach the question of how to address potential impacts from future WMS.

1.2 Purpose of Current Study

This study is intended to serve as a continuation of the 2006 Region H study by investigating the impacts of individual WMS on B&E inflows and to evaluate the feasibility of meeting existing B&E targets through operational strategies in the contributing basins. This methodology includes the development of various future conditions models to represent each management strategy and provide comparison to determine the magnitude of strategy impacts. Models will also be created to meet existing B&E targets using operational techniques while utilizing current and future WMS.

Additionally, this study is intended to determine impacts to instream flows in each basin. This analysis has not been performed as part of the Region H planning process up to this point. This includes a review of instream flows at certain critical points as well as field observations to provide data on habitat quality along with observed flow regimes.

1.3 Water Management Strategies in 2006 Region H Regional Water Plan

The 2006 Region H RWP examined 32 WMS. Strategies were evaluated based on a number of parameters, including yield, cost, location, water quality, various environmental impacts, and several other factors. Of these, 23 were recommended by the RWP as recommended WMS. This study selected 17 of the recommended WMS as potential candidates for modeling. The WMS selected for study are summarized below. For additional details, see Chapter 4 of the 2006 Region H RWP. Estimated Year 2060 yields for the strategies are shown in *Table 1-1*.

Table 1-1. WMS Supply Volume for Selected Strategies

No.	Strategy	Volume[1] (ac-ft)
1	Municipal Conservation	101,000
2	Irrigation Conservation	77,900
3	Freeport Desalination	28,000
4	Expanded Groundwater	91,000
5	Expand/Increase Contracts	68,300
6	New Contracts	293,400
7	BRA System Operations	163,700
8	Allens Creek Reservoir	97,400
9	Little River Off-Channel Reservoir	32,100
10	Non-Municipal Contractual Transfers	21,000
11	Wastewater Reuse for Industry	67,200
12	Trinity River Authority (TRA) to Houston Contract	150,000
13	TRA to San Jacinto River Authority (SJRA) Contract	50,000
14	Houston to GCWA Contract	56,000
15	Houston Indirect Reuse	52,500
16	North Harris County Regional Water Authority (NHCRWA) Indirect Reuse	31,400
17	Lake Houston Additional Yield	[2]1,000

1. Rounded to nearest 100 ac-ft.
2. Modeled at full unallocated volume of 32,500 ac-ft.

1. Municipal Conservation: This WMS relies on demand reduction to allow existing supplies to meet demands for longer periods of time. This can also potentially delay the need to develop new municipal supplies. Potential conservation methods include water system audits, conservation pricing, plumbing fixture retrofits, landscape irrigation conservation, and incentives for purchasing water-efficient appliances, as well as a number of other methods.

2. Irrigation Conservation: The Irrigation Conservation strategy is similar in intent to the municipal conservation WMS. Potential conservation methods include irrigation scheduling, leveling and contour farming, ditch lining, and drip line installation, as well as other methods.

3. Freeport Desalination: The Freeport Desalination WMS involves the construction of a 10 MGD desalination facility in Freeport, Texas on the site of the Dow chemical plant. The proposed strategy includes the ability to upgrade to 100 MGD by 2060. Water desalinated by the plant would be piped upstream for municipal use in demand centers in Fort Bend and Brazoria Counties.

4. Expanded Use of Groundwater: This WMS relies on sustainable expansion of existing groundwater supplies, with limits on increases to correspond with groundwater reduction plans and conservation district rules. Increases are within the limits of sustainable yield and subject to groundwater conservation district and subsidence district rules.

5. Expand/Increase Current Contracts: This WMS includes allocation of currently permitted water supplies for use by current contract participants. This includes the extension of current

contracts with terms ending before the year 2060, as well as the increase of current contracts to meet future demands.

6. New Contracts from Existing Supply: New contracts would be created from existing supply sources.

7. BRA System Operations Permit: The Brazos River Authority (BRA) System Operations WMS aims to increase the yield of BRA reservoirs by coordinating operation of reservoirs as a system and the permitting of a portion of the return flows in the Brazos River basin. This would allow for additional yield without the need for construction of new infrastructure.

8. Allens Creek Reservoir: The Allens Creek Reservoir WMS is a proposed off-channel reservoir in Austin County. The reservoir would hold peak flows diverted from the Brazos River, with diversions to the reservoir indexed to streamflow. Water from the reservoir would be used to supply municipal, industrial, and irrigation needs in several counties.

9. Little-River Off-Channel Reservoir: This WMS would be an off-channel reservoir in Milam County intended to divert and store excess flows for producing firm capacity. The WMS was originally assessed by the Brazos G region but has been investigated by Region H.

10. Non-Municipal Contractual Transfers: The Non-Municipal Contractual Transfer WMS involves transferring surplus water supply to neighboring counties and basins with projected shortages. These transfers would make use of existing conveyances where possible.

11. Wastewater Reuse for Industry: Water for this WMS would come from treated effluent from three City of Houston (COH) Waste Water Treatment Plants (WWTPs). After treatment, water would be piped to industrial users along the south side of the Houston Ship Channel corridor.

12. TRA to Houston Contract: This is a surface water agreement between the COH and TRA to allow COH to acquire a portion of uncommitted TRA water supplies from the Lake Livingston-Wallisville Saltwater Barrier system.

13. TRA to SJRA Contract: This strategy proposes the transfer of some SJRA supply in the Trinity River and some TRA supply in Lake Livingston to Montgomery County via Lake Houston. Water may be transferred through the proposed Luce Bayou conveyance.

14. Houston to Gulf Coast Water Authority (GCWA) Transfer: The Houston to GCWA WMS involves the transfer of water from the Coastal Water Authority (CWA) system to GCWA's Texas City Reservoir by way of the CWA Bayport facility. Shortages would be met in Galveston County and possibly Fort Bend County.

15. Houston Indirect Wastewater Reuse: Water for this WMS would be reclaimed from effluent from 35 City of Houston WWTPs in seven small basins. Water would receive additional treatment and be transferred by bed and banks permits to diversion locations for municipal and industrial users.

16. NHCRWA Indirect Wastewater Reuse: The NHCRWA Indirect Reuse strategy includes reclamation of water from up to 163 WWTPs in the NHCRWA service area discharging to tributaries of the San Jacinto River and Lake Houston. Water would be transferred via bed and banks permits to diversion locations to serve industrial reuse and municipal and commercial irrigation reuse.

17. Lake Houston Additional Yield: Based on WRAP modeling for the last RWP, additional unappropriated volume was identified in Lake Houston. This strategy reflects the permitting of this storage.

Section 2 – Development of Water Availability Models for Evaluating Management Strategies

Several model conditions were devised and executed for the Neches-Trinity, Trinity, Trinity-San Jacinto, San Jacinto, and San Jacinto-Brazos Basins to determine the impacts of WMS on inflows to Galveston Bay. Each model represented a particular condition that could be compared to other simulations to determine incremental impacts from individual strategies. The resulting B&E inflows were compared on a basis of frequency to identify any impacts from future strategies that would further hinder the rate of compliance with meeting inflow targets beyond current conditions.

A process was then developed for adjusting reservoir operations to increase B&E inflows during months when future strategies caused a net decrease in frequency for meeting inflow targets. Reservoir spills from Lake Houston in the San Jacinto River Basin and Lake Livingston in the Trinity River Basin were recommended in order to create a condition of zero net impact on inflows to Galveston Bay. A review of water right reliability following this exercise indicated no impact to the reliability of rights resulting from this change to reservoir operations.

A series of four models were originally developed as baseline conditions ranging from Naturalized Flows to a Future 2060 Condition with Existing Permits and Full Return Flows model. This future conditions model, which included upstream strategies in the upper basins, was then modified with the proposed Region H strategies described above. Once the individual strategies had been modeled, a comprehensive model including all of the Region H strategies was developed to represent an expected Future 2060 Condition. Finally, an additional model run of the TCEQ Run 3 (Full Diversion Without Return Flows) was requested by the Region H Planning Group for purposes of comparison with the other models.

2.1 Scenario A: Naturalized Flow

Naturalized flows for all study basins were determined using the TCEQ current conditions (Run 8) WRAP models without modifications. The most recent versions available from the TCEQ website were used for all basins except the Trinity, for which an unreleased updated version was provided by TCEQ. Naturalized flows were retrieved from the model output file using a 2NAT record in the TABLES program.

2.2 Scenario B: Existing Diversions With Full Return Flows

Existing diversions with return flows were analyzed using the same models as those from Scenario A. Regulated flows for this and all subsequent scenarios were retrieved from model output using a 2REG record in the TABLES program.

2.3 Scenario C: Full Authorized Diversions With Full Return Flows

This scenario was based on TCEQ Full Authorized Diversion (Run 3) models. As with Scenarios A and B, the most recent versions available from the TCEQ website were used for all basins except the Trinity, for which an unreleased updated version was provided by TCEQ. Because the Run 3 model includes almost no return flows, Constant Inflow (CI) and Return Flow (RF) cards for each basin were imported from the Run 8 model if present in the Run 8. CI cards imported from Run 8 reflect flows from a current conditions diversion level. However, since the majority of CI cards represent groundwater inputs to the system, no adjustment was required. The exception was the San Jacinto Basin, which includes considerable surface water inflows. For the San Jacinto model, CI cards were scaled up to represent Full Authorized Diversion conditions.

In order to create a Full Authorized Diversions With Return Flows model, a program was developed to extract Run 8 return flows and insert them into the Run 3 model. The program scanned the Run 8 and Run 3 models and, for each model, developed a table of several parameters included on the WR cards. These included the control point, use, priority number, return flow parameters (Run 8 only), and water right identifier. The two tables were then compared and, for diversions with matching parameters, the Run 8 return flow data was copied into the corresponding Run 3 diversion. Non-matching records, or records for which no change was necessary, were not altered.

2.4 Scenario D: Future 2060 Conditions With Existing Permits and Full Return Flows

The Strategy C models discussed in the preceding section were used to develop the series of models corresponding to the various strategies, referred to as the D_0 models. Year 2060 SV/SA records (if available) giving surface area and volume relationships for reservoirs replaced the existing Year 2000 SV/SA records to account for the loss of reservoir storage volume from the effects of sedimentation over time. For the Neches Trinity, Trinity-San Jacinto, and San Jacinto models, no other changes required consideration. Two of the basins, the Trinity and the Brazos/San Jacinto-Brazos, required modification due to the presence of WMS in portions of the basins located in areas outside of Region H.

For the Trinity model, upstream strategies from Region C were included. Sections of code related to these strategies were copied from a file representing Region C's WMS for the TWDB Streamflow Assessment Study found in the 2007 SWP. This file was provided by TWDB. In addition to altering the Strategy D DAT file, changes were also made to the DIS file due to the addition of several control points. For the Brazos/San Jacinto-Brazos model, changes were made based on Region G's 2001 WMS (Brazos G Regional Water Planning Group 2001) as modeled in the same TWDB study. As with the Trinity model, changes for Strategy D were made to both the DAT and DIS files. The resultant models, identified as D_0 models, represent Year 2060 conditions with Full Authorized Diversions and expected return flows, upstream WMS, and no term water rights. However, the D_0 model contained no Region H strategies.

The D_0 models were used as base models for the individual WMS scenarios described in detail below. Changes made for each scenario were specific to the nature of the WMS. Because the regional water planning database (DB07) gives volumes associated with specific WMS for each WUG impacted, it was necessary to associate relevant WUGs with model control points for a number of the strategies examined. As control points in the model are generally not explicitly identified with a WUG, the process of associating WUGs and control points was performed manually. Stream segments and control points for each basin, along with WUG boundaries and WWTP locations, were examined in a GIS environment. The process was fairly straightforward for the majority of WUGs representing communities and cities. Generally, the community's WWTP outfall was located near a return flow control point within or downstream of the WUG boundary, leading to selection of that control point. For distributed WUGs, such as County-Other, the process of matching WUGs and control points was more complex. Control points were associated with these distributed WUGs in what was determined to be the most reasonable location for the county and basin. If possible, the control points selected were located at an outfall near the major demand centers in the area. If no significant demand centers were identified nearby, the point at the downstream corner of the county-basin was selected.

2.4.1 D_1: Municipal Conservation

Because the D_0 model includes Full Authorized Diversion, this conservation strategy was not modeled, as it does not alter diversion amounts under the Full Authorized Diversion condition. Any water conserved under one use would still be used in another capacity by another WUG.

2.4.2 D_2: Irrigation Conservation

Similar to the D_1 strategy, use of a Full Authorized Diversion base model precluded modeling of the irrigation conservation scenario.

2.4.3 D_3: Freeport Seawater Desalination

This strategy model was developed from the Brazos/San Jacinto-Brazos D_0 model. The effects of added desalination supply were approximated by new return flows at points of use associated with the strategy. The added return flows were modeled with three CI cards at two locations representing the WUGs for Brazos Manufacturing, Brazos County-Other, and San Jacinto-Brazos County-Other. Because detailed information on monthly supply volumes was not available for the strategy, the monthly distributions of WMS volume for the WUGs were based on existing information in the model. The UC cards, which give monthly percentages of annual water right diversions, were grouped together by water use and averaged to yield a monthly pattern for each use type in the basin. The annual WMS volumes associated with the three strategy WUGs were multiplied by these usage pattern to create monthly strategy volumes. These monthly strategy volumes were further scaled by a return flow percentage to convert them to return flow volumes. Assumed return flow factors were 60 percent return flow for municipal use, 40 percent for mining, industrial, and livestock uses, and 0 percent for irrigation. These factors were selected based on prior experience as well as information from existing WAM models. Irrigation return flows were set to 0 percent to maintain consistency with existing Current Conditions return flow factors. Monthly strategy return flows were then converted to CI card format and added to the model.

2.4.4 D_4: Expanded Use of Groundwater

The WMS associated with expanded use of groundwater supplies was modeled in all of the study basins. Because additional groundwater will be utilized near the point of production before entering the stream network, effects of expanded groundwater use were approximated as new return flows. Return flows were modeled with 214 CI cards, one for each point-of-use WUG. As with Scenario D_3, annual WMS volumes were converted into monthly return flows. A similar procedure to that used in the Brazos/San Jacinto-Brazos Basin was used to develop monthly average usage coefficients for each use basin and use type. Assumed return flow factors were 60 percent return flow for municipal use, 40 percent for mining, industrial, and livestock uses, and 0 percent for irrigation.

2.4.5 D_5: Expand/Increase Current Contracts

This strategy was not modeled as the WRAP program allocates water for water right diversions, not contracts. Additionally, since the base model includes Full Authorized Diversions, water that would be transferred has already been accounted for under an existing diversion.

2.4.6 D_6: New Contracts From Existing Supply

This strategy was not modeled for similar reasons as Scenario D_5.

2.4.7 D_7: BRA System Operations Permit

The Brazos System Operations permit was incorporated into the Brazos/San Jacinto-Brazos D_0 model from the TWDB Region G WMS model, with the portion of the permit dealing with Region H reservoirs removed. To simulate the full system operations permit, sections of the code that had been commented out for Region H were reactivated. This reactivated a diversion for the Region H WMS. The diversion amount was updated to reflect the volume given in the most recent Regional Water Planning Group (RWPG) database. Twenty-eight CI cards were added to reflect return flows at the WUG level from this diversion. These cards were generated by multiplying the WMS volume for each WUG by a monthly distribution (same pattern as the UC card for the diversion) and a return flow factor. CI cards were also added to the San Jacinto and Trinity models to represent an interbasin transfer (IBT) from the Brazos Basin. The CI cards for the IBTs were determined in a similar manner to the return flows.

2.4.8 D_8: Allens Creek Reservoir

The Allens Creek Reservoir code was already included in the Brazos/San Jacinto-Brazos D_0 model but commented out. In order to simulate Allens Creek Reservoir, these sections of the model were reinstated. This reactivated instream flow requirements and the WMS diversion for Allens Creek. The diversion amount was altered to reflect the latest value from the RWPG database. The SV/SA card for Allens Creek Reservoir was also uncommented. CI cards were used to represent return flows at the WUG level as well as the IBT of water to the San Jacinto-Brazos Basin. These were calculated in a manner similar to Scenario D_7. Brazos System Operations associated with Allens Creek Reservoir were not reactivated. The IBT from the Brazos Basin to the San Jacinto Basin was also modeled in the San Jacinto model with CI cards at the WUG level.

2.4.9 D_9: Little River Off-Channel Reservoir

The Little River Off-Channel Reservoir (LROCR) was included in the TWDB upstream strategy Brazos/San Jacinto-Brazos model and was incorporated in the D_0 model in a commented-out form. The sections of code associated with LROCR were uncommented to simulate this strategy and the associated diversion. CI cards were added to reflect WUG level return flows from the diversion as well as the IBT to the San Jacinto-Brazos Basin. This strategy also required a section of the DIS file for the Brazos/San Jacinto-Brazos model to be uncommented.

2.4.10 D_{10}: Non-Municipal Contractual Transfers

This strategy was not modeled for similar reasons as Scenarios D_5 and D_6.

2.4.11 D_{11}: Wastewater Reuse for Industry

Wastewater reuse for industry was modeled through the alteration and addition of CI cards in the San Jacinto Basin. Two CI cards representing the three source WWTPs were reduced by the WMS amount. The specific reduction for each plant was assumed proportional to total plant output. Return flows from the strategy were assumed to occur along the Houston Ship Channel. Existing CI cards for industrial return flows in the target area were identified and converted to monthly percentages. The WMS volume was assumed to be distributed evenly among these 26 locations; the volume was scaled using a return flow factor of 0.4 for industrial use and was converted into 26 new CI cards with monthly distributions matching those of the existing cards. These new CI cards, representing return flows from industrial users, were added to the model after existing CI cards. Because WRAP automatically sums monthly values for multiple CI cards at the same control point, the pre-existing CI cards for flows along the Ship Channel were not removed or replaced.

2.4.12 D_{12}: TRA to Houston Contract

The Trinity Basin is the source of WMS water for this scenario. However, since the Trinity model already reflects the WMS water leaving the basin, no additional changes were necessary in the source basin. For the receiving basins, changes were made to the San Jacinto and Brazos/San Jacinto-Brazos models. A total of 75 CI cards were added in the San Jacinto and Brazos/San Jacinto-Brazos models to reflect return flows from points of use. The monthly patterns of the CI cards were based on the average CI card pattern (percentage of total annual flow for each month) for the corresponding basin and usage type. CI cards assume 60 percent return flow for municipal use, 40 percent for mining, industrial, and livestock uses, and 0 percent for irrigation.

2.4.13 D_{13}: TRA to SJRA Contract

No change was made to the Trinity model under this strategy as the Trinity model already reflects the WMS water leaving the basin. CI cards were added for the southern part of Montgomery County near Conroe, Texas to reflect return flows from points of use. The monthly patterns of the CI cards were based on the average CI card pattern (percentage of total annual flow for each month) for the corresponding basin and usage type. CI cards assume 60 percent return flow for municipal use, 40 percent for mining, industrial, and livestock uses, and 0 percent for irrigation.

2.4.14 D_{14}: Houston to GCWA Transfer

No change was made to the Trinity model under this strategy as the Trinity model already reflects the WMS water leaving the basin. Five total CI cards were added in the Brazos, San Jacinto-Brazos, and San Jacinto Basins to reflect return flows from this WMS. The monthly patterns of the CI cards were based on the average CI card pattern (percentage of total annual flow for each month) for the corresponding basin and usage type. CI cards assume 60 percent return flow for municipal use, 40 percent for mining, industrial, and livestock uses, and 0 percent for irrigation.

2.4.15 D_{15}: Houston Indirect Wastewater Reuse

As noted previously, this scenario involves reclaiming effluent from WWTPs in seven sub-basins in the San Jacinto model for municipal and industrial uses. Locations of specific CI cards for the WWTPs used by the WMS were determined from the Water Availability Modeling for the San Jacinto Basin report (Espey, Padden 2000). The CI cards were sorted by sub-basin and summed. The monthly flow volumes were then divided by the annual total of the CI cards, yielding seven sets of monthly percentages, each representing one sub-basin. These were then converted into UC cards and added to the model to give monthly diversion distributions for the WMS in each relevant sub-basin. Diversions associated with the strategy were represented by eight WR cards (including an IBT to the San Jacinto-Brazos Basin from Sims Bayou) with annual diversion targets proportional to the WWTP flow in each sub-basin. Based on the implementation decade given in DB07, the priority dates for all eight water rights were set to 1/1/2050, junior to all other water rights in the model. Return flows from diversions were assumed to be returned the same month to the next downstream control point, with a return flow factor of 40 percent to represent industrial use. The only exception is the IBT from Sims Bayou to the San Jacinto-Brazos Basin, for which return flows are prevented from returning to the San Jacinto model using an OUT statement. For the Brazos/San Jacinto-Brazos model, the IBT to the San Jacinto-Brazos Basin was modeled using two CI cards representing the Harris Manufacturing and Harris Steam Electric WUGs.

2.4.16 D_{16}: NHCRWA Indirect Wastewater Reuse

While this WMS utilizes outflow from a large number of WWTPs, specific information about volumes and monthly patterns of flow from individual plants was not available. For this reason, Scenario D_{16} relied on a generalized approach to model indirect wastewater reuse. Allocation of flow volumes involved GIS analysis of WWTP locations. Potential source WWTPs were examined in ArcMap and overlaid with data layers for stream segments, sub-basin boundaries, and the NHCRWA boundaries. WWTP locations were identified primarily in the Greens Bayou Basin or the White Oak Bayou Basin. Available WWTP flow for each category for the WMS was assumed proportional to the number of WWTPs in that category. Of the 31,400 acre-feet identified for the WMS, 4,816 acre-feet was allocated to the Greens Bayou Basin, 6,357 acre-feet to the White Oak Bayou Basin, and the remaining 20,227 acre-feet to the NHCRWA boundary. The WMS was modeled with three new water right diversion WR cards, with diversion locations at the most downstream location of each boundary and annual diversion targets as given above. The assigned priority date of 1/1/2050, which was based off of information in DB07, is the most junior in the model. Water from the D_{16} strategy is intended for combined industrial reuse and municipal and industrial irrigation; however, the relative volumes for each of these uses are unknown. For this reason, the more conservative return flow factor of 0 percent for irrigation was applied to all three WR cards.

2.4.17 D_{17}: Lake Houston Additional Yield

For the scenario utilizing additional unappropriated flow from Lake Houston, the WMS was represented as a new water right. A WR card with an annual diversion total of 32,500 acre-feet from Lake Houston was added to the model. Monthly diversion distribution was based on the existing municipal usage UC card in the model. The water right was given a priority date of 01/01/2010, as DB07 lists the WMS as potentially active by 2010. Return flows were assumed to be returned the same month as the diversion, with a return flow factor of 60 percent due to the municipal usage type. A WS card at Lake Houston associated with the right was added, with the storage volume for the right located at the top of the conservation pool.

2.5 Scenario E: Future 2060 Conditions With Return Flows and All Recommended WMS

Scenario E incorporated all modeled D strategies for each basin. This was accomplished by inserting code for each of the individual strategies into the model. For several of the basins, multiple strategies relied on representing return flows at the WUG level as CI cards. In these cases, D strategy CI cards did not replace existing cards, but rather were added to the end of the existing list of constant inflows.

2.6 Scenario F: Full Authorized Diversions With No Return Flows

Full Authorized Diversions with no return flows were determined from an unmodified copy of the TCEQ Full Authorized Diversion (Run 3) WRAP models. Models were executed normally and regulated flows were retrieved from model output using a 2REG record in the TABLES program.

Section 3 – Evaluation of Bay and Estuary Inflows and Target Attainment

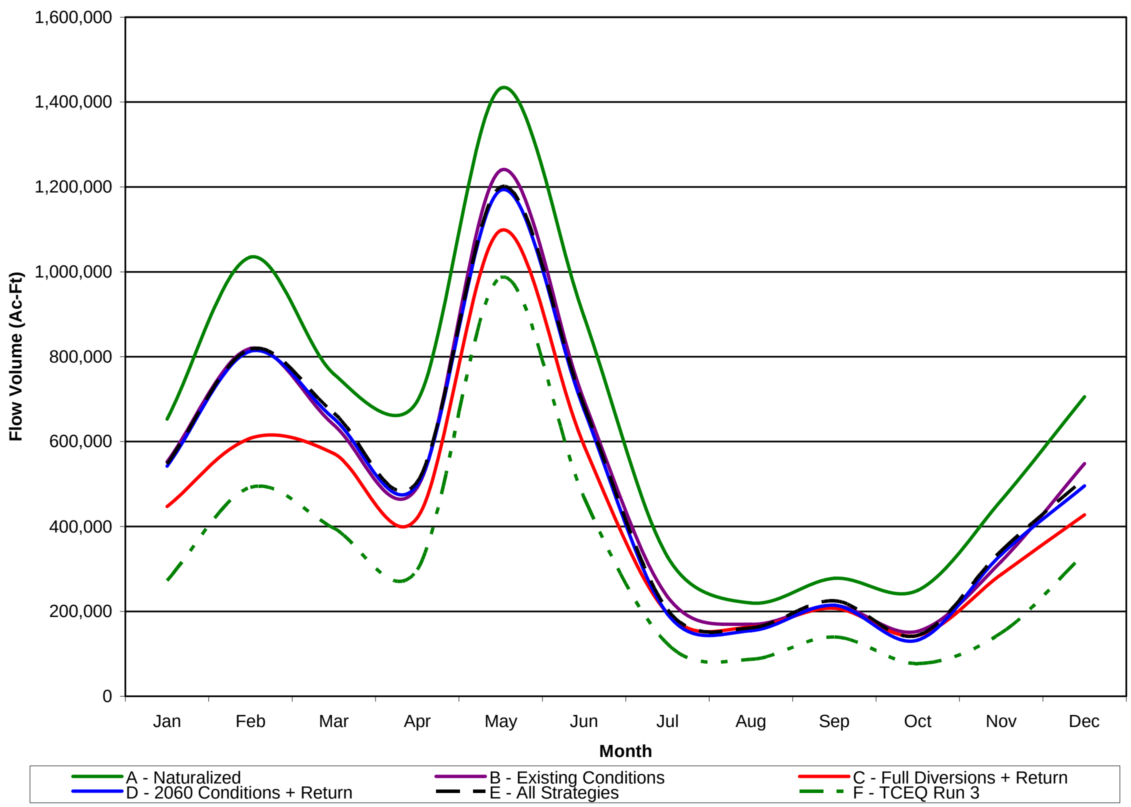
3.1 B&E Flow Results

The TABLES program was used to output regulated flows for relevant control points for all (A-F) scenarios. Resultant regulated flows are given in *Appendix B*. The impacts of recommended WMS were then determined through an analysis of both instream flows and B&E inflows. These two processes are discussed in greater detail below.

3.1.1 B&E Inflow Targets and Attainment Frequency

WRAP strategy model output was used to determine effects of WMS implementation on B&E flows into Galveston Bay for the Year 2060 condition. Monthly median B&E flows were determined for A, B, C, D_0, E, and F. As noted earlier, the strategy models represent a Full Authorized Diversion scenario with the inclusion of expected return flows and strategies from upstream regions. A comparison of monthly medians is given in *Figure 3-1* below.

Figure 3-1. WRAP Model Median Monthly Bay and Estuary Inflows



As shown in *Figure 3-1*, median flows for the D_0 and E models are lower than the naturalized flows but higher than the TCEQ Run 3 (full diversions with limited return flows) model. This is partially due to the inclusion of expected return flows (see the C model curve) and partially due to the inclusion of WMS. Median flows for the E model were also found to be slightly lower than current conditions for the majority of the year, but exceed current conditions by 2.6 to 7.8 percent for March, April, September, and November. B&E flows for the E model were also evaluated with reference to B&E inflow targets recommended by the TWDB. There are three sets of targets designed for maintaining fisheries. These are:

- Max H – The sequence of monthly inflows required for maximum B&E fisheries harvest as recommended by TWDB/Texas Parks and Wildlife Department (TPWD)

- Min Q – The sequence of monthly inflows that minimizes annual volume needed to maintain the B&E fisheries harvest as recommended by TWDB/TPWD

- Min Q-Sal – The sequence of monthly inflows that maintains the B&E salinity constraint as recommended by TWDB/TPWD

Monthly values for all three annual targets for the Galveston Bay system are given in *Table 3-1* below. In general, Max H represents a target condition for ultimate production while Min Q-Sal represents a base condition that must be maintained on a more reliable basis.

Table 3-1. Monthly Galveston Bay Inflow Targets

Month	Max H	Min Q	Min Q-Sal
1	150,500	150,500	150,490
2	155,200	216,700	216,700
3	652,800	363,900	363,900
4	632,500	352,600	267,270
5	1,273,700	679,700	309,970
6	839,700	448,100	413,560
7	211,500	232,700	211,500
8	140,000	154,000	140,000
9	103,000	330,200	102,960
10	78,600	251,900	78,600
11	351,500	351,500	164,390
12	626,800	626,800	93,870
TOTAL	**5,215,800**	**4,158,600**	**2,513,210**

It is not feasible to meet all three of these goals 100 percent of the time while still meeting water demands within these regions. Rather, recommendations proposed by the GBFIG are used in this study to a desired annual frequency for which these targets should be met. Region H formally adopted GBFIG-proposed frequencies of attainment during the 2001 cycle of Regional Water Planning. GBFIG proposed a 50 percent frequency of attainment for Max H, 60 percent for Min Q, and 75 percent for Min Q-Sal. Prior study of freshwater inflows for Galveston Bay (Espey Consultants 2008) demonstrates that consideration should be given to the quantity, quality, seasonality, and location of inflows. However, the GBFIG recommendations do not explicitly address a desired frequency for the seasonality (i.e., monthly distribution) of freshwater inflows. For this study, the recommended annual frequency was used as a placeholder for the evaluation of seasonal variations (i.e., monthly distribution). The frequency of meeting target flows (frequency of target attainment [FTA]) on an annual basis is given in *Table 3-2*.

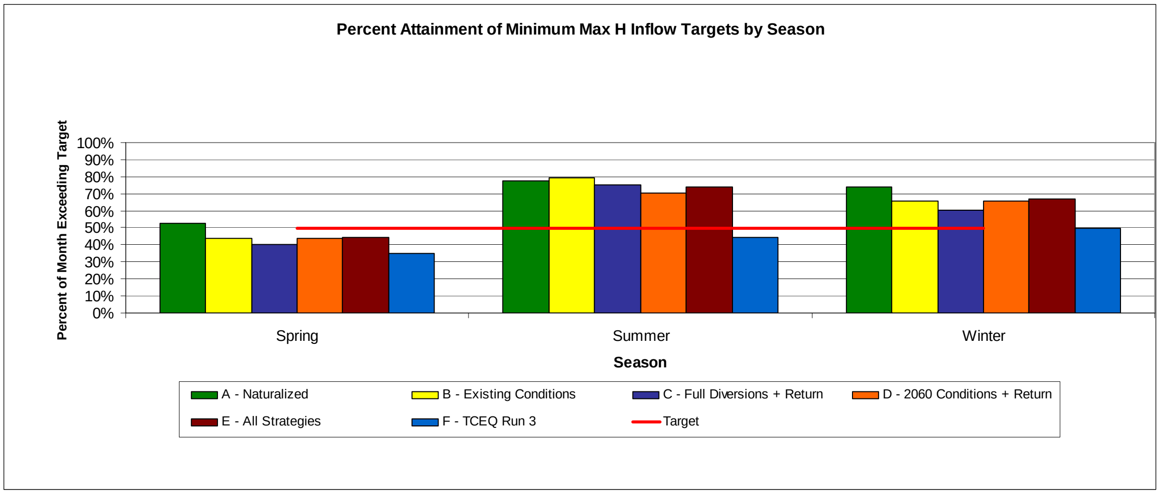
Table 3-2. Frequency of Target Attainment

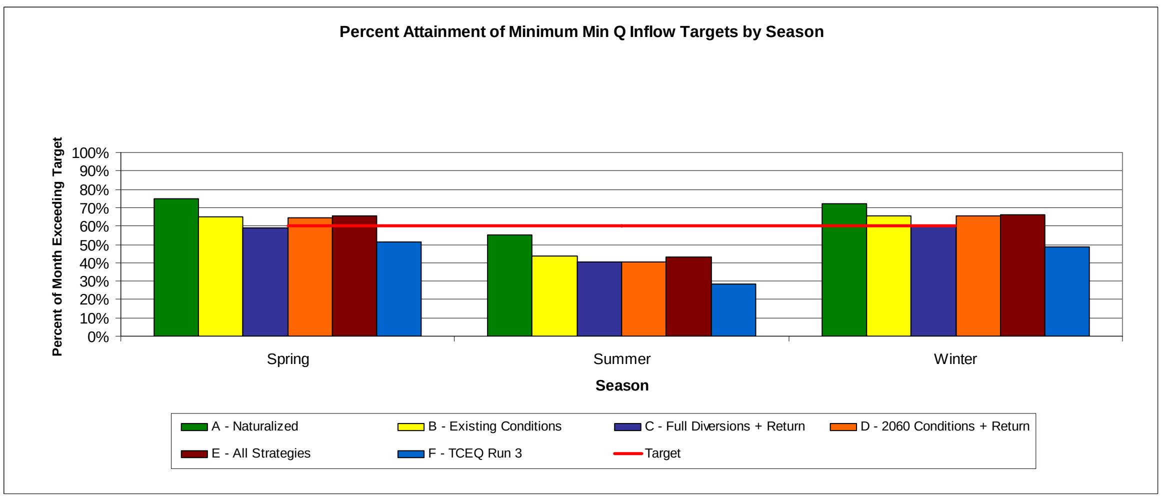
Scenario	**Max H** (%)	**Min Q** (%)	**Min Q-Sal** (%)
GBFIG Recommendation	50	60	75
A - Naturalized	68	67	83
B – Current Conditions	63	58	79
C – Full Diversion	59	53	75
D – 2060 Conditions	60	56	74
E – All Strategies	62	59	77
F – TCEQ Run 3	43	43	56

As shown in the table, the E model meets the recommended GBFIG annual B&E targets at the desired frequency for both the Max H and Min Q-Sal flow. The frequency of attainment for Min Q for the E model is 59 percent, just one percent less than the recommended 60 percent proposed by GBFIG. In general, with the exception of the naturalized flow model and the TCEQ Run 3 model, all of the scenarios examined either achieved or nearly achieved the desired annual frequency of attainment for Max H and Min Q-Sal. The Min Q recommended target frequencies were not achieved under any scenario other than naturalized flow. Note that individual years missing annual targets typically were below the targets by a small amount; however, for purposes of determining annual frequency of attainment, a shortage of even one acre-foot per year counts as failure to meet that year's target.

FTA can also be viewed from a seasonal and monthly perspective, as shown in *Figures 3-2* and *3-3*. For the purpose of this study, three seasons were developed based on the observed flow regime. The spring season was assumed to consist of the months from March through June, while summer was represented as July through October, and the winter season represented as November through February.

Figure 3-2. Seasonal Frequency of Target Attainment





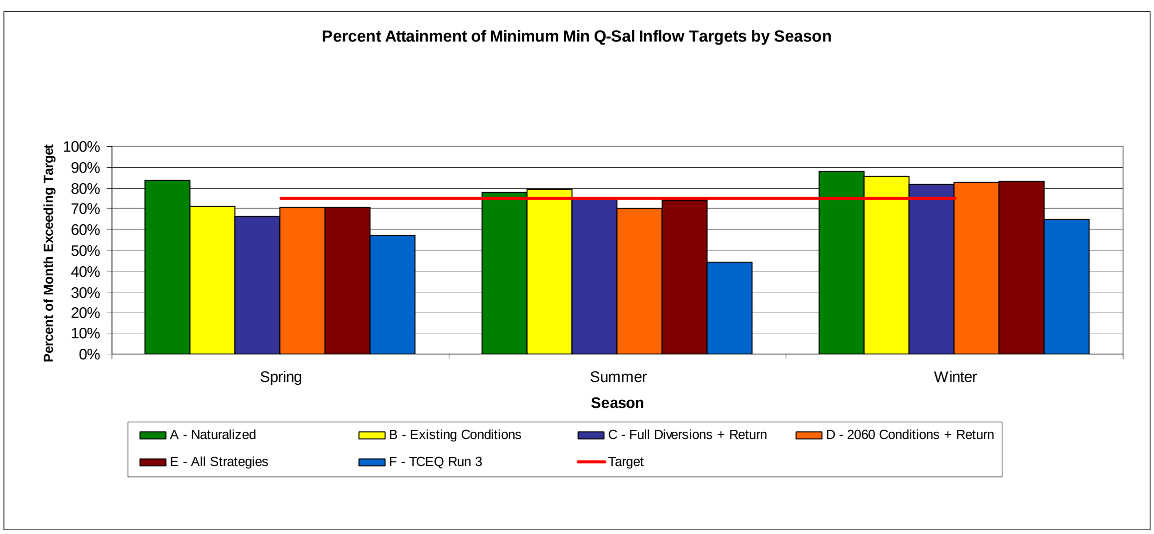
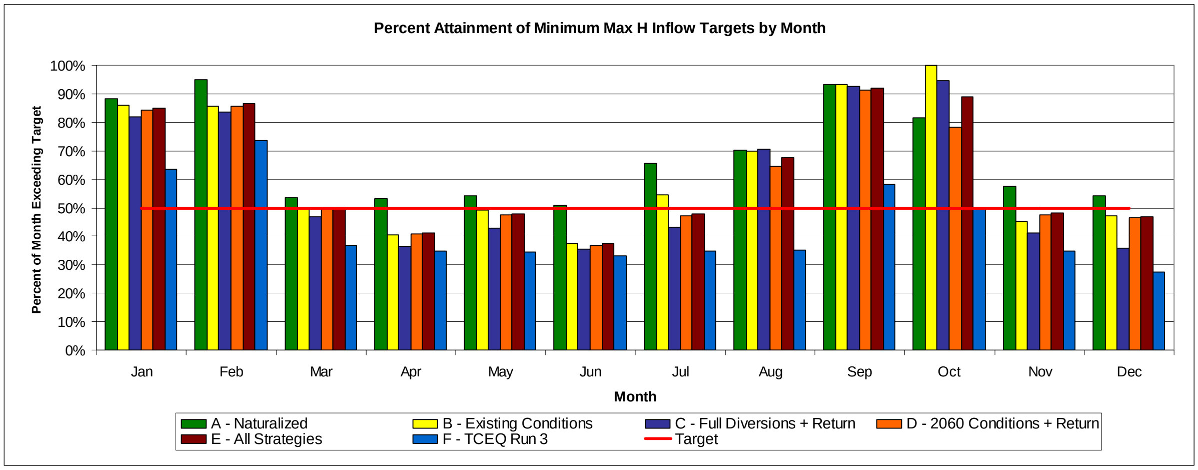
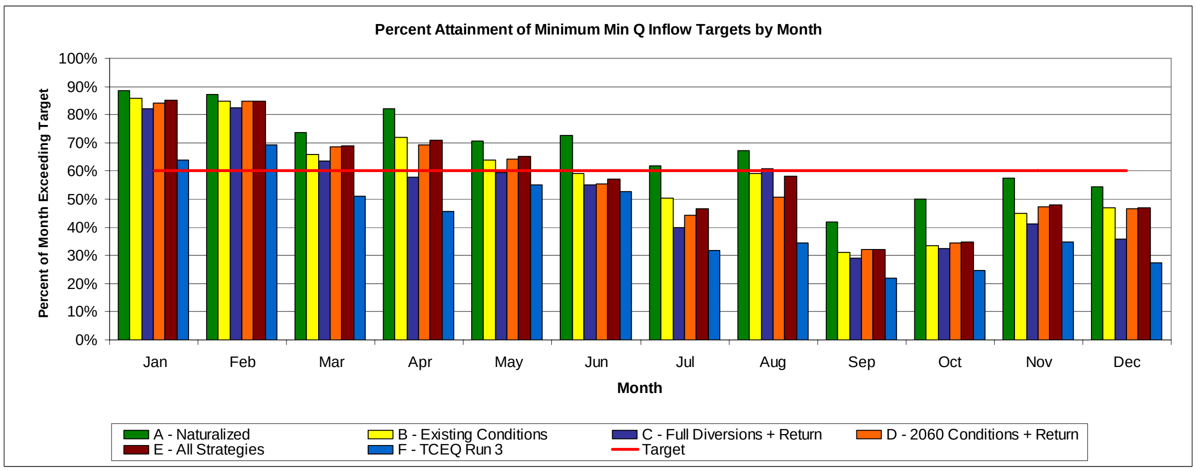
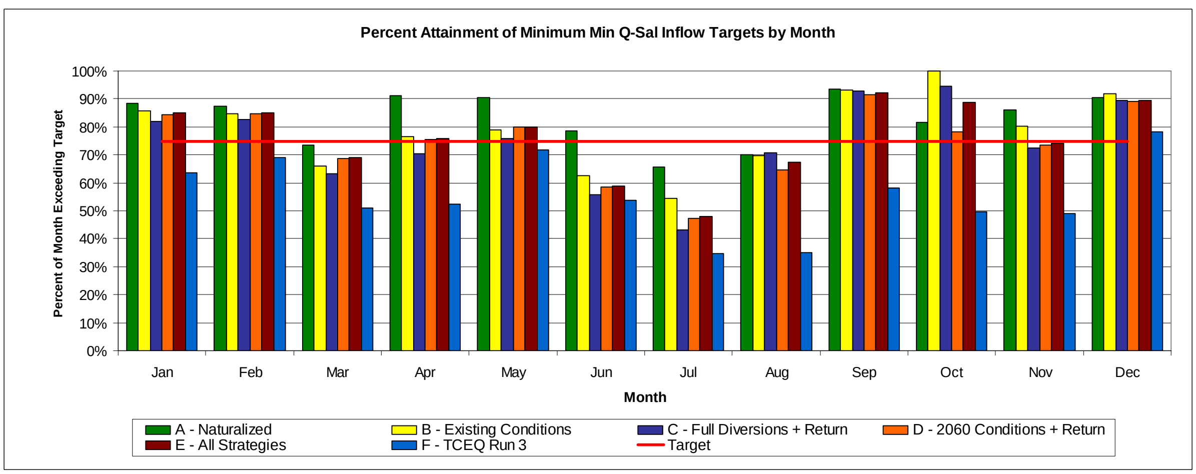


Figure 3-3. Monthly Frequency of Target Attainment







In addition to the E model, all strategies were modeled separately to determine their individual impacts. The impacts of each strategy contributed only minor variation in frequency of B&E target attainment to the base model; the majority of months showed no change, with the few months altered typically varying from the base model by ± 2 percent frequency or less. The exception was the TRA to Houston Contract (D_{12}) model with a volume of 153,000 ac-ft/year, which was up to 10 percentage points higher in meeting frequency goals than the base model on a monthly basis. However, some of the modeled impact of the TRA to Houston strategy is an artifact of the original Full Authorized Diversion models used to develop the base models for this study. In these original models, the full volume of the interbasin transfer was already shown leaving the Trinity basin; however, the importation of water into the San Jacinto Basin from the IBT was not shown. In reality, the IBT would be expected to alter the location of B&E inflows but should not cause an increase in volume. FTA for the D_{12} model in comparison the D_0 and E models is given in *Table 3-3*.

Table 3-3. FTA for D_0, D_{12}, and E Models

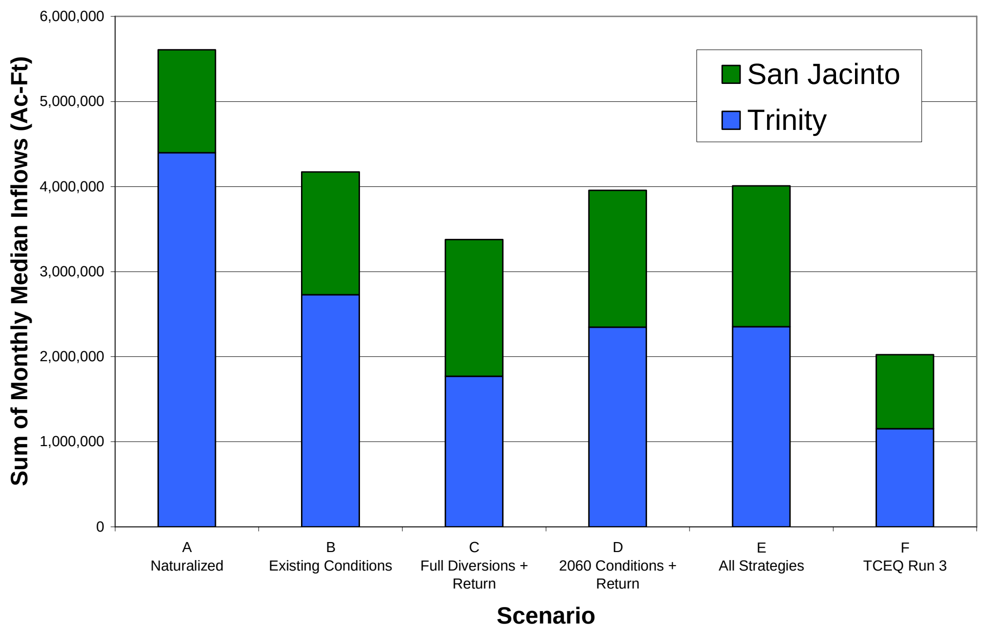
Month	Max H			Min Q			Min Q-Sal		
	[1]D_0 (%)	[2]ΔD_{12} (%)	ΔE (%)	D_0 (%)	ΔD_{12} (%)	ΔE (%)	D_0 (%)	ΔD_{12} (%)	ΔE (%)
1	84	2	1	84	2	1	84	2	1
2	86	2	1	85	0	0	85	0	0
3	50	0	0	69	0	0	69	0	0
4	41	0	0	69	1	2	75	0	0
5	48	0	0	64	1	1	80	0	0
6	37	0	0	56	2	2	58	0	0
7	47	0	1	44	0	2	47	0	1
8	65	2	3	51	6	8	65	2	3
9	91	1	1	32	0	0	91	1	1
10	78	10	11	35	0	0	78	10	11
11	47	1	1	47	1	1	73	0	1
12	47	0	0	47	0	0	89	1	1

1. D_0 represents the FTA for the base model.
2. ΔD_{12} and ΔE values indicate increase in frequency of attainment values from the D_0 model.

3.1.2 Location of B&E Inflows

Implementation of WMS will impact not only the FTA but also the proportion of inflow supplied by each basin. This is especially important given that several strategies proposed involve IBTs of water in the Trinity and San Jacinto Basins. Inflows for the San Jacinto and Trinity Basins for several model runs are shown in *Figure 3-4*. Note that the remaining basins are smaller contributors to overall B&E flow and vary by a smaller amount than the two basins shown. This is largely due to the presence of IBTs for the Trinity and San Jacinto Basins.

Figure 3-4. B&E Contributions of the San Jacinto and Trinity Basins



As shown in the figure, for naturalized conditions as well as the current conditions model, B&E inflows are dominated by the Trinity Basin. The proportion of flow provided by the Trinity is lower for the remaining models, including the C model (Full Authorized Diversions + expected return flow). However, the implementation of upstream WMS shown for the D_0 model causes an increase in the relative contributions of the Trinity as compared to the C model. The proportion is slightly lower for the E model, demonstrating that the Region H strategies slightly increase the proportion of water coming from the San Jacinto Basin. This is largely due to the IBT of water into the San Jacinto system.

3.2 Evaluation of Alternatives for Meeting GBFIG Targets

3.2.1 Concept and Target Conditions

As part of the scope of services for the environmental flows investigation, alternatives were considered to allow the WMS (E) models to meet B&E flow targets at the desired frequency for Year 2060 conditions. This task is not intended to determine flow needs for the bay, nor to develop an applied operational solution for achieving desired B&E flows. Rather, the task is intended simply to use the goals already proposed by TWDB and Region H to evaluate how these goals may be achieved and what impacts to future water supply may result. The models used in this process functioned by modifying reservoir operations to reduce B&E target flow shortages. The goal of the modeling process was to assess if a methodology could be developed to achieve a desired target B&E inflow frequency while also maintaining current and future water supplies (that is, without reducing firm yields). Two sets of modified WMS models were developed, one for Max H and another for Min Q-Sal. Models are based on a Year 2060 full diversion scenario with expected return flows and all modeled WMS strategies (E model base).

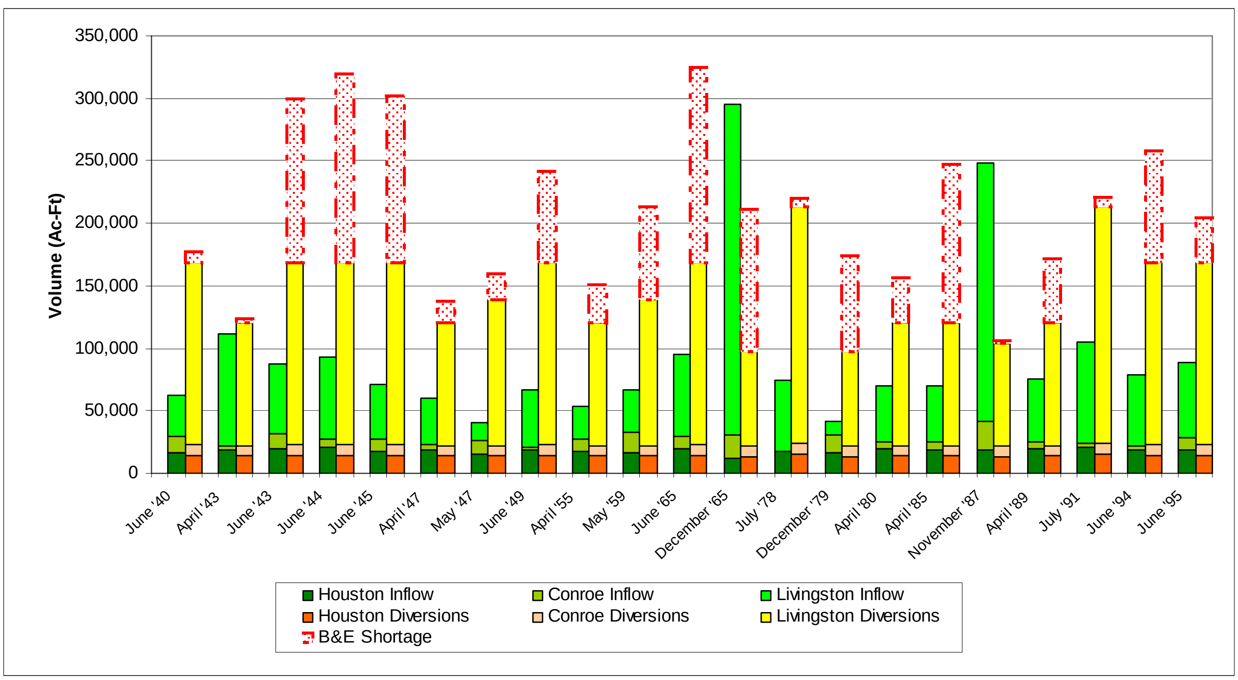
Max H was chosen as a target condition since Max H target flows are achieved at the desired frequency (50 percent of monthly records for each month) under naturalized conditions. Monthly Min Q and Min Q-Sal targets are not achieved at the desired frequency even for naturalized conditions.

The Max H targets represent the proposed peak of total annual fisheries harvest for Galveston Bay bound by the lowest decile and median monthly values and salinity viability limits as output by TWDB methodology. Min Q-Sal was also investigated because it represents a proposed minimum acceptable inflow required to maintain the salinity needed for B&E fisheries productivity rather than the higher flow targets.

3.2.2 Methodology

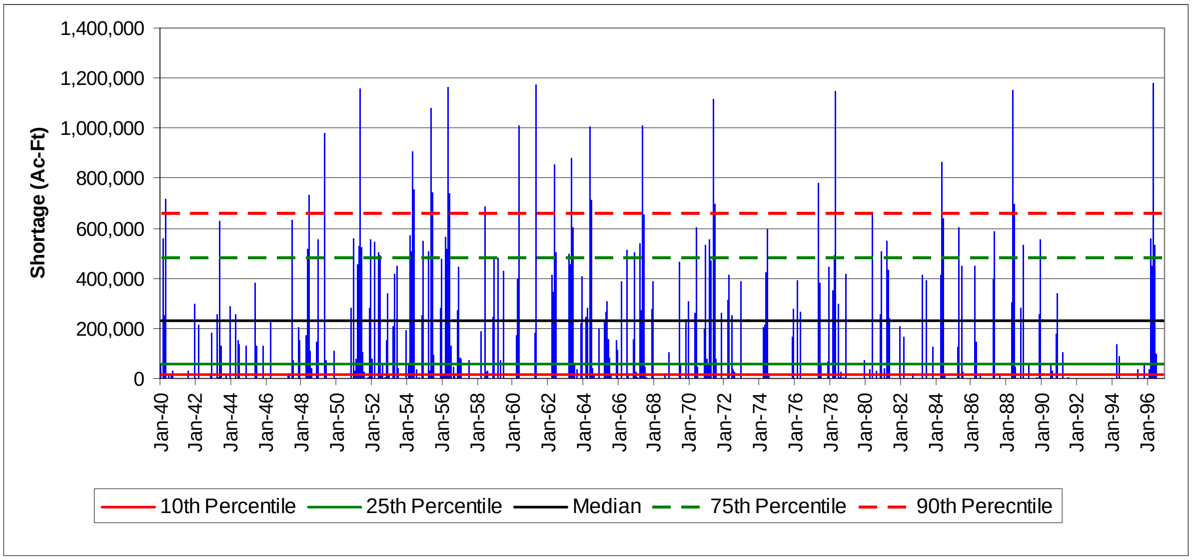
It was assumed that B&E inflow targets are achieved by any flow that equals or exceeds the target flow; thus, flow cannot be too high for the target, but can be too low. A limitation of this approach is that it does not consider a bracket of flow. In some situations, excessive flows could result in less than optimum conditions. It is important to note that the State's Max H, Min Q, and Min Q-Sal flow regimes are not individual flow targets but rather represent optimal harvest when all 12 months in a year are at or near monthly targets. However, Espey Consultants (2008) has noted that the pattern of flows defined by Max H does not occur historically; in order to meet the 50% frequency for Max H, the monthly Max H targets would have to be bracketed by ±1,045 percent. FTA is increased by increasing the number of months meeting the volume target, but not by uniformly increasing volumes. The most efficient way to achieve this is to target the months with the smallest shortages and increase the B&E flows for those months to target levels. The primary concern in selecting a specific approach to increasing flows is avoiding superseding the existing priority system; that is, interfering with existing and future water rights and strategies. Setting an instream flow requirement at the basin outlet or similar approaches using pass-through flows from streamflow would likely impact existing rights. Pass-through flows from reservoirs are also likely to create conflicts with existing rights. As shown in *Figure 3-5*, the amount of water available for reservoir pass-through is also sometimes inadequate to meet existing and future demands, indicating that this could not be used without impacting firm yield.

Figure 3-5. Available Reservoir Water and Demands



The only remaining option, and the one least likely to interfere directly with the priority system, is the discrete release of water from reservoir storage. From a reservoir operations standpoint, this is equivalent to managing releases when shortages for a particular month are less than some specified level. Such an operating scenario in which reservoir releases would be made to address only the smallest B&E target flow shortages would minimize the volume of reservoir releases needed to meet frequency goals and in turn decreases the possibility of reducing the firm yield of existing and future water rights. The range of Max H shortages is shown in *Figure 3-6*.

Figure 3-6. Monthly Target Shortages for Max H



While there are a large number of months with shortages and a median shortage value of 230,000 acre-feet, only a limited number of the smallest shortages must be corrected to achieve the desired frequency goals (50 percent for Max H and 75 percent for Min Q-Sal).

For the Max H condition, frequency of attainment of monthly B&E targets for the E model, described earlier, was compared to the target frequency of attainment. For months with frequencies less than 50 percent, the frequency shortage was defined as the difference between 50 percent and the simulated frequency of attainment. Months with shortages below the targets were identified and ranked in size. Months with the smallest shortages were selected for adjustment by pulling adequate supply out of reservoir storage to meet the Max H target. In WRAP, this was achieved by establishing “dummy” water rights at the basin outlets of the Trinity and San Jacinto Basins. These rights called for reservoir releases (from Lake Houston in the San Jacinto Basin and Lake Livingston in the Trinity Basin) only during the months of smallest shortages identified as described above, with the release amount set slightly larger than the monthly shortage. The outlet rights were not allowed to divert via streamflow depletions and were not allowed to refill reservoir storage after meeting diversion targets. Monthly targets for the dummy water rights were set manually using Target Series (TS) cards associated with the “dummy” water right in each basin. Targets were divided between the two basins based on a ratio of unadjusted monthly reservoir volume. This averaged approximately six percent for Lake Houston and 94 percent for Lake Livingston. The process of determining the number of smallest months and setting reservoir releases was repeated iteratively until the desired 50 percent frequency of attainment was met. The target months selected for modification are illustrated in *Figure 3-7*. Monthly information on frequency of attainment, target reservoir release volumes, and the modified months are given in *Table 3-4*.

Figure 3-7. Frequency and Volume of Reservoir Releases for Max H Attainment

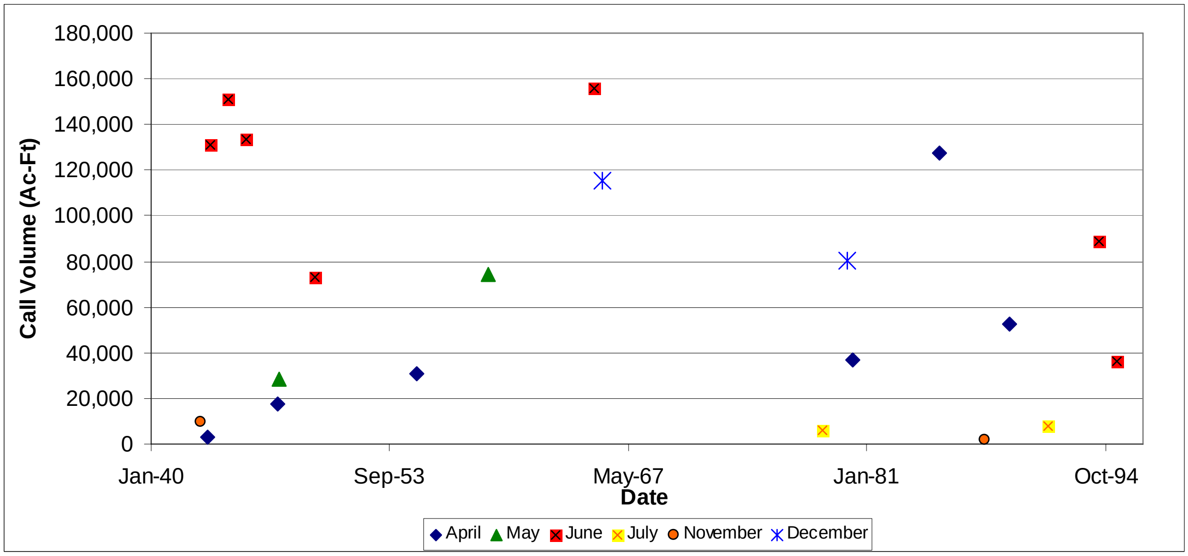


Table 3-4. Frequency of Max H Target Attainment

Month	E Model Frequency (%)	Maximum Target Volume (ac-ft)	Target Percentile of Shortage (%)	Revised Frequency (%)	Months Adjusted
January	85.0			85.0	
February	86.5			86.5	
March	50.3			50.3	
April	**41.0**	127,500	15.1	50.1	6
May	**47.8**	74,200	3.4	50.1	2
June	**37.3**	156,100	20.0	50.1	8
July	**47.9**	7,900	3.4	50.1	2
August	67.5			67.5	
September	92.1			92.1	
October	88.8			88.8	
November	**48.1**	9,400	3.4	50.1	1
December	**46.8**	115,400	3.5	50.1	2

The Maximum Target Volume column gives the monthly upper limit of shortages to be corrected through reservoir releases; shortages greater than this these amounts would not result in a reservoir release for that month. A similar process was carried out for the Min Q-Sal targets, with the goal for frequency of attainment set to 75 percent. Pre-revision monthly target attainment for Min Q-Sal is shown in *Figure 3-8*. Reservoir release calls are shown in *Figure 3-9*, with frequency information in *Table 3-5*.

Figure 3-8. Monthly Target Shortages for Min Q-Sal

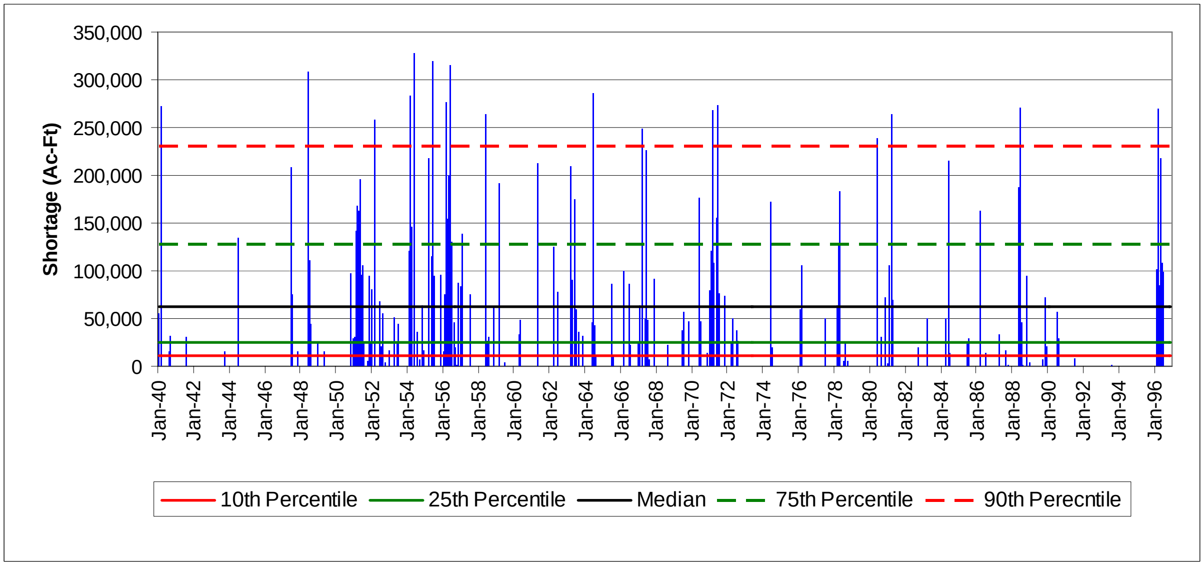


Figure 3-9. Frequency and Volume of Reservoir Releases for Min Q-Sal Attainment

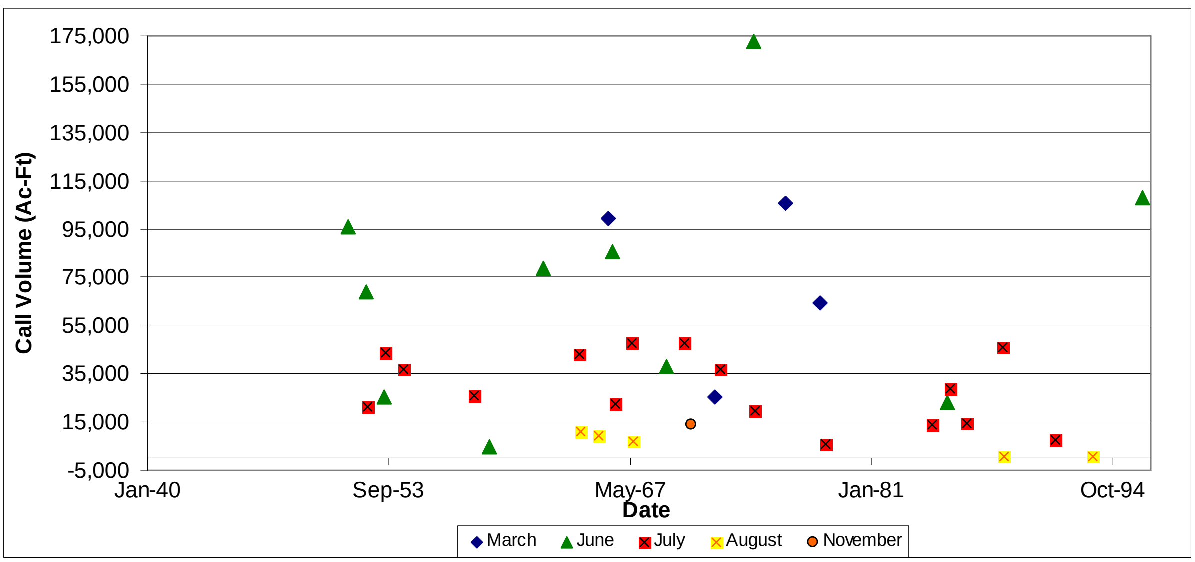


Table 3-5. Frequency of Min Q-Sal Target Attainment

Month	E Model Frequency (%)	Maximum Target Volume (ac-ft)	Target Percentile of Shortage (%)	Revised Frequency (%)	Months Adjusted
January	85.0			85.0	
February	84.9			84.9	
March	**68.9**	105,500	17.6	75.1	4
April	75.7			75.7	
May	80.0			80.0	
June	**58.8**	172,600	39.2	75.1	10
July	**47.9**	48,100	51.8	75.1	16
August	**67.5**	11,200	22.2	75.1	5
September	92.1			92.1	
October	88.8			88.8	
November	**74.0**	14,200	1.5	75.1	1
December	89.6			89.6	

3.3 Impacts to Future Water Supply

The impacts to future water supply as a result of the methodology used to address B&E target flow shortages can be demonstrated as a function of future firm yield and future reservoir storage. The release of stored water from Lake Houston and Lake Livingston will result in a reduction of water supply available for diversion for both of these reservoirs as well as potential upstream supply reductions. Supply impacts can be quantified as a reduction in future firm yield and/or a reduction in future reservoir storage. The following report sections address these supply impacts.

3.3.1 Water Right Yield

Firm yields were also calculated for the E model and revised models for selected water rights to determine the impact of managing for FTA on existing rights and future strategies. The firm yield analysis differed from that used in the previous RWP in that the B&E models include return flows, unlike the 2006 RWP. A similar scenario was used in the last RWP for Lake Livingston; however, other project yields in the 2006 RWP were determined without return flows included. For this study, firm yields were approximated as the minimum annual diversion from model results rather than using a Firm Yield (FY) card in the WRAP model. The key rights targeted included supplies identified in the 2006 RWP as well as potentially impacted WMS. Results from the revised models were compared to the E model to determine any change in minimum annual diversion. The results, shown in *Table 3-6* below, demonstrate that in spite of the significant effects on reservoir levels, the altered reservoir operations used to meet FTA goals do not alter the firm yields of the Trinity or San Jacinto Basins. This is because the reservoirs do not empty at any time during the study and monthly diversions continue to be met from a combination of reservoir inflow and stored water.

Table 3-6. Minimum Annual Diversions for Max H and Min Q-Sal Reservoir Operation

Basin	Description	Permit (ac-ft)	Model Minimum Annual Diversion (ac-ft)		
			E	Revised Max H	Revised Min Q-Sal
San Jacinto	Lake Houston	168,000	168,000	168,000	168,000
San Jacinto	Lake Conroe	100,000	82,266	82,266	82,266
Trinity	COH Livingston	940,800	940,800	940,800	940,800
Trinity	*SJRA/Devers ROR	58,500	58,285	58,285	58,285
Trinity	*COH/Dayton	38,000	34,084	34,084	34,084
Trinity	CLCND - Lake Anahuac	39,613	9,317	9,317	9,317
Trinity	*CLCND Fixed Right - CWA	73,334	73,334	73,334	73,334
Trinity	*SJRA - CLCND Fixed Right - CWA	30,000	30,000	30,000	30,000
Trinity	Livingston - TRA	403,200	403,200	403,200	403,200

*Established through fixed right agreements.

The above results, indicating no impact to firm yield supply due to reservoir releases, is a result primarily of the inclusion of expected return flows in the E model. The import of water coupled with the inclusion of expected return flows in the E model creates significant volumes of water in the lower Trinity and San Jacinto basins made available for firm yield diversions and B&E flow releases. These return flows, however, are not currently permitted for use in the lower basins and it is noted that without the inclusion of these return flows, the impact to future firm yield for the supplies listed in *Table 3-6* would be significantly more pronounced.

3.3.2 Reservoir Levels

Impacts to reservoir volumes in the revised E model for Max H and Min Q-Sal targets are shown in *Figures 3-10* and *3-11*. For Lake Houston, managing releases to meet the Max H and Min Q-Sal frequency goals resulted in extended periods of reduced reservoir volume. Lake Houston does not completely refill after 1942 for Max H and 1951 for Min Q-Sal. While Lake Houston averages 98 percent of full for the unaltered E model during the period of record, the revised Max H and Min Q-Sal models average 90 and 87 percent, respectively. The effects of revised reservoir operations are greater for Lake Livingston, which averaged 95 percent of full volume for the E model, 81 percent for Max H revisions, and 78 percent for Min Q-Sal revisions. As with Lake Houston, Lake Livingston did not refill after 1943 for Max H and 1951 for Min Q-Sal.

Figure 3-10. Lake Houston Storage Volume for Revised Reservoir Operation

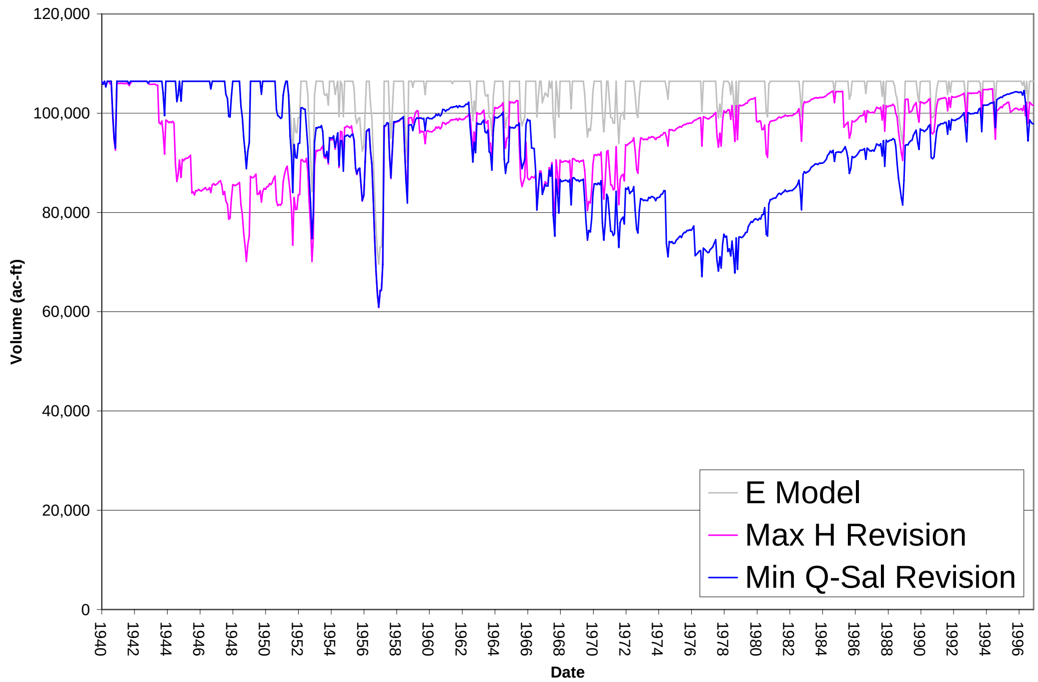
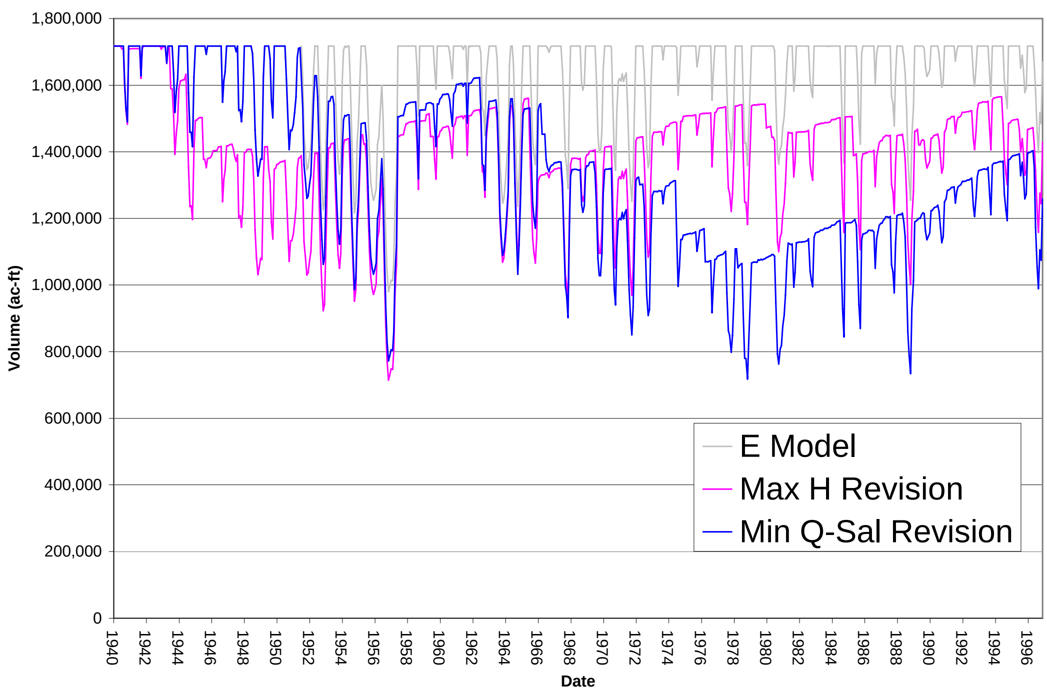


Figure 3-11. Lake Livingston Storage Volume for Revised Reservoir Operation



Section 4 – Evaluation of Instream Flow Requirements for Future Water Management Strategies

4.1 Identification of Critical Segments

A list of 26 segments with the potential to be impacted by Region H WMS was developed from a compilation of segments studied in the TWDB Streamflow Assessment found in the 2002 SWP. Regulated flows at the 26 segments were determined for the base (D_0) models as well as for all WMS models, including the composite E model. Based on monthly results for the model simulation period, 10th percentile flows were calculated to investigate low flow conditions. For each WMS, 10th percentile flows at each of the 26 segments were compared to the D_0 models. For each WMS, the stream segment with the greatest (absolute) percentage difference from the base model was considered to be the most critical segment for that strategy (see *Exhibit 2*). For the 13 strategy models, six segments were identified in the Brazos and San Jacinto Basins as being particularly influenced by Region H WMS. Lyons flows, generally considered to represent a general low-flow condition adequate to maintain sound ecologic function, were calculated for the segments for comparison purposes. Please note that Lyons flows were developed from WAM Run 8. A summary of highly impacted segments is presented in *Table 4-1.* An expanded summary of instream flow critical segments, along with graphical representation of strategy impacts on a monthly basis, are provided in *Appendix C*.

Table 4-1. Impacts of WMS Implementation on Critical Stream Segments

WRAP Identifier	Basin	Strategy	10th Percentile Flows			Lyons Flow (ac-ft)
			D_0 (ac-ft)	Strategy (ac-ft)	Change (%)	
532801	Brazos	Freeport Desalination	41,101	40,776	-0.8	68,751
		BRA System Ops		39,246	-4.5	
		Allens Creek		40,027	-2.6	
BRRI70	Brazos	Little River	55,925	55,028	-1.6	78,697
		Houston to GCWA		55,324	-1.1	
SPSP	San Jacinto	TRA to Houston	1,461	4,223	189.1	1,607
		TRA to SJRA		2,736	87.3	
		All Strategies		5,522	278.0	
1004	San Jacinto	Expanded GW	2,082	2,937	41.1	2,444
A5191P	San Jacinto	Indust. WW Reuse	59,845	56,482	-5.6	39,041
		Houston Indir. Reuse		56,863	-5.0	
		NHCRWA Indir. Reuse		59,039	-1.3	
SRGB	San Jacinto	Lake Houston Yield	65,550	66,973	2.2	43,805

With the exception of the Freeport Desalination and the Houston to GCWA transfer strategies, WMS from increased inputs such as increased groundwater, IBTs, or additional permitted reservoir yield resulted in positive impacts to 10th percentile flows. These positive impacts tended to occur year round, but were greatest during the summer months with some indicating large increases in flow through early fall. The remaining strategies, which resulted in an overall negative impact (i.e., reduced flows) at the critical segments, fell into two distinct groups. The three wastewater reuse strategies (Houston, NHCRWA, and industrial), along with the Freeport Desalination strategy, caused fairly uniform reductions to 10th percentile flows throughout the year, with little or no seasonable variability. For the Freeport Desalination WMS, the critical segment is located upstream of the WMS inputs locations. This suggests that these increases are firming up downstream rights using increased constant inputs, resulting in reduced pass-through flows in upstream segments. The remaining reduction-causing WMS were the three reservoir strategies (BRA System Operations, Allens Creek, and Little River) and the Houston to GCWA transfer. Unlike the reuse WMS, flow reductions were not uniformly distributed and tended to intensify during the spring and summer seasons.

The greatest positive impact for any critical segment was a result of the TRA to Houston Transfer, which created an overall increase in 10th percentile flow of 189 percent. The greatest reduction was -5.6 percent for industrial wastewater reuse. For the model representing full implementation of all strategies (E), the change at the critical segment was a positive increase of 278 percent.

As shown in *Table 4-1*, strategy flows in the San Jacinto Basin exceeded Lyons flow levels, while the Brazos Basin strategy flows were well below calculated Lyons flows; one should note that for the critical segments in the Brazos Basin, 10th percentile flows for D_0 were already lower than Lyons flows. The observation that a number of strategy flows in the San Jacinto Basin exceeded the Lyons flows, even when strategy impacts reduced flow, suggest that categorization of a segment as critical is not a clear indication of its ecological condition.

4.2 Lyons Flows and Field Evaluations

The identification of critical segments described above was paired with a field study to enhance understanding and applicability of flow conditions at the identified segments. While points were labeled as critical, identification as being most impacted does not in of itself reveal whether low-flow or reduced-flow conditions represent an ecologically degraded state. For this reason, the second stage of the instream flow study involved calculating Lyons flows for relevant segments combined with field evaluation of instream flow conditions. Results were then used to examine possible environmental repercussions of WMS. Lyons flows were calculated based on regulated flow rates for the Current Conditions (Run 8) model; values were calculated as 60 percent of median flows for March through September and 40 percent of median flows for October through February.

Field examination of stream segments provided a visual assessment of ecological conditions of the segments. This was combined with quantitative measurement of stage and flow from the United States Geological Survey (USGS) gauges, which enabled qualitative analysis of stream condition to be related to calculated Lyons flows. Seven stream segments were identified in the Brazos, San Jacinto, San Jacinto-Trinity, and Trinity Basins from the TWDB Streamflow Assessment for inclusion in the field study. Selected segments were chosen based on accessibility, availability of streamflow measurement (proximity to reliable USGS gauges), and reliable flow output from WRAP. Sites were examined during a low-flow period in late July 2008 so that recorded flows would be representative of low flow conditions. Segments were primarily evaluated for Channel Flow Status (CFS) based on TCEQ Surface Water Quality Monitoring (SWQM) procedures (TCEQ 2003). Flow status was defined as high if less than five percent of channel substrate was exposed; moderate if five to 25 percent was exposed; and low if greater than 25 percent was exposed. Observations were also made of any potential wetlands or riparian corridor in observable range of the survey point. A description of each survey point along with site photographs and observed and Lyons flow are located in *Appendix D*. A summary of Lyons and observed flows is presented in *Table 4-2* below.

Table 4-2. Lyons and Observed Flows for Field Study Points

WRAP ID	Location	Lyons Flow (cfs)	[1]Obs. Flow (cfs)	[2]Low Flow Days	[3]CFS	Potential Wetland (Y/N)	Potential Riparian Corridor? (Y/N)
8TRRO	Trinity River near Romayor	1,098	1,000	58	M	N	Y
802	Trinity River at Liberty	1,217	<1,217	NA	M	N	Y
9CBCR	Cedar Bayou near Crosby	4	0.6	6	L	N	N
A3979A	Luce Bayou near Huffman	12	0.2	64	L	Y	Y
1004	W Fork San Jacinto near Porter	40	23	20	M	Y	Y
1009	Cypress Creek near Westfield	40	30	1	H	N	N
532801	Brazos River near Rosharon	1,118	208	15	L	N	N

[1]For segment 802, a flow gauge reading was not available during the observation period. However, flow was estimated to be below the Lyons flow as the recorded stage during the observation period was below the stage associated with the Lyons flow.
[3]Number of days prior to observation with average daily flow below Lyons Flow
[3]L = Low, M = Moderate, H = High

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Section 5 – Discussion

5.1 Bay and Estuary Inflows

5.1.1 Changes in Volume, Timing, and Location of B&E Inflows

The overall impact of strategy implementation is shown in *Figure 3-1*, *Section 3.1.1*. The figure demonstrates that the strategy model (E), while slightly lower than current conditions (B) for several months of the year, is well above B&E flows for the TCEQ Full Authorized Diversion (F) model. As noted earlier, this is partially due to the inclusion of WMS and partially due to the inclusion of expected return flows (see the C model curve). Although the dynamics of the model make explicitly tracking water from its source (return flow vs. WMS) difficult, some idea of the relative importance of the two can be gathered from comparing C, D_0, and E model monthly medians to those from the F model. Using this approximation, on a monthly basis between 36 and 100 percent of the increase in flow above the F model is attributable to return flows; in fact, for two months the C model median flow exceeds the E model, demonstrating that for some months WMS implementation causes a reduction in B&E discharge. This is not, however, an indication that WMS have a negative impact on B&E flows.

Based on the comparison of C and E models, WMS create an increase in B&E discharge over return flows for all months except August and October, with monthly increases as high as 209,800 ac-ft. This includes WMS for both Region H and upper basin WMS. Comparing the D_0 and E models to the C model, the majority of increase in monthly medians over the C model is observed in the D_0 model, with the E model tending to be only slightly higher than the D_0 model. This suggests that the upstream Region C WMS tend to have a greater impact on B&E flows than the proposed Region H WMS examined in this study. There were several exceptions, with greater Region H impacts for July, August, and October. For all three of these months, the models indicated a decrease in monthly median flow caused by upper basin WMS that was wholly or partially negated by Region H WMS. Overall, Region H WMS increased monthly median flows by 5,000 to 17,100 acre-feet. This small volume relative to total B&E inflow, in addition to the generally much greater contributions of Region C WMS, suggests that the impacts of Region H WMS on total B&E flows will be minimal.

Strategy D_{12}, the TRA to Houston transfer, was identified earlier as the WMS with the greatest individual impact. By strategy volume, this was the second largest strategy at 152,700 acre-feet per year, with only the Brazos System Operations WMS (163,700 acre-feet per year) being larger. Please note that this does not include contractual transfers which could not be modeled. The BRA System Operations strategy created minor increases in monthly median B&E flow for most of the year, but created a reduced discharge for November and December. Strategy D_{12} created increased median monthly B&E discharge year round, with changes varying from approximately 4,600 to 14,200 acre-feet.

As shown in *Figure 3-2*, for both Max H and Min Q-Sal, failure to meet B&E targets at the recommended frequency occurs primarily during the spring for all models except naturalized flow. For Min Q, failure to meet targets with sufficient frequency occurred primarily during the summer. The TCEQ Run 3 model failed to meet targets at recommended frequency for all seasons for all three targets. Please note that for the Min Q target, B&E flows do not meet the target with adequate frequency for the summer season under any flow condition, including naturalized flow. On a monthly basis (*Figure 3-3*), the E model failed to meet attainment frequency goals for Max H for six months (April – July, November, December), Min Q for seven months (June – December), and Min Q-Sal for five months (March, June – August, November). For all but one of these months, the desired FTA was also not reached by the current conditions model. For Min Q and Min Q-Sal, naturalized flows failed to meet targets with adequate frequency for several months. For Min Q, the naturalized condition was below target attainment for September through December. For Min Q-Sal, naturalized flows failed to meet frequency goals for March, July, and August.

The function of the Galveston B&E system is influenced by a number of factors. The seasonal variability of WMS effects is highlighted by the results discussed in the preceding paragraphs. Beyond volume and timing of flows, one should also consider the relative proportion of inflows contributed by each basin. While the TWDB flow targets treat the B&E system as a single unit, in reality the B&E system is not perfectly homogeneous across all locations. Local ecological dynamics may vary from one basin outlet to another and among the various parts of the estuary system. As noted earlier, the Trinity Basin dominates inflows into the B&E system, followed by the San Jacinto Basin, with the other rivers making relatively minor contributions. Viewed over the entire period of record, movement from a naturalized condition (A model) to current conditions (B model) shows a substantial shift toward the San Jacinto Basin, while the Future 2060 Conditions with strategies (E model) has similar proportions to current conditions. Viewing the proportions of flow on the basis of monthly medians reveals a more substantial impact. While the proportion of flow for the Trinity Basin in the B model is reduced by 11 percent or less from naturalized conditions for December through June, the remainder of the year shows a reduction in median proportion of 25 to 49 percent. The proportion of flow from the Trinity Basin during this half of the year is further decreased in the E model, with median flows for July through October reflecting little or no contribution from the Trinity Basin.

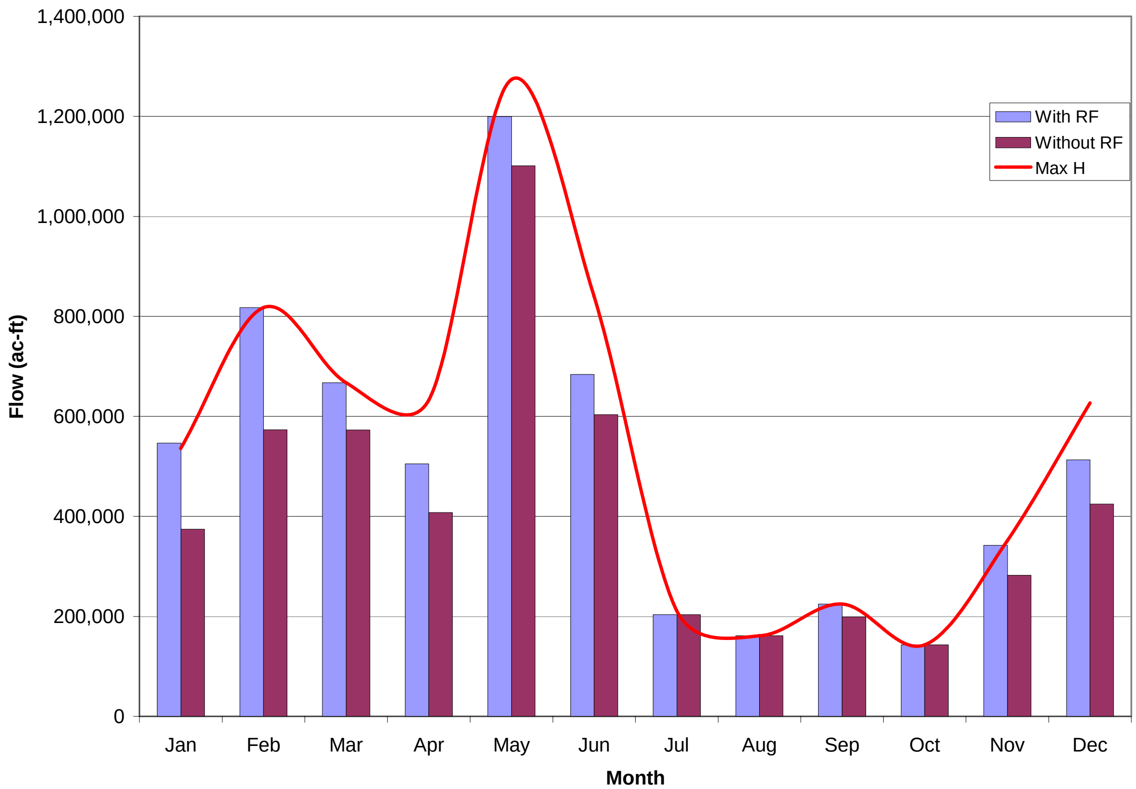
The extended period of low median monthly contributions from the Trinity Basin reflected under non-naturalized conditions, especially for the E model, bears consideration due to the potential for excessive local salinity and ecological damage. However, two factors suggest that inflow location change caused by strategy implementation would not be inherently responsible for damage to the B&E system. The first factor is that the majority of the change in flow location is present in the current conditions model, which represents the existing, healthy condition of the B&Es. The second factor is that the further shift away from the Trinity Basin and the resultant four month period of near-nonexistent flows are not a function of strategy implementation, but rather an artifact of a Full Authorized Diversion condition. Examination of median monthly flows (*Appendix B*) for the C (Full Authorized Diversions with Return Flow), D_0 (C Model + Upstream WMS), and F (TCEQ Full Authorized Diversion) models shows that all three have extremely low B&E discharge in the Trinity Basin during the period of concern. While the C model has higher flows in the Trinity Basin than the F model during the period of concern, the strategy models (D_0 through E) have lower flows, implying that strategy implementation does result in some flow reduction. However, the fact that the D_0 and E models have identical median discharges during this period suggests that additional shift of water away from the Trinity Basin could be largely a result of upstream strategies.

5.1.2 Upper Basin Return Flows

Upper basin return flows are an important consideration in this study due to their inclusion in the base model and, in particular, the substantial contributions made by Region C return flows to Region H in the Trinity Basin model. Water imports into the upper Trinity River Basin account for additional return flows that may potentially be an important source for both lower basin water rights and B&E inflows. This is made even more important due to the Trinity being a source basin for several major IBTs to the San Jacinto supplying the major demand centers in Region H. The importance of return flows to the WMS models presented in this study is highlighted by a comparison of the C and F model results. For every month of the full period of simulation, the addition of return flows in the C model resulted in increased B&E flow over the F model, with a minimum monthly increase of 27,897 acre-feet and a median increase of 80,878 acre-feet.

In addition to the primary models carried out for the study, an additional secondary model was developed to determine the effects of removing upper basin return flows from the Trinity model for expected Year 2060 conditions. Using the unmodified E model as a base, non-Region H constant inflow cards were removed from the model code, along with any identified Region C return flows not explicitly associated with modeling reservoir operations. The revised model was executed and examined on the basis of B&E discharge and minimum annual diversion (as a proxy for firm yield) for key supply rights. As shown in *Figure 5-1*, removal of upstream return flows resulted in substantial reductions of median flow for the first half of the year, with relatively smaller changes for the rest of the year. Over the entire period of record, this is equivalent to a 20 percent reduction in B&E discharge from the Trinity Basin.

Figure 5-1. Comparison of Trinity Basin B&E Median Monthly Discharge With and Without Region C Return Flows



As seen in *Table 5-1*, of the seven major supply rights examined, six experienced a reduction in firm yield due to removal of upper basin return flows. These reductions in firm yield ranged from 34 to 54 percent, with the year of minimum annual diversion occurring primarily in 1956 during the drought of record. As such, any future Region C WMS which reduces return flows to Region H will have the potential to substantially alter B&E flow regimes as well as the firm yield of water rights in the Trinity and San Jacinto Basins.

Table 5-1. Minimum Annual Diversions With and Without Upper Basin Return Flow

Basin	Description	Permit	E Model		E Model without RF	
			MAD (ac-ft)	Min. Date	MAD (ac-ft)	Min. Date
Trinity	COH Livingston	940,800	940,800	NA	536,303	1956
Trinity	*SJRA/Devers ROR	58,500	58,285	1950	33,718	1956
Trinity	*COH/Dayton	38,000	34,084	1956	15,846	1956
Trinity	CLCND - Lake Anahuac	39,613	9,317	1956	9,317	1956
Trinity	*CLCND Fixed Right - CWA	73,334	73,334	NA	43,207	1956
Trinity	*SJRA - CLCND Fixed Right - CWA	30,000	30,000	NA	17,322	1963
Trinity	Livingston - TRA	403,200	403,200	NA	264,408	1956

5.1.3 Frequency of Target Attainment

The evaluation of alternatives for meeting TWDB targets at GBFIG-recommended frequency was successful for both Max H and Min Q-Sal conditions; the desired FTA was met for both conditions while maintaining minimum annual diversions for current and future water supplies. The annual yields for major supply rights were not impacted, primarily due to significant upper basin return flows in the Trinity Basin as discussed in *Section 5.1.2*. 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 ac-ft) and for Lake Livingston by 17 percent (284,603 ac-ft). The storage loss was larger for the Min Q-Sal condition, with the median storage level reduced by 11 percent (12,069 ac-ft) in Lake Houston and 24 percent (404,816 ac-ft) in Lake Livingston. The greater loss of storage for Min Q-Sal may seem counterintuitive, given that the monthly targets are less than or equal to the Max H targets (48 percent of Max H on an annual basis); however, the FTA for Min Q-Sal is greater (75 percent vs. 50 percent) than that for Max H. Because the methodology used in this study attempts to modify frequency and therefore minimizes the volume required to meet FTA, it appears that the loss of storage may be unavoidable unless the desired FTA differed from the current GBFIG recommendation.

Results of the alternative analysis are focused on and are applicable only to expected Year 2060 conditions. Due to the staging of scenarios and return flows over time, the most critical scenario for FTA or reservoir response may occur at an intermediate decade or decades. The Region H planning scope for the 2011 RWP has elements to address pre-2060 decades during the second biennium of the plan.

5.1.4 Considerations

There are a number of concerns related to the presented evaluation of alternatives for meeting FTA. Foremost, the approach used to meet FTA is a “hard-wired” approach that couldn’t be realistically replicated as a reservoir operating rule. The operating rule applied in the model equates to, “If monthly flow *Y* is less than monthly minimum *X*, release (*X*-*Y*) of additional water from the reservoir.” However, actual application of this rule would require foreknowledge of total flow for the upcoming month. Additionally, reservoirs are operated at timescales much smaller than a monthly basis. Even if future shortages could be known on a monthly basis, there would be no clear way to translate this into daily operational rules; trying to apply FTA on a daily basis would also be unreasonable.

Another predictive issue is related to reservoir operation and the maintenance of firm water supplies for both anticipated and unexpected conditions. If drought exceeds the known drought of record, simulated in this study, reservoir storage may be critical for maintaining firm yield. Although drops in reservoir level in this exercise never impacted yield, the maintenance of a reduced reservoir level reduces a water supply's protection against unforeseen drought conditions. Furthermore, it is noteworthy to observe that the reservoir levels at the end of the revised reservoir operation simulations never reach a full level. In both the model and actual operation, the reservoirs of concern are not refilled at a set priority through a water right or agreement but rather are limited to impounding unappropriated flows available at the reservoir location. Even if one assumes that the period of record is representative of future conditions to come, successive cycles of the period of record would result in continually dwindling reservoir levels and, ultimately, a loss of firm yield.

Another concern with the approach taken is the validity of assuming that annual GBFIG targets are applicable on a seasonal or monthly basis. Sub-annual time scales are clearly of importance; it is mathematically possible to meet an annual flow target while flows for one or more months could be low enough to be ecologically inadequate. Whether FTA is more critical for some seasons or months than others has not yet been established. The application of the annual GBFIG FTA to monthly targets was made due to a lack of a more reasonable alternative and should be studied further.

Finally, while the purpose of this study is not to evaluate B&E needs or develop new flow targets or FTA, the underlying assumption that B&E flow needs are met if the desired FTA is achieved must be considered critically. One potential concern is that this approach does not consider a bracket of flows, but only if the flow equals or exceeds the desired B&E flow. This does not account for the possibility that, in some circumstances, excessive flows may also result in less than optimum conditions. It is important to remember that the State's Max H, Min Q, and Min Q-Sal flow regimes are not made up of individual flow targets but rather represent optimal harvest when all 12 months in a year are at or near the monthly target. However, Espey Consultants (2008) has noted that the pattern of flows defined by Max H does not occur historically; in order to meet the 50% frequency on Max H, the monthly Max H targets would have to be bracketed by ±1,045 percent. Monthly flow patterns for the Max H and Min Q-Sal models are given in *Figures 5-2* and *5-3*. As seen in the figures, the revised model median for Max H and 25th percentile for Min Q-Sal (corresponding to 50 and 75 percent FTA) are at or above the target values for all months of the year. While this means that the FTA requirement has been met using the definitions and assumptions for this study, the difference in distribution between the targets and revised models indicate flow conditions that do not meet optimum goals as provided by TWDB targets. Additionally, it is important to recognize that these are percentile distributions; even if the median or 25th percentile curve perfectly matched the targets, this does not guarantee that every month of a particular year was at or near target as required to meet TWDB's definition of optimal performance.

Figure 5-2. Distribution of Monthly B&E Inflows for Max H Revised Operation Model

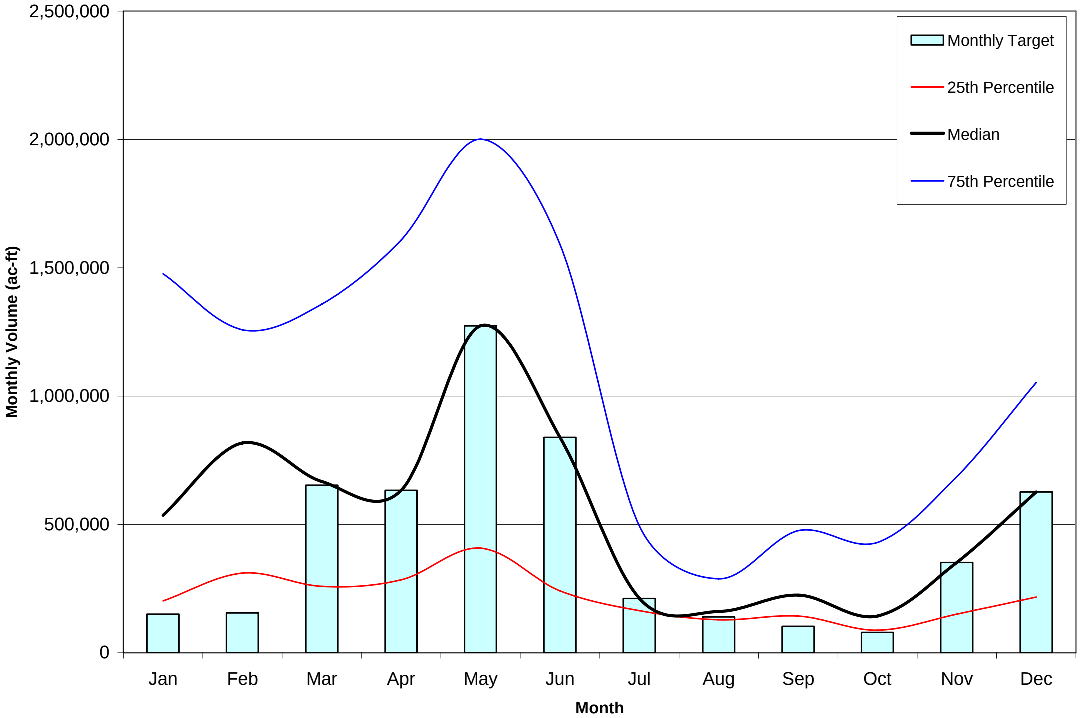
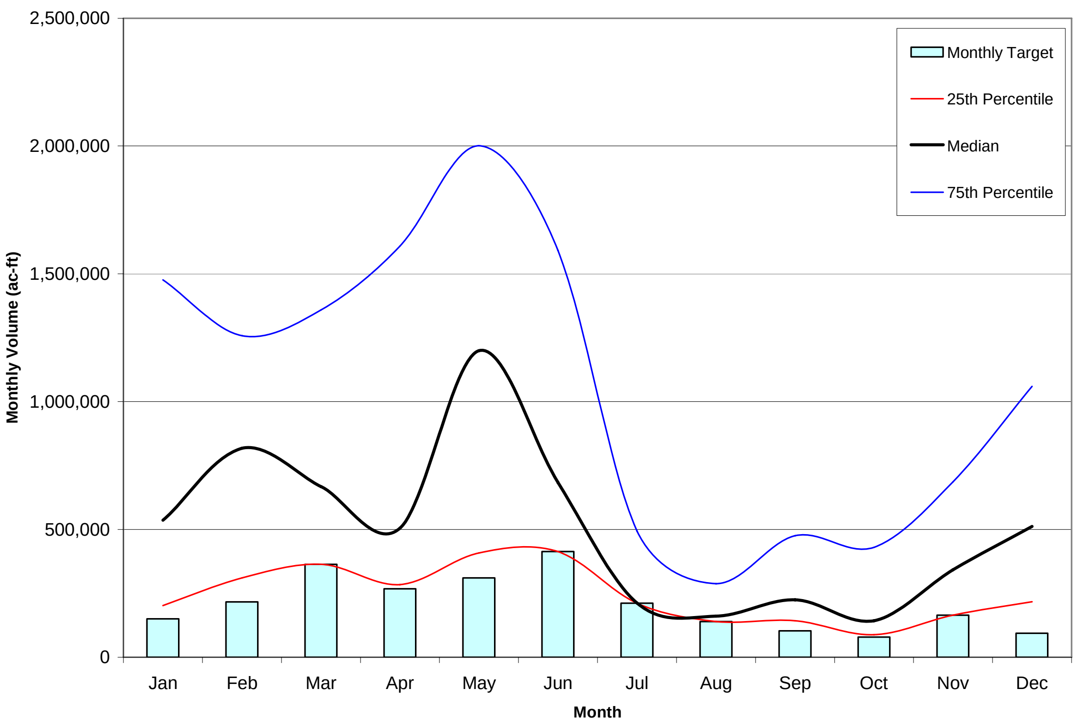


Figure 5-3. Distribution of Monthly B&E Inflows for Min Q-Sal Revised Operation Model



5.2 Instream Flows

5.2.1 Critical Segments

As shown in *Table 4-1* in the preceding section, the critical (most impacted) segments for the various strategy models occurred at six locations in the San Jacinto Basin and lower portion of the Brazos Basin. The critical changes in the San Jacinto Basin are predominantly increases due to increased supply (IBTs, increased groundwater inputs, Lake Houston yield) to the San Jacinto Basin and decreases created by reuse strategies. While one would expect the large IBT projects to substantially impact the source (Trinity Basin) basin, this is not the case due to the large IBTs being included in the TCEQ Full Authorized Diversion (F) model, which was used to build the base model (D_0) for Region H WMS implementation.

The positive increases in flow due to IBTs occurred year round but were greatest for the summer period. Due to the approximately uniform distribution of additional supply from IBT strategies in the source basin, this is not due to the monthly input distribution. Rather, for the base (D_0) model, median and 10th percentile flows in the San Jacinto Basin tend to be lower during the summer and early winter months, especially at the critical segments. Since flows at these points tend to be low during the summer, the proportional change caused by the uniform input is greater than for higher-flow periods. The reduction in flow at some segments in the San Jacinto due to reuse may seem counterintuitive since additional demands are being met without the development of new water sources. However, the reuse strategies result in either a reduction of return flows to streams or the withdrawal of return flows at some point as part of a bed and banks permit conveyance. The same is true of other points impacted by these strategies (see *Appendix C*).

Critical stream segments in the Brazos Basin were impacted mainly by reservoir projects, as well as the Houston to GCWA transfer and Freeport Desalination. All critical segments in the Brazos Basin showed decreased 10th percentile flows to WMS due to diminished pass-through flows from upstream rights, even for the increased supplies created by Freeport Desalination and the Houston to GCWA transfer. The change in 10th percentile flow at critical segments in the Brazos Basin, though consistently negative, was minor on an annual basis, with decreases of 4.6 percent or less annually. Changes were also generally small for monthly 10th percentile values, with the exception of a 28 percent reduction in May for the Allens Creek WMS. For these two strategies, the critical segments are located upstream of the locations of increased input. This suggests that, unlike the increased supply strategies in the San Jacinto Basin, these increases are firming up downstream rights using increased constant inputs, resulting in reduced pass-through flows in upstream segments. The BRA System Operations and Allens Creek strategies showed the greatest percent reduction in flow during the winter and spring months, due to “scalping” of higher seasonal flows. The Little River Off-Channel Reservoir exhibited its largest change in August. This is a function of the peaked monthly usage distribution pattern associated in the model with the Little River Off-Channel diversion, which reaches its highest levels in July and August and is substantially lower for the remainder of the year.

5.2.2 Field Observations

As noted in the results earlier, field observations of flow and environmental condition were made at seven locations during a period of low flow conditions of approximately Lyons flow levels. Because natural variations in flow precluded examining all of the stream segments simultaneously at exact flow rates, observed flows were somewhat lower than the Lyons value. USGS flow values, where available, varied widely in relation to the target condition for field observation, ranging from 2 to 91percent of Lyons flow. Based on CFS indicators, the observed flow status was primarily low to moderate. By the definition of Lyons flows, the observed flow conditions at all visited segments would represent an ecologically distressed condition. However, classification of several segments as moderate flow status, along with observations of channel condition and vegetation, did not indicate significant ecological degradation (see *Appendix D* for photographs and summary). While some observed locations did show indications of mild bank erosion, streams generally appeared in fair to good condition, with healthy vegetation and observed presence of aquatic wildlife. None of the segments examined showed signs of ecological degradation caused by low flows. For several stations, flows had been low for an extended period but only below the Lyons flow for a short time or oscillated above and below the Lyons Flow. However, for the Trinity River at Romayor and Luce Bayou near Huffman, average daily flows had been below Lyons flow for approximately two months. Grass growth near the water line in some locations confirmed this extended low flow period. In spite of this, significant ecological degradation was not observed and in fact the Trinity River showed a "moderate" channel flow status. While it appears that the Lyons flow and TCEQ channel flow status both have some merit in indicating general comparative levels of flow for the stream segments, neither appears to serve as a clear indicator of stream health, at least at the timescales observed. It is possible that for more prolonged low flow periods ecological conditions would eventually coincide with the indicators.

Additionally, it is important to note that observations were taken as closely as possible to easily accessible USGS gauging stations to get accurate flow results. These stations are typically located at bridges and stream crossings which have generally been channelized or altered to some degree and may not perfectly represent more natural segments immediately upstream or downstream.

Visual observations of more natural segments suggested that even at the low flow rates, stream health was not seriously impaired. Additionally, viable wetlands and riparian corridors were observed in the immediate vicinity of some of the survey points. This conflict between the definition of Lyons flow and observed indicators of stream health call into question the applicability of Lyons flow as a stream health indicator in this area. As such, more study would be required to determine whether the Lyons flows are representative of an ecologically sound condition for Region H stream segments. This question may be addressed more clearly by the Texas Instream Flows Program.

Section 6 – Conclusions

This study was intended to evaluate the impacts of individual management strategies on environmental flows including both B&E inflows and instream flows in channels. Furthermore, an evaluation of impacts to existing and future water supplies was performed for two scenarios aimed at increasing the frequency of attaining B&E inflow targets. The following observations were made through the course of the study:

B&E Inflow Volume, Location, and Target Attainment

- In general, the inclusion of strategies upstream of and within Region H generally leads to a net increase in B&E inflows due to the import of new water to the basin.
- Impacts of individual Region H WMS are relatively minor with the exception of the TRA to Houston transfer, which resulted in an increase in FTA of up to 10 percent for one month.
- Shortages in meeting Max H and Min Q-Sal targets occur generally in the spring. Shortages for Min Q generally occur during the summer months.
- B&E flows generally transition from originating in the Trinity River Basin to the San Jacinto River Basin as time passes and additional water is diverted to meet demands in the latter basin.
- Removal of return flows from Region C were found to result in a 20 percent reduction in B&E discharges from the Trinity River which represents a substantial impact to the total volume of B&E flows. Reductions in firm yield for six of seven key water rights were also caused by this elimination of upstream return flows.

Revised Models for Increasing FTA

- A methodology using the release of stored water was identified as the most effective means of increasing FTA while minimizing impacts to firm yield. Two separate models were developed to increase the occurrence of meeting monthly Max H and Min Q-Sal targets at the desired level.
- Although no reductions in firm yield were identified during the period of record, reductions in reservoir storage point to a reduced level of reliability in reservoir supply during unforeseen drought conditions and successive occurrences of the observed period of record.
- The developed methodology approaches recommended targets as “minimum criteria” to be met, rather than a pattern of flows for an optimal level of estuary production. Additional steps would be required to address target attainment from this perspective.

Instream Flows

- The predominant changes to instream flows are increases in flow due to new water sources such as IBTs and groundwater.
- Reservoir and operations projects in the Brazos River Basin resulted in reductions in stream flow.
- Field observations were made at a time when stream levels were at a rate near that of the calculated Lyons flows for each segment. Despite this flow condition, there were no indications of impaired stream health at the observed locations.

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Section 7 – References

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EXHIBITS

REGION H
Water Planning Group

Exhibit 1:
Basins with Study Control Points

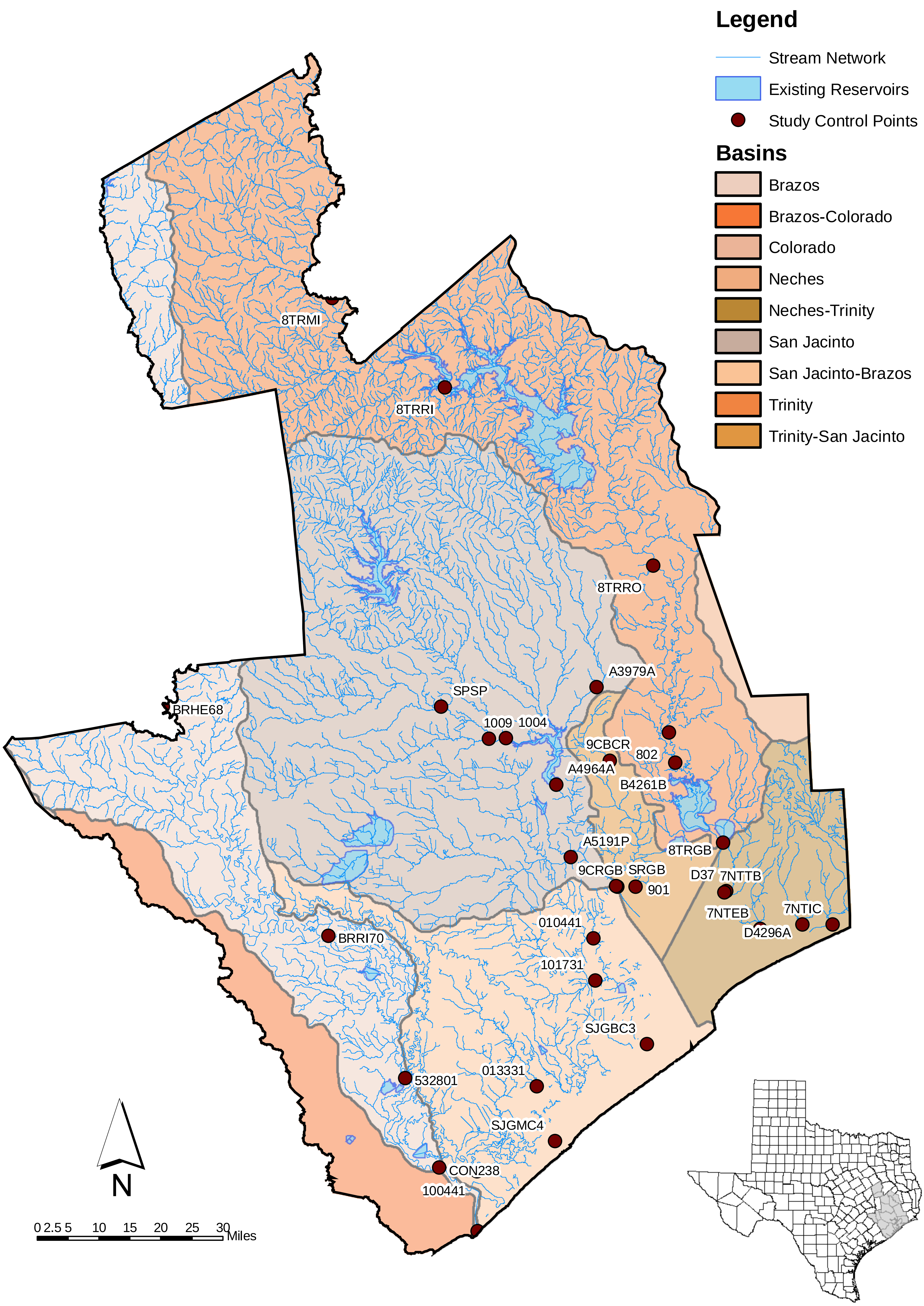
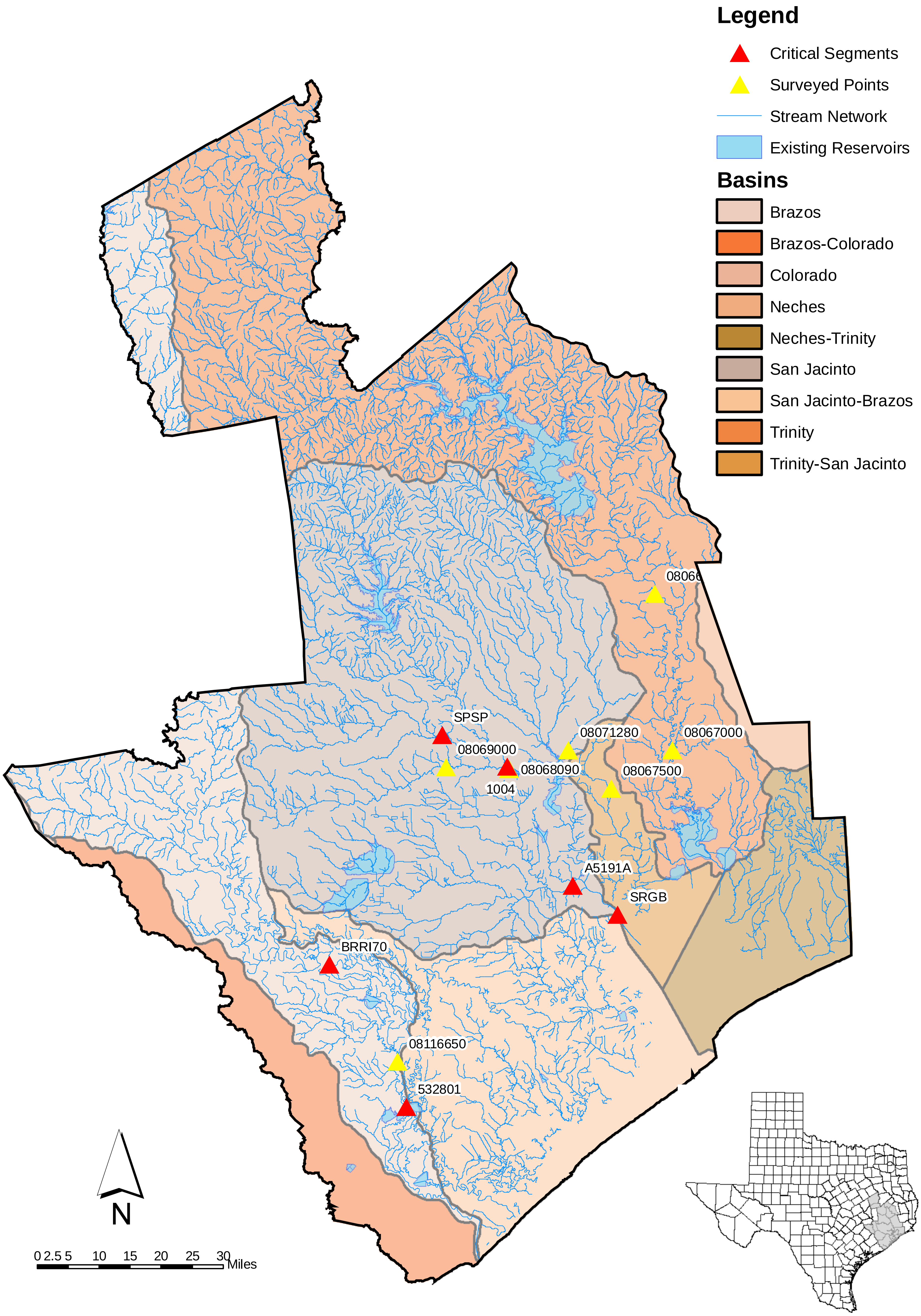


Exhibit 2: Critical Segments and Survey Points



APPENDIX A

MEDIAN FLOWS FOR SELECTED CONTROL POINTS FOR MODELS A THROUGH F

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
CON111	1	104,378	75,556	69,270	74,183	74,183	74,068	82,014	77,644	72,588	74,183	74,128	74,183	74,183	74,183	74,183	74,183	82,014	72,588	80,920	56,261
	2	162,011	109,995	103,092	104,978	104,753	104,739	104,828	98,115	101,116	104,978	104,741	104,978	104,745	104,978	104,978	104,978	104,978	98,115	103,540	86,954
	3	164,356	110,070	95,553	114,306	111,078	118,469	121,535	118,416	106,394	114,306	115,892	114,306	113,663	114,306	114,306	114,306	121,535	106,394	123,160	82,303
	4	237,130	171,629	152,255	181,286	181,304	181,166	181,187	182,270	180,813	181,286	181,232	181,286	181,304	181,286	181,286	181,286	182,270	180,813	176,641	139,907
	5	529,019	451,973	430,477	438,457	438,467	438,457	438,466	438,441	436,405	438,457	438,469	438,457	438,469	438,457	438,457	438,457	438,469	436,405	436,232	408,401
	6	330,171	198,870	185,385	235,755	235,765	235,667	236,077	236,460	234,854	235,755	235,766	235,755	232,086	235,755	235,755	235,755	236,460	232,086	238,034	172,014
	7	123,755	82,777	70,955	117,073	112,236	117,289	118,474	116,131	107,259	117,073	112,544	117,073	110,935	117,073	117,073	117,073	118,474	107,259	126,941	61,344
	8	85,761	51,251	48,204	104,054	103,314	104,564	112,587	100,012	100,559	104,054	100,834	104,054	101,429	104,054	104,054	104,054	112,587	100,012	114,601	40,374
	9	102,518	57,037	46,320	99,237	90,615	92,569	103,694	94,509	98,335	99,237	93,917	99,237	91,047	99,237	99,237	99,237	103,694	90,615	94,273	39,894
	10	132,269	82,212	61,614	109,453	104,571	109,196	109,996	100,086	97,558	109,453	104,717	109,453	104,216	109,453	109,453	109,453	109,996	97,558	97,907	51,211
	11	84,076	62,602	53,435	71,790	69,152	73,157	75,348	71,849	67,387	71,790	73,290	71,790	72,746	71,790	71,790	71,790	75,348	67,387	75,646	48,423
	12	122,473	86,514	81,397	89,863	89,867	88,977	90,828	90,306	89,205	89,863	89,867	89,863	89,868	89,863	89,863	89,863	90,828	88,977	89,384	69,633
BRBR59	1	110,736	82,699	78,200	81,748	81,748	81,748	85,681	82,852	79,045	81,748	81,748	81,748	81,748	81,748	81,748	81,748	85,681	79,045	83,504	65,752
	2	171,538	114,152	110,562	113,583	113,361	113,346	112,695	106,548	109,761	113,583	113,348	113,583	113,352	113,583	113,583	113,583	113,583	106,548	109,938	93,326
	3	172,612	113,211	102,275	119,880	119,256	124,654	127,037	124,601	110,115	119,880	122,103	119,880	121,816	119,880	119,880	119,880	127,037	110,115	126,715	87,321
	4	239,134	178,212	159,449	182,738	182,759	182,623	180,763	184,807	183,273	182,738	182,685	182,738	182,760	182,738	182,738	182,738	184,807	180,763	183,013	147,693
	5	543,141	473,713	449,300	462,194	462,301	462,194	461,970	462,192	458,881	462,194	462,302	462,194	462,302	462,194	462,194	462,194	462,302	458,881	458,769	427,372
	6	337,116	197,016	185,311	242,811	242,496	242,327	240,618	243,167	243,417	242,811	242,810	242,811	238,782	242,811	242,811	242,811	243,417	238,782	241,336	172,015
	7	130,369	83,191	74,680	118,106	116,853	118,393	122,081	121,148	111,810	118,106	115,925	118,106	112,094	118,106	118,106	118,106	122,081	111,810	129,314	64,659
	8	90,054	56,746	54,431	104,008	103,276	105,172	112,745	101,724	101,143	104,008	102,141	104,008	101,492	104,008	104,008	104,008	112,745	101,143	114,684	44,277
	9	104,050	59,771	49,556	99,204	91,139	94,413	103,984	96,134	99,308	99,204	94,533	99,204	91,139	99,204	99,204	99,204	103,984	91,139	93,622	41,335
	10	136,794	87,202	65,335	104,290	104,065	104,035	111,041	103,718	98,990	104,290	104,215	104,290	103,925	104,290	104,290	104,290	111,041	98,990	106,065	54,866
	11	84,517	70,690	59,898	73,704	72,142	74,782	77,573	73,164	71,973	73,704	74,721	73,704	74,296	73,704	73,704	73,704	77,573	71,973	78,459	51,563
	12	130,118	93,324	85,840	93,749	93,749	93,749	97,587	93,754	94,427	93,749	93,749	93,749	93,750	93,749	93,749	93,749	97,587	93,749	96,159	74,151
BRHE68	1	192,722	177,520	171,014	175,886	175,721	176,102	175,601	175,756	174,312	175,886	175,721	175,886	175,887	175,886	175,886	175,886	176,102	174,312	173,699	158,408
	2	272,810	234,042	212,060	218,230	218,014	218,283	203,310	217,362	209,781	218,230	218,001	218,230	212,668	218,230	218,230	218,230	218,283	203,310	216,124	202,301
	3	258,134	211,471	188,471	212,496	212,728	212,649	210,976	216,304	211,718	212,496	212,448	212,496	212,780	212,496	212,496	212,496	216,304	210,976	219,624	177,914
	4	313,874	246,984	244,873	247,541	247,624	247,620	245,533	250,886	237,359	247,541	247,546	247,541	247,624	247,541	247,541	247,541	250,886	237,359	257,780	230,710
	5	757,525	681,756	654,262	678,876	678,891	678,883	678,884	678,879	675,107	678,876	678,887	678,876	678,893	678,876	678,876	678,876	678,893	675,107	674,914	636,243
	6	431,843	288,868	246,575	289,664	289,664	289,528	299,018	291,388	299,275	289,664	289,664	289,664	289,664	289,664	289,664	289,664	299,275	289,528	301,879	234,675
	7	175,112	116,331	96,717	148,712	138,151	147,919	152,517	144,472	147,475	148,712	138,048	148,712	141,890	148,712	148,712	148,712	152,517	138,048	158,279	87,873
	8	112,584	70,164	70,782	123,795	125,864	123,456	131,413	126,366	126,258	123,795	125,877	123,795	123,354	123,795	123,795	123,795	131,413	123,354	134,011	63,242
	9	123,504	98,399	95,429	123,066	123,066	123,257	127,973	131,620	123,015	123,066	123,119	123,066	123,066	123,066	123,066	123,066	131,620	123,015	125,915	84,074
	10	153,253	103,571	85,003	131,624	123,653	132,880	129,786	129,837	131,700	131,624	122,721	131,624	124,121	131,624	131,624	131,624	132,880	122,721	124,852	68,853
	11	152,892	128,006	104,022	102,288	102,094	101,932	108,346	115,793	101,899	102,288	102,162	102,288	102,045	102,288	102,288	102,288	115,793	101,899	120,077	92,623
	12	190,856	134,744	130,943	135,871	135,871	135,871	135,871	135,865	135,871	135,871	135,871	135,871	135,871	135,871	135,871	135,871	135,871	135,865	142,678	119,731
BRRI7D	1	221,069	200,689	178,285	168,311	168,140	168,223	160,539	158,931	164,777	168,311	168,244	168,311	168,301	168,311	168,311	168,311	168,311	158,931	143,864	163,703
	2	306,980	267,620	244,583	228,332	228,352	228,375	211,878	210,756	225,770	228,332	228,455	228,332	226,386	228,332	228,332	228,332	228,455	210,756	198,511	232,143
	3	311,682	226,293	207,504	214,716	214,943	215,100	208,389	209,891	213,371	214,716	214,773	214,716	214,994	214,716	214,716	214,716	215,100	208,389	204,356	198,396
	4	377,632	295,339	268,178	250,308	250,317	250,434	243,924	243,500	248,672	250,308	250,371	250,308	250,318	250,308	250,308	250,308	250,434	243,500	237,378	255,327
	5	835,946	764,906	688,762	705,836	705,843	706,252	696,017	695,269	706,597	705,836	705,993	705,836	709,950	705,836	705,836	705,836	709,950	695,269	677,093	665,887
	6	471,583	375,446	342,260	326,259	326,259	326,594	319,948	318,556	333,149	326,259	326,364	326,259	326,259	326,259	326,259	326,259	333,149	318,556	308,441	330,251
	7	214,691	131,161	106,667	111,061	102,990	110,531	103,823	104,214	107,961	111,061	103,939	111,061	109,056	111,061	111,061	111,061	111,061	102,990	102,074	96,876
	8	135,281	91,282	75,957	90,122	90,327	90,135	88,212	86,969	90,410	90,122	90,367	90,122	89,993	90,122	90,122	90,122	90,410	86,969	82,581	74,242
	9	152,261	110,221	88,389	85,503	84,615	85,120	77,337	85,656	83,482	85,503	85,554	85,503	84,615	85,503	85,503	85,503	85,656	77,337	74,678	77,625
	10	177,749	138,742	122,980	101,580	99,792	101,995	93,320	99,953	98,812	101,580	100,038	101,580	99,646	101,580	101,580	101,580	101,995	93,320	80,031	113,350
	11	161,498	139,244	118,463	77,340	77,158	77,362	71,517	82,101	77,801	77,340	78,165	77,340	78,757	77,340	77,340	77,340	82,101	71,517	67,619	99,615
	12	237,090	162,577	153,301	128,292	128,292	128,517	125,673	124,444	130,108	128,292	128,396	128,292	128,292	128,292	128,292	128,292	130,108	124,444	117,509	140,075

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
BRRI70	1	221,069	200,689	178,285	168,311	168,140	168,223	160,539	158,931	164,777	168,311	168,244	168,311	168,301	168,311	168,311	168,311	168,311	158,931	143,864	163,703
	2	306,980	267,620	244,583	228,332	228,352	228,375	211,878	210,756	225,770	228,332	228,455	228,332	226,386	228,332	228,332	228,332	228,455	210,756	198,511	232,143
	3	311,682	226,293	207,504	214,716	214,943	215,100	208,389	209,891	213,371	214,716	214,773	214,716	214,994	214,716	214,716	214,716	215,100	208,389	204,356	198,396
	4	377,632	295,339	268,178	250,308	250,317	250,434	243,924	243,500	248,672	250,308	250,371	250,308	250,318	250,308	250,308	250,308	250,434	243,500	237,378	255,327
	5	835,946	764,906	688,762	705,836	705,843	706,252	696,017	695,269	706,597	705,836	705,993	705,836	709,950	705,836	705,836	705,836	709,950	695,269	677,093	665,887
	6	471,583	375,446	342,260	326,259	326,259	326,594	319,948	318,556	333,149	326,259	326,364	326,259	326,259	326,259	326,259	326,259	333,149	318,556	308,441	330,251
	7	214,691	131,161	106,667	111,061	102,990	110,531	103,823	104,214	107,961	111,061	103,939	111,061	109,056	111,061	111,061	111,061	111,061	102,990	102,074	96,876
	8	135,281	91,282	75,957	90,122	90,327	90,135	88,212	86,969	90,410	90,122	90,367	90,122	89,993	90,122	90,122	90,122	90,410	86,969	82,581	74,242
	9	152,261	110,221	88,389	85,503	84,615	85,120	77,337	85,656	83,482	85,503	85,554	85,503	84,615	85,503	85,503	85,503	85,656	77,337	74,678	77,625
	10	177,749	138,742	122,980	101,580	99,792	101,995	93,320	99,953	98,812	101,580	100,038	101,580	99,646	101,580	101,580	101,580	101,995	93,320	80,031	113,350
	11	161,498	139,244	118,463	77,340	77,158	77,362	71,517	82,101	77,801	77,340	78,165	77,340	78,757	77,340	77,340	77,340	82,101	71,517	67,619	99,615
	12	237,090	162,577	153,301	128,292	128,292	128,517	125,673	124,444	130,108	128,292	128,396	128,292	128,292	128,292	128,292	128,292	130,108	124,444	117,509	140,075
532801	1	229,200	191,459	168,415	157,945	157,786	158,503	151,017	150,135	155,391	157,945	157,926	157,945	158,484	157,945	157,945	157,945	158,503	150,135	140,998	155,593
	2	340,757	272,397	253,674	227,925	227,926	228,374	200,833	209,602	222,813	227,925	228,066	227,925	223,320	227,925	227,925	227,925	228,374	200,833	198,574	228,961
	3	301,426	196,092	172,039	182,021	182,050	182,284	182,596	179,350	178,714	182,021	182,146	182,021	182,635	182,021	182,021	182,021	182,635	178,714	177,399	161,845
	4	363,601	262,855	239,888	222,686	222,698	222,959	218,707	216,904	220,636	222,686	222,790	222,686	223,324	222,686	222,686	222,686	223,324	216,904	206,152	222,164
	5	828,568	726,929	659,437	669,794	669,801	670,388	660,898	660,108	670,543	669,794	669,988	669,794	674,580	669,794	669,794	669,794	674,580	660,108	643,922	642,052
	6	501,940	368,071	329,135	328,357	328,365	328,894	313,938	319,097	331,483	328,357	328,510	328,357	329,194	328,357	328,357	328,357	331,483	313,938	299,676	318,246
	7	225,785	114,586	86,169	88,083	85,720	87,935	83,686	83,180	86,880	88,083	83,821	88,083	90,659	88,083	88,083	88,083	90,659	83,180	80,620	76,150
	8	148,460	57,815	43,503	63,221	62,433	63,135	61,653	62,262	62,663	63,221	63,214	63,221	63,352	63,221	63,221	63,221	63,352	61,653	58,834	35,239
	9	167,741	95,803	82,982	72,854	71,170	71,404	65,975	71,262	66,430	72,854	72,943	72,854	71,964	72,854	72,854	72,854	72,943	65,975	62,006	62,093
	10	208,931	143,895	101,311	106,543	102,183	108,222	92,984	91,202	100,343	106,543	101,426	106,543	104,186	106,543	106,543	106,543	108,222	91,202	66,733	91,590
	11	175,947	137,063	123,549	75,884	77,917	76,558	65,631	67,959	74,344	75,884	79,500	75,884	80,922	75,884	75,884	75,884	80,922	65,631	62,994	105,008
	12	254,327	174,757	156,760	138,507	138,507	138,871	137,898	135,383	140,224	138,507	138,648	138,507	139,068	138,507	138,507	138,507	140,224	135,383	127,717	133,748
CON238	1	231,627	180,583	151,937	141,598	141,853	142,167	136,565	134,558	140,423	141,598	141,615	141,598	142,133	141,598	141,598	141,598	142,167	134,558	128,282	140,868
	2	351,490	268,146	233,590	219,584	220,046	220,045	194,552	202,197	215,129	219,584	219,724	219,584	215,016	219,584	219,584	219,584	220,046	194,552	194,197	208,999
	3	300,030	177,353	149,329	159,142	159,699	159,420	161,780	157,379	156,545	159,142	159,267	159,142	159,752	159,142	159,142	159,142	161,780	156,545	158,740	139,058
	4	360,863	241,270	214,706	197,076	197,693	197,365	195,362	191,872	195,783	197,076	197,179	197,076	197,709	197,076	197,076	197,076	197,709	191,872	184,538	197,058
	5	824,474	701,591	628,839	639,112	639,796	639,722	632,831	630,594	640,742	639,112	639,305	639,112	643,860	639,112	639,112	639,112	643,860	630,594	618,663	611,531
	6	518,368	350,411	297,433	302,277	303,065	302,945	284,875	289,271	300,476	302,277	302,477	302,277	303,116	302,277	302,277	302,277	303,116	284,875	273,670	297,859
	7	226,500	89,281	55,956	58,235	56,421	58,335	55,267	55,294	55,844	58,235	53,598	58,235	60,398	58,235	58,235	58,235	60,398	53,598	60,340	45,860
	8	156,838	31,246	12,463	31,852	33,053	31,800	32,299	32,051	34,920	31,852	32,180	31,852	32,566	31,852	31,852	31,852	34,920	31,800	32,614	5,647
	9	170,413	77,003	58,054	49,944	46,235	45,904	45,814	50,562	46,419	49,944	50,084	49,944	46,436	49,944	49,944	49,944	50,562	45,814	44,686	42,155
	10	209,922	126,556	81,218	86,187	81,795	87,872	75,392	71,641	80,952	86,187	80,628	86,187	83,363	86,187	86,187	86,187	87,872	71,641	51,760	71,525
	11	175,466	122,503	105,596	61,111	61,692	61,772	55,020	54,447	58,062	61,111	62,417	61,111	63,746	61,111	61,111	61,111	63,746	54,447	55,701	87,151
	12	256,666	164,852	143,129	125,232	125,580	125,610	126,600	123,008	127,541	125,232	125,372	125,232	125,788	125,232	125,232	125,232	127,541	123,008	118,480	120,167

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
100441	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13331	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101731	1	0	1,357	1,134	3	436	172	3	271	3	3	3	3	3	3	3	3	436	3	873	3
	2	0	1,394	1,164	2	430	191	2	283	2	2	2	2	2	2	2	2	430	2	900	2
	3	0	1,516	1,263	0	463	210	0	312	0	0	0	0	0	0	0	0	463	0	991	0
	4	0	1,649	1,372	0	495	232	0	343	0	0	0	0	0	0	0	0	495	0	1,083	0
	5	0	1,709	1,420	0	579	264	0	381	0	0	0	0	0	0	0	0	579	0	1,237	0
	6	0	1,905	1,581	0	650	294	0	408	0	0	0	0	0	0	0	0	650	0	1,379	0
	7	0	2,036	1,689	0	738	315	0	442	0	0	0	0	0	0	0	0	738	0	1,531	0
	8	0	2,292	1,905	0	698	300	0	299	0	0	0	0	0	0	0	0	698	0	1,329	0
	9	0	2,219	1,851	0	633	251	0	434	0	0	0	0	0	0	0	0	633	0	1,327	0
	10	0	2,068	1,723	0	563	196	0	395	0	0	0	0	0	0	0	0	563	0	1,165	0
	11	0	1,892	1,578	2	482	176	2	363	2	2	2	2	2	2	2	2	482	2	1,020	2
	12	0	1,605	1,339	3	452	166	3	313	3	3	3	3	3	3	3	3	452	3	927	3
10441	1	0	1,852	1,544	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	0
	2	0	1,903	1,588	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	58	0
	3	0	2,069	1,727	0	0	275	0	0	0	0	0	0	0	0	0	0	275	0	569	0
	4	0	2,241	1,873	0	0	133	0	0	0	0	0	0	0	0	0	0	133	0	443	0
	5	0	2,307	1,932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	0
	6	0	2,551	2,145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	2,722	2,291	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	283	0
	8	0	3,079	2,591	0	0	156	0	0	0	0	0	0	0	0	0	0	156	0	426	0
	9	0	3,018	2,528	0	0	135	0	0	0	0	0	0	0	0	0	0	135	0	489	0
	10	0	2,819	2,362	0	0	500	0	89	0	0	0	0	0	7	0	0	500	0	831	0
	11	0	2,579	2,158	0	0	194	0	7	0	0	3	0	0	5	0	0	194	0	501	0
	12	0	2,193	1,829	1	0	7	1	5	1	1	3	1	1	4	1	1	7	0	221	1

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
SJGMC4	1	78,865	42,580	41,291	40,841	40,841	40,851	40,841	40,841	40,841	40,841	40,841	40,841	41,469	40,841	40,841	40,841	41,469	40,841	41,478	40,841
	2	74,584	52,236	51,408	50,951	50,951	50,961	50,951	50,951	50,951	50,951	50,951	50,951	51,718	50,951	50,951	50,951	51,718	50,951	51,729	50,951
	3	53,752	18,570	17,822	17,333	17,333	17,343	17,333	17,333	17,333	17,333	17,333	17,333	18,212	17,333	17,333	17,333	18,212	17,333	18,222	17,333
	4	58,104	25,002	23,491	22,959	22,959	22,974	22,959	22,959	22,959	22,959	22,959	22,959	23,967	22,959	22,959	22,959	23,967	22,959	23,982	22,959
	5	78,740	42,848	41,489	40,944	40,944	40,957	40,944	40,944	40,944	40,944	40,944	40,944	42,070	40,944	40,944	40,944	42,070	40,944	42,083	40,944
	6	102,152	53,804	52,140	51,530	51,530	51,545	51,530	51,530	51,530	51,530	51,530	51,530	52,813	51,530	51,530	51,530	52,813	51,530	52,828	51,530
	7	72,680	36,494	34,982	34,337	34,337	34,353	34,337	34,337	34,337	34,337	34,337	34,337	35,686	34,337	34,337	34,337	35,686	34,337	35,703	34,337
	8	55,605	27,801	26,618	25,915	25,915	25,929	25,915	25,915	25,915	25,915	25,915	25,915	27,203	25,915	25,915	25,915	27,203	25,915	27,217	25,915
	9	76,893	38,204	36,943	36,268	36,268	36,283	36,268	36,268	36,268	36,268	36,268	36,268	37,243	36,268	36,268	36,268	37,243	36,268	37,257	36,268
	10	60,372	11,571	11,129	10,494	10,494	10,506	10,494	10,494	10,494	10,494	10,494	10,494	11,188	10,494	10,494	10,494	11,188	10,494	11,200	10,494
	11	58,717	23,303	22,381	21,794	21,794	21,801	21,791	21,791	21,791	21,794	21,794	21,794	22,407	21,794	21,794	21,794	22,407	21,791	22,417	21,794
	12	63,739	37,574	36,771	36,261	36,261	36,271	36,261	36,261	36,261	36,261	36,261	36,261	36,837	36,261	36,261	36,261	36,837	36,261	36,848	36,261
SJGBC3	1	32,630	25,278	24,170	18,573	19,006	18,761	18,573	18,841	18,573	18,573	18,573	18,573	18,573	18,573	18,573	18,573	19,006	18,573	19,463	18,574
	2	30,859	28,569	27,429	21,684	22,111	21,916	21,684	21,964	21,684	21,684	21,684	21,684	21,684	21,684	21,684	21,684	22,111	21,684	22,766	21,684
	3	22,240	15,173	13,930	7,684	8,142	8,185	7,684	7,991	7,684	7,684	7,684	7,684	7,684	7,684	7,684	7,684	8,185	7,684	9,261	7,684
	4	24,040	18,784	17,427	10,628	11,124	10,970	10,628	10,972	10,628	10,628	10,628	10,628	10,628	10,628	10,628	10,628	11,124	10,628	12,135	10,628
	5	32,578	26,304	24,905	17,882	18,456	18,168	17,882	18,259	17,882	17,882	17,882	17,882	17,882	17,882	17,882	17,882	18,456	17,882	19,212	17,882
	6	42,265	31,926	30,379	22,546	23,192	22,866	22,546	22,950	22,546	22,546	22,546	22,546	22,546	22,546	22,546	22,546	23,192	22,546	23,952	22,547
	7	30,071	25,384	23,726	15,337	16,079	15,956	15,337	15,783	15,337	15,337	15,337	15,337	15,337	15,356	15,337	15,337	16,079	15,337	17,473	15,337
	8	23,006	23,070	21,217	11,764	12,461	12,374	11,764	12,062	11,764	11,764	11,764	11,764	11,764	11,764	11,764	11,764	12,461	11,764	13,673	11,764
	9	31,814	25,437	23,633	15,829	16,460	16,113	15,829	16,262	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	16,460	15,829	17,492	15,829
	10	24,979	14,973	13,284	4,751	5,310	5,454	4,751	5,217	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	5,454	4,751	6,754	4,751
	11	24,294	18,909	17,362	9,559	10,039	9,977	9,559	9,920	9,559	9,559	9,559	9,559	9,559	9,559	9,559	9,559	10,039	9,559	11,128	9,562
	12	26,372	23,387	22,070	15,458	15,908	15,642	15,458	15,769	15,458	15,458	15,458	15,458	15,458	15,458	15,458	15,458	15,908	15,458	16,539	15,460
BRGM73	1	490,392	180,605	148,413	120,618	120,995	121,217	115,734	113,161	119,586	120,618	120,758	120,618	121,152	120,618	120,618	120,618	121,217	113,161	106,949	136,329
	2	569,103	267,776	230,091	198,692	199,152	199,181	173,785	181,392	194,259	198,692	198,831	198,692	194,146	198,692	198,692	198,692	199,181	173,785	173,463	204,220
	3	580,836	176,672	145,835	134,468	135,023	134,779	137,093	132,714	131,885	134,468	134,592	134,468	135,075	134,468	134,468	134,468	137,093	131,885	134,103	134,065
	4	646,934	240,306	211,211	170,298	170,913	170,622	168,450	165,110	169,012	170,298	170,401	170,298	170,928	170,298	170,298	170,298	170,928	165,110	157,717	192,036
	5	1,089,161	698,572	623,361	607,734	608,414	608,384	601,484	599,258	609,355	607,734	607,926	607,734	612,459	607,734	607,734	607,734	612,459	599,258	587,429	604,348
	6	775,098	348,804	293,571	270,589	271,374	271,302	253,167	257,648	268,690	270,589	270,788	270,589	271,424	270,589	270,589	270,589	271,424	253,167	242,066	292,325
	7	321,444	88,956	53,104	24,966	23,166	25,121	24,189	22,044	22,587	24,966	20,357	24,966	27,120	24,966	24,966	24,966	27,120	20,357	28,153	41,308
	8	182,223	31,870	10,239	2,169	1,902	1,397	1,032	1,466	5,676	2,169	1,902	2,169	1,902	2,169	2,169	2,169	5,676	1,032	2,605	3,594
	9	251,542	77,914	55,399	20,615	16,920	16,795	16,486	21,927	17,326	20,615	20,754	20,615	17,119	20,615	20,615	20,615	21,927	16,486	15,424	38,509
	10	384,135	126,058	78,490	58,979	54,539	60,696	48,294	44,491	53,826	58,979	53,377	58,979	56,099	58,979	58,979	58,979	60,696	44,491	24,821	66,941
	11	332,852	122,062	102,603	38,454	38,981	39,086	33,000	32,430	34,401	38,454	38,735	38,454	40,017	38,454	38,454	38,454	40,017	32,430	33,440	82,561
	12	481,520	164,623	139,914	104,082	104,428	104,490	105,452	101,868	106,389	104,082	104,221	104,082	104,635	104,082	104,082	104,082	106,389	101,868	97,396	115,549

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
A5191P	1	49,868	88,670	104,896	104,896	104,896	105,156	105,505	105,907	104,896	100,259	109,291	104,896	104,971	101,555	103,885	104,896	109,291	100,259	102,257	49,290
	2	59,337	97,744	113,744	113,744	113,744	114,004	114,381	114,804	113,744	109,381	118,139	113,744	113,819	110,494	112,755	113,744	118,139	109,381	111,569	59,156
	3	32,062	70,584	86,336	86,336	86,336	86,597	87,160	87,633	86,336	82,075	90,879	86,336	86,411	83,158	85,359	86,336	90,879	82,075	84,700	31,550
	4	24,817	62,713	77,911	77,911	77,911	78,179	78,824	79,348	77,911	74,075	82,467	77,911	77,985	74,875	76,972	77,911	82,467	74,075	77,102	24,264
	5	44,047	83,082	98,728	98,728	98,728	98,993	99,607	100,189	98,728	94,747	103,176	98,728	98,803	95,618	97,762	98,728	103,176	94,747	97,799	43,621
	6	26,913	68,177	84,503	84,503	84,503	84,770	85,459	86,092	84,503	80,559	88,951	84,503	84,578	81,264	83,516	84,503	88,951	80,559	83,669	26,419
	7	24,527	65,068	79,759	79,759	79,759	80,030	80,803	81,493	79,759	77,379	84,208	79,759	79,835	77,080	78,914	79,759	84,208	77,080	81,426	24,057
	8	20,650	63,287	79,067	79,067	79,067	79,339	80,062	80,255	79,067	76,482	83,515	79,067	79,143	76,204	78,182	79,067	83,515	76,204	79,711	20,391
	9	28,296	66,196	80,855	80,855	80,855	81,119	81,763	82,508	80,855	77,874	85,250	80,855	80,930	78,065	79,990	80,855	85,250	77,874	81,514	28,055
	10	23,887	59,571	73,844	73,844	73,844	74,105	74,665	75,353	73,844	70,506	78,244	73,844	73,919	71,029	72,976	73,844	78,244	70,506	73,888	23,737
	11	43,801	79,532	94,044	94,044	94,044	94,303	94,749	95,408	94,044	90,596	98,439	94,044	94,118	91,137	93,081	94,044	98,439	90,596	93,526	43,677
	12	44,089	80,279	94,957	94,957	94,957	95,217	95,565	96,128	94,957	91,289	99,352	94,957	95,031	92,046	94,080	94,957	99,352	91,289	94,012	43,954
SPSP	1	9,901	9,988	10,281	10,281	10,281	10,298	10,281	10,281	10,281	10,281	13,146	11,681	10,281	10,281	10,281	10,281	13,146	10,281	14,524	9,647
	2	12,996	13,300	13,555	13,555	13,555	13,573	13,555	13,555	13,555	13,555	16,304	14,755	13,555	13,555	13,555	13,555	16,304	13,555	17,522	12,948
	3	7,260	7,739	7,843	7,843	7,843	7,861	7,843	7,843	7,843	7,843	10,592	9,081	7,843	7,843	7,843	7,843	10,592	7,843	11,848	7,230
	4	5,887	6,409	6,271	6,297	6,297	6,366	6,271	6,297	6,297	6,297	9,106	7,432	6,297	6,297	6,297	6,293	9,106	6,271	10,199	5,744
	5	11,387	11,922	11,834	11,834	11,834	11,852	11,834	11,834	11,834	11,834	14,615	13,077	11,834	11,834	11,834	11,834	14,615	11,834	15,877	11,206
	6	4,576	5,137	5,044	5,044	5,044	5,062	5,044	5,044	5,044	5,044	7,826	6,316	5,044	5,044	5,044	5,044	7,826	5,044	9,115	4,409
	7	2,051	2,679	2,679	2,679	2,679	2,697	2,679	2,679	2,679	2,679	5,414	3,920	2,679	2,679	2,679	2,679	5,414	2,679	6,720	2,051
	8	1,714	2,371	2,371	2,371	2,371	2,389	2,371	2,371	2,371	2,371	5,153	3,707	2,371	2,371	2,371	2,371	5,153	2,371	6,438	1,714
	9	1,794	2,228	2,348	2,348	2,348	2,364	2,348	2,348	2,348	2,348	5,097	3,607	2,348	2,348	2,348	2,348	5,097	2,348	6,371	1,794
	10	2,035	2,671	2,671	2,671	2,671	2,689	2,671	2,671	2,671	2,671	5,419	3,933	2,671	2,671	2,671	2,671	5,419	2,671	6,583	2,035
	11	4,259	4,878	4,857	4,857	4,857	4,874	4,857	4,857	4,857	4,857	7,605	6,129	4,857	4,857	4,857	4,857	7,605	4,857	8,895	4,228
	12	8,441	9,053	9,030	9,030	9,030	9,048	9,030	9,030	9,030	9,030	11,779	10,303	9,030	9,030	9,030	9,030	11,779	9,030	13,070	8,398
1009	1	6,368	7,510	6,859	6,875	6,875	6,965	6,859	6,875	6,875	6,875	6,988	6,885	6,875	6,875	6,757	6,859	6,988	6,757	6,927	5,316
	2	9,434	10,559	9,715	9,715	9,715	9,666	9,715	9,715	9,715	9,715	9,811	9,715	9,715	9,715	9,599	9,683	9,811	9,599	9,659	8,230
	3	5,516	6,795	6,641	6,641	6,641	6,759	6,641	6,641	6,641	6,641	6,737	6,641	6,641	6,641	6,524	6,641	6,759	6,524	6,738	5,229
	4	3,450	4,684	4,455	4,455	4,455	4,573	4,455	4,455	4,455	4,455	4,551	4,455	4,455	4,455	4,352	4,455	4,573	4,352	4,568	3,053
	5	9,041	10,262	9,661	9,661	9,661	9,919	9,661	9,661	9,661	9,661	9,758	9,661	9,661	9,661	9,541	9,661	9,919	9,541	9,916	8,185
	6	5,388	6,866	6,458	6,458	6,458	6,564	6,458	6,458	6,458	6,458	6,555	6,458	6,458	6,458	6,344	6,458	6,564	6,344	6,549	4,977
	7	2,734	4,121	4,121	4,121	4,121	4,241	4,121	4,121	4,121	4,121	4,219	4,121	4,121	4,121	4,121	4,121	4,241	4,121	4,338	2,734
	8	2,041	3,509	3,509	3,509	3,509	3,629	3,509	3,509	3,509	3,509	3,489	3,391	3,509	3,509	3,509	3,509	3,629	3,391	3,589	2,041
	9	2,938	4,287	4,342	4,342	4,342	4,460	4,342	4,342	4,342	4,342	4,439	4,342	4,342	4,342	4,237	4,342	4,460	4,237	4,451	2,938
	10	2,577	4,052	4,052	4,052	4,052	4,170	4,052	4,052	4,052	4,052	4,148	4,052	4,052	4,052	4,052	4,052	4,170	4,052	4,266	2,577
	11	4,169	5,555	5,400	5,447	5,447	5,581	5,400	5,447	5,447	5,447	5,559	5,463	5,447	5,447	5,339	5,400	5,581	5,339	5,683	3,966
	12	7,490	8,912	8,935	8,935	8,935	9,052	8,935	8,935	8,935	8,935	9,031	8,935	8,935	8,935	8,821	8,935	9,052	8,821	9,035	7,143
1004	1	33,793	31,987	20,748	20,919	20,919	21,823	20,748	20,919	20,919	20,919	20,919	21,594	20,919	20,919	20,919	20,919	21,823	20,748	22,498	20,229
	2	45,650	30,319	27,559	27,559	27,559	27,666	27,559	27,559	27,559	27,559	27,641	28,321	27,559	27,559	27,559	27,559	28,321	27,559	28,670	26,951
	3	28,484	23,726	19,336	19,451	19,451	15,620	19,324	19,451	19,451	19,451	15,499	16,164	19,451	19,451	19,451	19,451	19,451	15,499	16,272	18,725
	4	22,188	14,738	13,084	13,084	13,084	13,195	13,084	13,084	13,084	13,084	13,084	13,712	13,084	13,084	13,084	13,084	13,712	13,084	13,823	12,943
	5	36,049	26,709	24,595	24,595	24,595	24,709	24,595	24,595	24,595	24,595	24,595	25,253	24,595	24,595	24,595	24,595	25,253	24,595	25,367	24,085
	6	15,109	10,001	9,980	9,980	9,980	10,100	9,980	9,980	9,980	9,980	9,980	10,641	9,980	9,980	9,980	9,980	10,641	9,980	10,761	9,836
	7	3,972	4,074	4,074	4,074	4,074	4,272	4,074	4,074	4,074	4,074	4,074	4,646	4,074	4,074	4,074	4,074	4,646	4,074	4,783	3,625
	8	2,499	3,005	3,005	3,005	3,005	3,949	3,005	3,005	3,005	3,005	3,004	3,638	3,005	3,005	3,005	3,005	3,949	3,004	3,910	2,499
	9	3,279	3,608	3,608	3,608	3,608	4,020	3,608	3,608	3,608	3,608	3,340	3,916	3,608	3,608	3,608	3,799	4,020	3,340	4,527	3,279
	10	3,205	3,520	3,511	3,511	3,511	3,975	3,511	3,511	3,511	3,511	3,511	4,033	3,511	3,511	3,511	3,584	4,033	3,511	4,272	3,142
	11	9,759	6,516	7,063	6,516	6,516	6,918	7,063	6,516	6,516	6,516	6,523	7,080	6,516	6,516	6,516	7,187	7,187	6,516	7,211	6,714
	12	34,857	19,697	19,692	19,692	19,692	19,799	19,692	19,692	19,692	19,692	19,692	20,364	19,692	19,692	19,692	19,692	20,364	19,692	20,484	19,163

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
A3979A	1	8,409	8,173	8,168	8,168	8,168	8,244	8,168	8,168	8,168	8,168	8,168	8,168	8,168	8,168	8,168	8,168	8,244	8,168	8,244	8,168
	2	8,367	8,162	8,157	8,157	8,157	8,233	8,157	8,157	8,157	8,157	8,157	8,157	8,157	8,157	8,157	8,157	8,233	8,157	8,233	8,157
	3	5,852	5,529	5,529	5,529	5,529	5,606	5,529	5,529	5,529	5,529	5,517	5,517	5,529	5,529	5,529	5,529	5,606	5,517	5,594	5,529
	4	4,009	3,529	3,518	3,518	3,518	3,595	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,595	3,518	3,595	3,518
	5	9,993	9,165	9,147	9,147	9,147	9,225	9,147	9,147	9,147	9,147	9,147	9,147	9,147	9,147	9,147	9,147	9,225	9,147	9,225	9,147
	6	3,701	2,834	2,814	2,814	2,814	2,894	2,814	2,814	2,814	2,814	2,814	2,814	2,814	2,814	2,814	2,814	2,894	2,814	2,894	3,129
	7	1,383	1,245	1,259	1,245	1,245	1,327	1,259	1,245	1,245	1,245	1,197	1,197	1,245	1,245	1,245	1,245	1,327	1,197	1,113	1,383
	8	903	903	903	903	903	986	903	903	903	903	877	877	903	903	903	903	986	877	948	903
	9	1,167	1,167	1,167	1,167	1,167	1,245	1,167	1,167	1,167	1,167	1,159	1,159	1,167	1,167	1,167	1,167	1,245	1,159	1,237	1,167
	10	1,196	1,196	1,196	1,196	1,196	1,206	1,196	1,196	1,196	1,196	1,130	1,130	1,196	1,196	1,196	1,196	1,206	1,130	988	1,196
	11	2,895	2,728	2,724	2,696	2,696	2,771	2,724	2,696	2,696	2,696	2,696	2,696	2,696	2,696	2,696	2,724	2,771	2,696	2,771	2,724
	12	7,352	7,142	7,137	7,137	7,137	7,214	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,214	7,137	7,214	7,137
A4964A	1	112,486	77,309	66,080	66,139	66,139	66,494	66,053	66,139	66,139	66,139	69,010	68,772	66,139	66,139	66,016	62,598	69,010	62,598	69,177	60,455
	2	114,359	83,511	82,741	81,926	81,926	84,163	83,081	81,926	81,926	81,926	86,645	86,263	81,926	81,926	81,811	75,800	86,645	75,800	86,948	70,633
	3	72,904	52,374	49,790	49,711	49,711	50,182	49,826	49,711	49,711	49,711	52,593	52,253	49,711	49,711	49,596	47,014	52,593	47,014	52,793	45,982
	4	51,972	27,856	27,705	27,769	27,769	28,125	27,496	27,769	27,769	27,769	30,641	30,055	27,769	27,769	27,666	25,072	30,641	25,072	30,481	24,085
	5	129,289	102,007	95,623	95,998	95,998	96,525	95,451	95,998	95,998	95,998	98,925	98,528	95,998	95,998	95,880	93,268	98,925	93,268	99,129	91,781
	6	52,304	23,345	21,877	22,507	22,507	22,997	21,585	22,507	22,507	22,507	25,424	25,073	22,507	22,507	22,394	19,777	25,424	19,777	25,637	18,003
	7	19,839	0	0	0	0	0	0	0	0	0	574	109	0	0	0	0	574	0	693	0
	8	12,417	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	17,658	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	16,056	0	0	0	0	0	0	0	0	0	1,954	1,505	0	0	0	0	1,954	0	2,045	0
	11	37,681	18,042	19,380	18,967	18,967	19,431	19,408	18,967	18,967	18,967	21,849	21,409	18,967	18,967	18,859	13,694	21,849	13,694	21,950	12,853
	12	95,079	62,674	62,425	65,526	65,526	67,858	62,425	65,526	65,526	65,526	70,536	70,224	65,526	65,526	65,412	59,727	70,536	59,727	70,764	58,706
SRGB	1	145,953	164,191	177,569	177,192	177,192	177,887	178,364	178,204	177,192	172,779	184,496	179,759	177,267	173,781	176,059	176,112	184,496	172,779	179,520	114,242
	2	177,467	189,198	202,336	202,297	202,297	203,676	202,992	203,356	202,297	198,157	209,708	204,805	202,372	199,047	201,188	201,216	209,708	198,157	205,682	140,104
	3	126,978	146,864	162,931	163,010	163,010	163,749	163,614	164,198	163,010	158,984	170,414	165,552	163,085	159,720	161,918	161,931	170,414	158,984	166,184	100,503
	4	83,463	99,146	113,919	114,293	114,293	115,036	114,538	115,610	114,293	110,703	121,698	116,579	114,368	111,258	113,250	113,214	121,698	110,703	118,160	52,722
	5	185,394	207,405	203,283	203,548	203,548	204,182	204,088	205,008	203,548	199,821	211,030	206,078	203,623	200,327	202,464	202,456	211,030	199,821	207,488	140,165
	6	84,573	103,356	120,322	121,031	121,031	121,793	120,951	122,620	121,031	117,363	128,524	123,597	121,106	117,792	119,929	119,939	128,524	117,363	125,374	53,875
	7	45,096	73,008	89,101	89,101	89,101	89,380	90,145	90,835	89,101	87,059	93,843	89,101	89,177	86,423	88,256	90,739	93,843	86,423	93,170	28,257
	8	39,506	68,819	86,057	86,057	86,057	86,336	87,051	87,245	86,057	83,822	90,633	86,057	86,132	83,193	85,171	87,695	90,633	83,193	88,825	22,020
	9	47,743	71,851	87,670	87,670	87,670	87,940	88,577	89,323	87,670	84,965	94,117	89,154	87,744	84,879	86,805	89,288	94,117	84,879	92,404	30,557
	10	41,955	65,638	80,840	80,829	80,829	81,225	81,650	82,338	80,829	77,724	87,896	82,921	80,904	78,014	79,961	82,160	87,896	77,724	85,580	26,662
	11	80,007	94,524	109,857	110,521	110,521	111,283	110,602	111,886	110,521	107,291	117,963	113,001	110,596	107,508	109,451	108,784	117,963	107,291	115,046	53,237
	12	152,567	160,275	172,583	172,826	172,826	173,562	172,911	174,002	172,826	169,388	180,242	175,396	172,901	169,915	171,840	165,101	180,242	165,101	177,009	107,672

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
9CBCR	1	2,727	2,049	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407	1,407
	2	3,131	2,685	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470	2,470
	3	1,842	1,432	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284	1,284
	4	1,850	1,206	681	681	681	681	681	681	681	681	681	681	681	681	681	681	681	681	681	681
	5	2,957	2,027	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358
	6	1,903	908	244	244	244	244	244	244	244	244	244	244	244	244	244	244	244	244	244	244
	7	1,053	393	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
	8	614	200	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
	9	626	336	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161
	10	644	393	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
	11	1,052	1,026	911	911	911	911	911	911	911	911	911	911	911	911	911	911	911	911	911	911
	12	2,572	2,111	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021	2,021
901	1	8,476	8,759	6,923	6,923	6,923	6,986	6,923	6,923	6,923	6,923	6,923	6,923	6,923	6,923	6,923	6,923	6,986	6,923	6,986	5,867
	2	9,734	10,135	9,423	9,423	9,423	9,536	9,423	9,423	9,423	9,423	9,423	9,423	9,423	9,423	9,423	9,423	9,536	9,423	9,536	8,391
	3	5,725	6,184	5,570	5,570	5,570	5,639	5,570	5,570	5,570	5,570	5,570	5,570	5,570	5,570	5,570	5,570	5,639	5,570	5,639	4,551
	4	5,751	5,618	4,829	4,829	4,829	4,896	4,829	4,829	4,829	4,829	4,829	4,829	4,829	4,829	4,829	4,829	4,896	4,829	4,896	3,823
	5	9,192	8,576	7,570	7,570	7,570	7,653	7,570	7,570	7,570	7,570	7,570	7,570	7,570	7,570	7,570	7,570	7,653	7,570	7,653	6,526
	6	5,916	5,153	4,348	4,348	4,348	4,410	4,348	4,348	4,348	4,348	4,348	4,348	4,348	4,348	4,348	4,348	4,410	4,348	4,410	3,292
	7	3,273	2,936	2,705	2,705	2,705	2,832	2,705	2,705	2,705	2,705	2,705	2,705	2,705	2,705	2,705	2,705	2,832	2,705	2,832	1,674
	8	1,907	2,220	2,153	2,153	2,153	2,266	2,153	2,153	2,153	2,153	2,153	2,153	2,153	2,153	2,153	2,153	2,266	2,153	2,266	1,134
	9	1,945	2,539	2,554	2,554	2,554	2,631	2,554	2,554	2,554	2,554	2,554	2,554	2,554	2,554	2,554	2,554	2,631	2,554	2,631	1,535
	10	2,003	2,593	2,277	2,277	2,277	2,348	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,348	2,277	2,348	1,307
	11	3,270	4,246	4,262	4,262	4,262	4,327	4,262	4,262	4,262	4,262	4,262	4,262	4,262	4,262	4,262	4,262	4,327	4,262	4,327	3,243
	12	7,995	8,953	8,970	8,970	8,970	9,038	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	9,038	8,970	9,038	7,963
9CBGB	1	10,378	11,223	9,386	9,386	9,386	9,453	9,386	9,386	9,386	9,386	9,386	9,386	9,386	9,386	9,386	9,386	9,453	9,386	9,453	7,870
	2	11,918	12,768	12,056	12,056	12,056	12,172	12,056	12,056	12,056	12,056	12,056	12,056	12,056	12,056	12,056	12,056	12,172	12,056	12,172	10,576
	3	7,010	8,102	7,459	7,459	7,459	7,520	7,459	7,459	7,459	7,459	7,459	7,459	7,459	7,459	7,459	7,459	7,520	7,459	7,520	5,996
	4	7,041	7,347	6,558	6,558	6,558	6,629	6,558	6,558	6,558	6,558	6,558	6,558	6,558	6,558	6,558	6,558	6,629	6,558	6,629	5,113
	5	11,254	11,093	10,087	10,087	10,087	10,174	10,087	10,087	10,087	10,087	10,087	10,087	10,087	10,087	10,087	10,087	10,174	10,087	10,174	8,589
	6	7,244	6,924	6,119	6,119	6,119	6,207	6,119	6,119	6,119	6,119	6,119	6,119	6,119	6,119	6,119	6,119	6,207	6,119	6,207	4,604
	7	4,008	4,120	3,889	3,889	3,889	4,020	3,889	3,889	3,889	3,889	3,889	3,889	3,889	3,889	3,889	3,889	4,020	3,889	4,020	2,408
	8	2,335	3,091	3,024	3,024	3,024	3,142	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,142	3,024	3,142	1,562
	9	2,381	3,430	3,415	3,415	3,415	3,496	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,415	3,496	3,415	3,496	1,952
	10	2,452	3,465	3,149	3,149	3,149	3,223	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,149	3,223	3,149	3,223	1,756
	11	4,004	5,424	5,440	5,440	5,440	5,508	5,440	5,440	5,440	5,440	5,440	5,440	5,440	5,440	5,440	5,440	5,508	5,440	5,508	3,977
	12	9,789	11,185	11,202	11,202	11,202	11,273	11,202	11,202	11,202	11,202	11,202	11,202	11,202	11,202	11,202	11,202	11,273	11,202	11,273	9,757

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
8TRMI	1	247,355	177,903	182,458	228,052	228,052	228,093	228,052	228,052	228,052	228,052	228,052	228,052	228,052	228,052	228,052	228,052	228,093	228,052	228,093	134,150
	2	353,959	196,448	174,335	271,077	271,077	271,115	271,077	271,077	271,077	271,077	271,077	271,077	271,077	271,077	271,077	271,077	271,115	271,077	271,116	139,796
	3	365,771	244,526	247,173	325,032	325,032	325,071	325,034	325,032	325,032	325,032	325,032	325,032	325,032	325,032	325,032	325,032	325,071	325,032	325,072	216,974
	4	349,537	257,191	241,580	304,482	304,482	304,525	304,482	304,482	304,482	304,482	304,482	304,482	304,482	304,482	304,482	304,482	304,525	304,482	304,525	182,962
	5	645,902	487,123	455,727	605,216	605,216	605,265	605,261	605,216	605,216	605,216	605,216	605,216	605,216	605,216	605,216	605,216	605,265	605,216	605,310	405,035
	6	370,174	287,564	273,194	324,563	324,563	324,621	324,563	324,563	324,563	324,563	324,563	324,563	324,563	324,563	324,563	324,563	324,621	324,563	324,621	242,674
	7	116,521	89,498	94,601	138,162	138,162	138,236	138,213	138,162	138,162	138,162	138,162	138,162	138,162	138,162	138,162	138,162	138,236	138,162	138,288	60,112
	8	38,896	54,997	57,564	96,402	96,402	96,490	96,402	96,402	96,402	96,402	96,402	96,402	96,402	96,402	96,402	96,402	96,490	96,402	96,490	25,512
	9	72,931	60,690	64,948	109,696	109,696	109,752	109,696	109,696	109,696	109,696	109,696	109,696	109,696	109,696	109,696	109,696	109,752	109,696	109,752	29,638
	10	141,153	94,290	94,724	134,561	134,561	134,611	134,561	134,561	134,561	134,561	134,561	134,561	134,561	134,561	134,561	134,561	134,611	134,561	134,611	57,072
	11	135,787	108,976	110,991	151,694	151,694	151,728	151,694	151,694	151,694	151,694	151,694	151,694	151,694	151,694	151,694	151,694	151,728	151,694	151,728	71,090
	12	225,435	166,040	167,520	209,624	209,624	209,661	209,624	209,624	209,624	209,624	209,624	209,624	209,624	209,624	209,624	209,624	209,661	209,624	209,661	126,550
8TRRI	1	265,375	203,114	210,384	272,029	272,029	272,181	272,029	272,029	272,029	272,029	272,029	272,029	272,029	272,029	272,029	272,029	272,181	272,029	272,181	156,797
	2	378,696	257,445	258,102	333,160	333,160	333,301	333,160	333,160	333,160	333,160	333,160	333,160	333,160	333,160	333,160	333,160	333,301	333,160	333,301	215,671
	3	410,309	288,713	304,601	353,633	353,633	353,774	353,634	353,633	353,633	353,633	353,633	353,633	353,633	353,633	353,633	353,633	353,774	353,633	353,775	256,842
	4	430,469	313,557	287,504	385,295	385,295	385,458	385,370	385,295	385,295	385,295	385,295	385,295	385,295	385,295	385,295	385,295	385,458	385,295	385,532	263,414
	5	701,026	581,356	536,960	665,044	665,044	665,227	665,046	665,044	665,044	665,044	665,044	665,044	665,044	665,044	665,044	665,044	665,227	665,044	665,228	511,308
	6	391,902	298,629	290,319	341,538	341,538	341,961	341,548	341,538	341,538	341,538	341,538	341,538	341,538	341,538	341,538	341,538	341,961	341,538	341,971	252,544
	7	136,951	102,522	102,523	148,656	148,656	148,934	148,657	148,656	148,656	148,656	148,656	148,656	148,656	148,656	148,656	148,656	148,934	148,656	148,936	75,019
	8	41,455	58,089	58,722	96,133	96,133	96,426	96,133	96,133	96,133	96,133	96,133	96,133	96,133	96,133	96,133	96,133	96,426	96,133	96,426	29,866
	9	77,594	67,144	70,948	113,176	113,176	113,385	113,176	113,176	113,176	113,176	113,176	113,176	113,176	113,176	113,176	113,176	113,385	113,176	113,385	39,289
	10	145,051	106,745	114,971	149,806	149,806	149,991	149,812	149,806	149,806	149,806	149,806	149,806	149,806	149,806	149,806	149,806	149,991	149,806	149,996	71,097
	11	159,026	134,307	146,561	180,096	180,096	180,243	180,096	180,096	180,096	180,096	180,096	180,096	180,096	180,096	180,096	180,096	180,243	180,096	180,243	107,685
	12	256,825	207,006	216,979	251,418	251,418	250,898	251,418	251,418	251,418	251,418	251,418	251,418	251,418	251,418	251,418	251,418	251,418	250,898	250,898	175,184
8TRRO	1	343,792	253,950	199,858	288,938	288,938	289,183	288,939	288,938	288,938	288,938	299,125	292,354	288,938	288,938	288,938	288,938	299,125	288,938	302,787	85,922
	2	515,998	360,465	323,754	392,313	392,313	392,551	392,314	392,313	392,313	392,313	401,828	395,527	392,313	392,313	392,313	392,313	401,828	392,313	405,281	176,373
	3	462,033	376,006	360,336	396,258	396,258	396,502	396,258	396,258	396,258	396,258	405,360	399,544	396,258	396,258	396,258	396,258	405,360	396,258	408,891	251,702
	4	514,811	354,426	317,664	390,435	390,435	390,703	390,475	390,435	390,435	390,435	401,874	393,955	390,435	390,435	390,435	390,435	401,874	390,435	405,702	244,957
	5	800,313	670,465	594,075	691,548	691,548	691,853	691,842	691,548	691,548	691,548	704,163	695,621	691,548	691,548	691,548	691,548	704,163	691,548	708,835	445,977
	6	466,608	319,411	245,929	320,920	320,920	321,277	320,921	320,920	320,920	320,920	335,612	325,844	320,920	320,920	320,920	320,920	335,612	320,920	340,895	204,055
	7	163,123	112,491	164,207	164,250	164,250	163,484	164,250	164,250	164,250	164,250	182,259	168,207	164,250	164,250	164,250	164,250	182,259	163,484	187,319	161,987
	8	45,702	105,615	158,630	158,468	158,468	157,701	158,468	158,468	158,468	158,468	161,918	161,443	158,468	158,468	158,468	158,468	161,918	157,701	161,151	151,278
	9	87,593	82,721	112,461	112,722	112,722	112,145	112,722	112,722	112,722	112,722	113,420	113,115	112,722	112,722	112,722	112,722	113,420	112,145	112,832	109,779
	10	125,283	74,585	92,958	92,991	92,991	92,473	92,991	92,991	92,991	92,991	93,413	93,232	92,991	92,991	92,991	92,991	93,413	92,473	92,895	90,339
	11	205,788	116,936	70,081	80,851	80,851	84,087	80,851	80,851	80,851	80,851	90,671	86,496	80,851	80,851	80,851	80,851	90,671	80,851	97,218	69,681
	12	331,753	250,521	109,904	233,973	233,973	234,207	233,974	233,973	233,973	233,973	242,617	237,085	233,973	233,973	233,973	233,973	242,617	233,973	245,965	65,643
802	1	354,568	274,737	220,631	297,265	297,265	297,543	297,266	297,265	297,265	297,265	280,099	280,099	297,265	297,265	297,265	297,265	297,543	280,099	280,378	103,860
	2	518,717	388,868	325,759	419,337	419,337	419,753	419,337	419,337	419,337	419,337	403,111	403,111	419,337	419,337	419,337	419,337	419,753	403,111	403,526	180,555
	3	468,300	397,283	363,559	417,660	417,660	418,054	417,728	417,660	417,660	417,660	400,395	400,395	417,660	417,660	417,660	417,660	418,054	400,395	400,856	259,405
	4	544,885	362,380	334,450	398,317	398,317	398,777	398,357	398,317	398,317	398,317	381,645	381,645	398,317	398,317	398,317	398,317	398,777	381,645	382,146	286,004
	5	822,729	707,419	598,602	695,887	695,887	696,415	696,181	695,887	695,887	695,887	675,926	675,926	695,887	695,887	695,887	695,887	696,415	675,926	676,747	465,820
	6	475,007	327,847	282,084	353,260	353,260	354,690	353,391	353,260	353,260	353,260	328,525	328,525	353,260	353,260	353,260	353,260	354,690	328,525	330,086	239,685
	7	184,553	124,757	165,932	165,420	165,420	164,979	165,420	165,420	165,420	165,420	135,343	135,343	165,420	165,420	165,420	165,420	165,420	135,343	134,901	165,096
	8	51,176	107,355	162,577	161,610	161,610	161,173	161,610	161,610	161,610	161,610	132,200	132,200	161,610	161,610	161,610	161,610	161,610	132,200	131,763	156,650
	9	98,060	84,298	114,406	114,308	114,308	113,978	114,308	114,308	114,308	114,308	91,626	91,626	114,308	114,308	114,308	114,308	114,308	91,626	91,296	113,586
	10	137,193	76,343	93,816	93,738	93,738	93,449	93,738	93,738	93,738	93,738	73,604	73,604	93,738	93,738	93,738	93,738	93,738	73,604	73,315	93,028
	11	215,315	122,347	71,493	94,771	94,771	95,212	94,772	94,771	94,771	94,771	78,075	78,075	94,771	94,771	94,771	94,771	95,212	78,075	78,517	70,816
	12	346,948	259,416	136,475	242,000	242,000	242,417	242,001	242,000	242,000	242,000	225,675	225,675	242,000	242,000	242,000	242,000	242,417	225,675	226,093	76,680

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
B4261B	1	358,240	253,624	149,140	226,705	226,705	227,212	226,706	226,705	226,705	226,705	226,705	226,705	226,705	226,705	226,705	226,705	227,212	226,705	227,212	51,638
	2	519,778	357,907	257,878	361,359	361,359	361,988	361,391	361,359	361,359	361,359	361,359	361,359	361,359	361,359	361,359	361,359	361,988	361,359	362,020	117,030
	3	470,746	358,879	293,548	348,784	348,784	349,382	348,852	348,784	348,784	348,784	348,784	348,784	348,784	348,784	348,784	348,784	349,382	348,784	349,450	189,712
	4	550,295	320,478	257,171	320,971	320,971	321,689	321,012	320,971	320,971	320,971	320,971	320,971	320,971	320,971	320,971	320,971	321,689	320,971	321,729	208,814
	5	831,481	655,757	505,788	603,007	603,007	603,817	603,301	603,007	603,007	603,007	603,007	603,007	603,007	603,007	603,007	603,007	603,817	603,007	604,111	378,906
	6	482,060	270,134	181,861	245,222	245,222	246,980	245,353	245,222	245,222	245,222	245,222	245,222	245,222	245,222	245,222	245,222	246,980	245,222	247,111	140,333
	7	184,826	48,230	18,011	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	15,829	16,210
	8	53,593	25,688	15,754	15,089	15,089	15,088	15,089	15,089	15,089	15,089	15,089	15,089	15,089	15,089	15,089	15,089	15,089	15,088	15,088	14,609
	9	98,954	24,470	8,171	7,840	7,840	7,839	7,840	7,840	7,840	7,840	7,840	7,840	7,840	7,840	7,840	7,840	7,840	7,839	7,839	7,987
	10	139,507	25,937	3,194	2,900	2,900	2,899	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,899	2,899	3,461
	11	217,588	83,888	3,106	25,213	25,213	25,874	25,214	25,213	25,213	25,213	25,213	25,213	25,213	25,213	25,213	25,213	25,874	25,213	25,875	2,774
	12	355,621	237,642	81,802	180,054	180,054	180,665	180,055	180,054	180,054	180,054	180,054	180,054	180,054	180,054	180,054	180,054	180,665	180,054	180,666	14,001
8TRGB	1	365,784	264,884	150,864	229,396	229,396	229,903	229,397	229,396	229,396	229,396	229,396	229,396	229,396	229,396	229,396	229,396	229,903	229,396	229,904	60,344
	2	542,859	370,475	257,613	376,859	376,859	377,481	376,859	376,859	376,859	376,859	376,859	376,859	376,859	376,859	376,859	376,859	377,481	376,859	377,482	119,120
	3	475,774	361,279	291,853	348,320	348,320	348,918	348,387	348,320	348,320	348,320	348,320	348,320	348,320	348,320	348,320	348,320	348,918	348,320	348,986	188,424
	4	561,410	321,921	256,016	319,816	319,816	320,533	319,856	319,816	319,816	319,816	319,816	319,816	319,816	319,816	319,816	319,816	320,533	319,816	320,574	207,659
	5	849,466	651,610	500,246	597,465	597,465	598,275	597,759	597,465	597,465	597,465	597,465	597,465	597,465	597,465	597,465	597,465	598,275	597,465	598,569	383,128
	6	498,158	305,608	204,411	254,507	254,507	255,467	254,506	254,507	254,507	254,507	254,507	254,507	254,507	254,507	254,507	254,507	255,467	254,506	255,468	167,848
	7	191,939	36,241	3,684	1,531	1,531	1,534	1,531	1,531	1,531	1,531	1,531	1,531	1,531	1,531	1,531	1,531	1,534	1,531	1,534	1,286
	8	58,559	12,444	772	375	375	375	375	375	375	375	375	375	375	375	375	375	375	375	375	706
	9	100,791	18,999	903	464	464	464	464	464	464	464	464	464	464	464	464	464	464	464	464	739
	10	144,262	26,435	2,356	440	440	440	440	440	440	440	440	440	440	440	440	440	440	440	440	680
	11	224,396	88,682	9,786	37,705	37,705	37,942	37,705	37,705	37,705	37,705	37,705	37,705	37,705	37,705	37,705	37,705	37,942	37,705	37,942	7,041
	12	384,938	269,987	91,709	181,228	181,228	181,839	181,259	181,228	181,228	181,228	181,228	181,228	181,228	181,228	181,228	181,228	181,839	181,228	181,870	16,162

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
D37	1	1,434	1,405	847	847	847	847	847	847	847	847	847	847	847	847	847	847	847	847	847	847
	2	940	898	773	773	773	773	773	773	773	773	773	773	773	773	773	773	773	773	773	773
	3	616	566	542	542	542	542	542	542	542	542	542	542	542	542	542	542	542	542	542	542
	4	1,644	1,467	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389	1,389
	5	1,661	1,424	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322	1,322
	6	2,616	2,306	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007	2,007
	7	1,768	1,414	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394
	8	1,295	1,154	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275
	9	2,596	2,537	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596
	10	1,408	1,359	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408
	11	1,154	1,108	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154	1,154
	12	1,736	1,709	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736
7NTTB	1	4,775	4,578	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971
	2	3,131	2,925	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650	2,650
	3	2,050	1,788	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707	1,707
	4	5,473	4,578	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307	4,307
	5	5,531	4,343	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151	4,151
	6	8,708	7,222	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835	6,835
	7	5,885	4,651	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555	4,555
	8	4,311	3,484	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518
	9	8,643	8,328	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317	8,317
	10	4,688	4,469	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476	4,476
	11	3,842	3,614	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612	3,612
	12	5,779	5,644	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642
D4296A	1	6,175	5,207	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409	4,409
	2	4,050	3,212	3,133	3,133	3,133	3,134	3,133	3,133	3,133	3,133	3,133	3,133	3,133	3,133	3,133	3,133	3,134	3,133	3,134	3,133
	3	2,922	1,878	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804	1,804
	4	5,523	2,201	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954	1,954
	5	6,772	2,324	1,919	1,919	1,919	1,920	1,919	1,919	1,919	1,919	1,919	1,919	1,919	1,919	1,919	1,919	1,920	1,919	1,920	1,919
	6	8,931	3,576	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100
	7	6,908	2,209	1,965	1,965	1,965	1,966	1,965	1,965	1,965	1,965	1,965	1,965	1,965	1,965	1,965	1,965	1,966	1,965	1,966	1,965
	8	5,273	2,815	2,532	2,532	2,532	2,533	2,532	2,532	2,532	2,532	2,532	2,532	2,532	2,532	2,532	2,532	2,533	2,532	2,533	2,532
	9	10,360	8,996	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961	8,961
	10	5,224	4,061	4,051	4,051	4,051	4,052	4,051	4,051	4,051	4,051	4,051	4,051	4,051	4,051	4,051	4,051	4,052	4,051	4,052	4,051
	11	4,918	4,046	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004	4,004
	12	7,001	6,333	6,352	6,352	6,352	6,353	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,353	6,352	6,353	6,352
7NTEB	1	16,084	13,874	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699	11,699
	2	10,549	8,956	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375	8,375
	3	7,611	5,761	5,258	5,258	5,258	5,259	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,258	5,259	5,258	5,259	5,258
	4	14,385	9,646	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152	9,152
	5	17,639	11,472	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684	10,684
	6	23,263	14,917	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331	14,331
	7	17,994	11,702	11,614	11,614	11,614	11,615	11,614	11,614	11,614	11,614	11,614	11,614	11,614	11,614	11,614	11,614	11,615	11,614	11,615	11,614
	8	13,735	10,665	10,552	10,552	10,552	10,553	10,552	10,552	10,552	10,552	10,552	10,552	10,552	10,552	10,552	10,552	10,553	10,552	10,553	10,552
	9	26,986	25,132	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090
	10	13,608	11,435	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643	11,643
	11	12,811	11,458	11,415	11,415	11,415	11,416	11,415	11,415	11,415	11,415	11,415	11,415	11,415	11,415	11,415	11,415	11,416	11,415	11,416	11,415
	12	18,235	17,040	17,086	17,086	17,086	17,087	17,086	17,086	17,086	17,086	17,086	17,086	17,086	17,086	17,086	17,086	17,087	17,086	17,087	17,086

CP	Month	A	B	C	D_0	D_3	D_4	D_7	D_8	D_9	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{MAX}	D_{MIN}	E	F
		All Flows in Units of Acre-Feet																			
7NTIC	1	8,902	8,296	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446	6,446
	2	5,676	5,184	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714	4,714
	3	4,255	3,704	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316	3,316
	4	9,502	7,839	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178	7,178
	5	11,414	8,835	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819	7,819
	6	10,996	7,731	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659	6,659
	7	7,267	5,349	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369
	8	5,899	4,811	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344	4,344
	9	11,063	10,087	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503	10,503
	10	7,963	6,950	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968	6,968
	11	7,844	7,328	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484	7,484
	12	9,276	8,635	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996	8,996

APPENDIX B

10^{TH} PERCENTILE FLOWS FOR CRITICAL SEGMENTS ANALYSIS

10th Percentile Flows for Examined Control Points (Units of Acre-Feet)																										
Strategy	**532801**	**CON238**	**BRRI70**	**BRRI7D**	**100441**	**13331**	**101731**	**10441**	**D37**	**7NTTB**	**D4296A**	**7NTEB**	**A5191P**	**SPSP**	**1009**	**1004**	**A3979A**	**A4964A**	**SRGB**	**8TRMI**	**8TRRI**	**8TRRO**	**802**	**B4261B**	**9CBCR**	**901**
D_0	41,101	23,721	55,925	55,925	0	0	0	0	27	139	0	561	59,845	1,461	1,996	2,082	559	0	65,550	86,138	89,543	70,893	74,146	1,737	13	1,350
D_3	40,776	23,736	55,518	55,518	0	0	434	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D_4	41,411	23,692	56,073	56,073	0	0	169	0	27	139	0	561	60,069	1,474	2,100	2,937	640	0	66,000	86,197	89,760	70,792	74,143	1,737	13	1,422
D_7	39,246	23,784	54,684	54,684	0	0	0	0	NA	NA	NA	NA	60,601	1,461	2,004	2,082	559	0	66,330	86,138	89,543	70,893	74,146	1,737	NA	NA
D_8	40,027	23,390	54,918	54,918	0	0	280	0	NA	NA	NA	NA	61,175	1,461	1,996	2,082	559	0	66,977	NA	NA	NA	NA	NA	NA	NA
D_9	40,592	23,714	55,028	55,028	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D_{11}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	56,482	1,461	1,996	2,082	559	0	62,338	NA	NA	NA	NA	NA	NA	NA
D_{12}	41,168	23,738	56,140	56,140	0	0	0	0	NA	NA	NA	NA	64,199	4,223	2,082	2,032	558	0	70,502	86,138	89,543	79,476	56,995	1,737	NA	NA
D_{13}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59,845	2,736	1,993	2,662	558	0	66,085	86,138	89,543	77,072	56,995	1,737	NA	NA
D_{14}	41,219	23,786	55,324	55,324	0	0	0	0	NA	NA	NA	NA	59,920	1,461	1,996	2,082	559	0	65,626	NA	NA	NA	NA	NA	NA	NA
D_{15}	41,101	23,721	55,925	55,925	0	0	0	0	NA	NA	NA	NA	56,863	1,461	1,996	2,082	559	0	62,568	NA	NA	NA	NA	NA	NA	NA
D_{16}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59,039	1,461	1,992	2,082	559	0	64,871	NA	NA	NA	NA	NA	NA	NA
D_{17}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59,845	1,461	1,996	2,082	559	0	66,973	NA	NA	NA	NA	NA	NA	NA
E	37,835	24,070	136,730	136,730	0	0	896	0	27	139	0	561	59,370	5,522	2,154	3,307	600	0	67,785	86,197	89,761	80,893	56,977	1,737	13	1,422

Absolute Percent Difference in Strategy and D_0 Flows for Examined Control Points																										
Strategy	**532801**	**CON238**	**BRRI70**	**BRRI7D**	**100441**	**13331**	**101731**	**10441**	**D37**	**7NTTB**	**D4296A**	**7NTEB**	**A5191P**	**SPSP**	**1009**	**1004**	**A3979A**	**A4964A**	**SRGB**	**8TRMI**	**8TRRI**	**8TRRO**	**802**	**B4261B**	**9CBCR**	**901**
D_0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
D_3	0.79	0.07	0.73	0.73	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D_4	0.75	0.12	0.26	0.26	NA	NA	NA	NA	0.00	0.00	NA	0.00	0.37	0.89	5.26	41.09	14.44	NA	0.69	0.07	0.24	0.14	0.00	0.01	0.00	5.33
D_7	4.51	0.27	2.22	2.22	NA	NA	NA	NA	NA	NA	NA	NA	1.26	0.04	0.41	0.00	0.00	NA	1.19	0.00	0.00	0.00	0.00	0.00	NA	NA
D_8	2.61	1.39	1.80	1.80	NA	NA	NA	NA	NA	NA	NA	NA	2.22	0.00	0.00	0.00	0.00	NA	2.18	NA	NA	NA	NA	NA	NA	NA
D_9	1.24	0.03	1.60	1.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D_{11}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.62	0.00	0.00	0.00	0.00	NA	4.90	NA	NA	NA	NA	NA	NA	NA
D_{12}	0.16	0.08	0.39	0.39	NA	NA	NA	NA	NA	NA	NA	NA	7.28	189.08	4.35	2.37	0.15	NA	7.55	0.00	0.00	12.11	23.13	0.00	NA	NA
D_{13}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	87.31	0.12	27.86	0.15	NA	0.82	0.00	0.00	8.72	23.13	0.00	NA	NA
D_{14}	0.29	0.28	1.07	1.07	NA	NA	NA	NA	NA	NA	NA	NA	0.13	0.00	0.00	0.00	0.00	NA	0.12	NA	NA	NA	NA	NA	NA	NA
D_{15}	0.00	0.00	0.00	0.00	NA	NA	NA	NA	NA	NA	NA	NA	4.98	0.00	0.00	0.00	0.00	NA	4.55	NA	NA	NA	NA	NA	NA	NA
D_{16}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.35	0.00	0.17	0.00	0.00	NA	1.04	NA	NA	NA	NA	NA	NA	NA
D_{17}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.04	0.00	0.00	0.00	NA	2.17	NA	NA	NA	NA	NA	NA	NA
E	7.95	1.47	144.49	144.49	NA	NA	NA	NA	0.00	0.00	NA	0.00	0.79	277.99	7.94	58.83	7.27	NA	3.41	0.07	0.24	14.11	23.15	0.01	0.00	5.33

APPENDIX C

FIELD STUDY AND CRITICAL SEGMENT SITE SUMMARY

Critical Segment - CP SPSP

Stream: San Jacinto River Basin

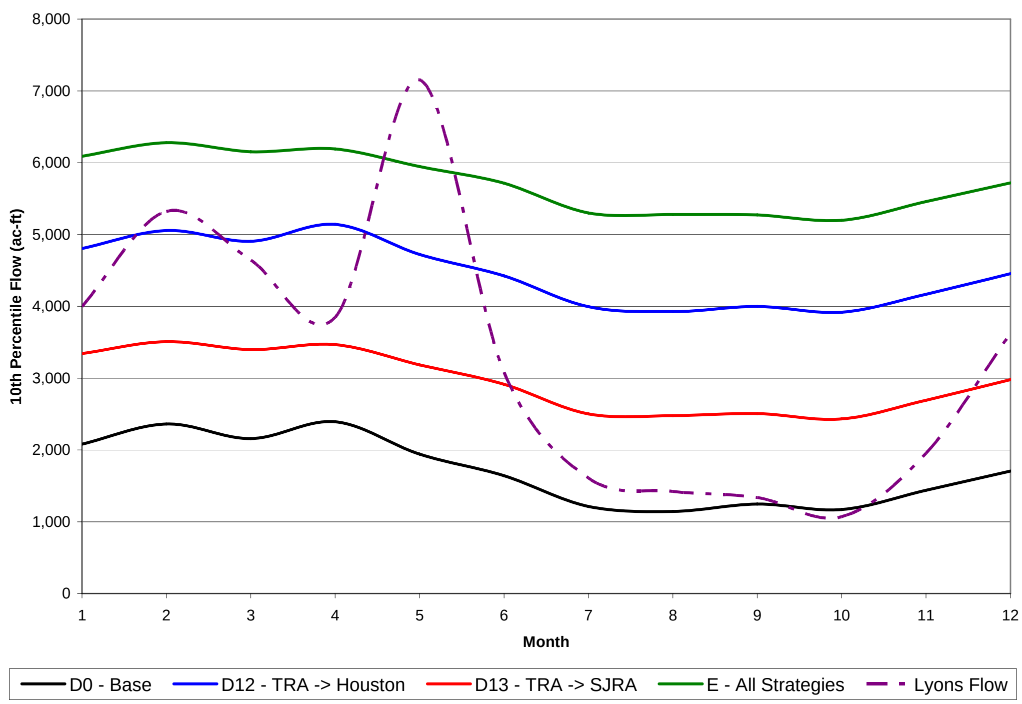
Segment: 1008 on Spring Creek
From the confluence with the West Fork San Jacinto River in Harris/Montgomery County to the most upstream crossing of FM 1736 in Waller County.

Impacted by: Bacteria – impaired water body on 2006 303(d) lists
Depressed Dissolved Oxygen

Characteristics: Freshwater Stream
Water Body size: 69.0 miles

Segment 1008 Use: Aquatic Life Use
General Use
Public Water Supply Use
Recreation Use

10th Percentile Flow for Critical Strategies:



References
2006 Texas 303(d) List; dated June 27, 2007
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_303d.pdf

2006 Texas Water Quality Inventory – Basin Assessment Data by Segment
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_basin10.pdf

Critical Segment - CP 1004

Stream: San Jacinto River Basin

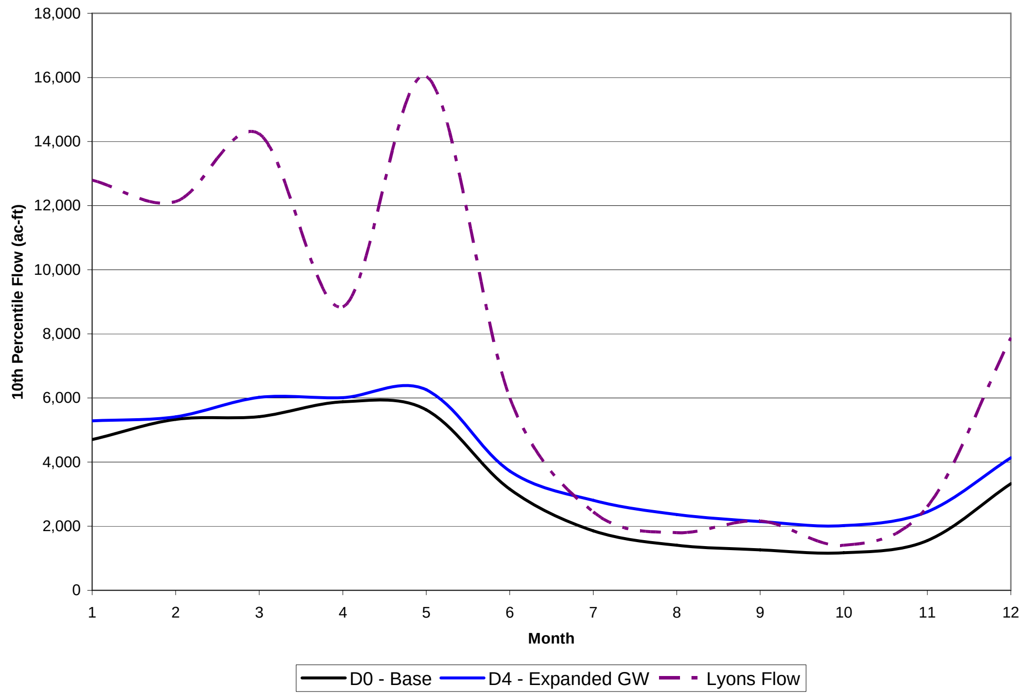
Segment: 1004 West Fork San Jacinto River
From the confluence of Spring Creek in Harris/Montgomery County to Conroe Dam in Montgomery County.

Impacted by: Bacteria – impaired water body on 2006 303(d) lists

Characteristics: Freshwater Stream
Water Body size: 40.0 miles

Segment 1004 Use: Aquatic Life Use
General Use
Public Water Supply Use
Recreation Use

10th Percentile Flow for Critical Strategies:



References
2006 Texas 303(d) List; dated June 27, 2007
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_303d.pdf

2006 Texas Water Quality Inventory – Basin Assessment Data by Segment
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_basin10.pdf

Critical Segment - CP A5191P

Stream: San Jacinto River Basin

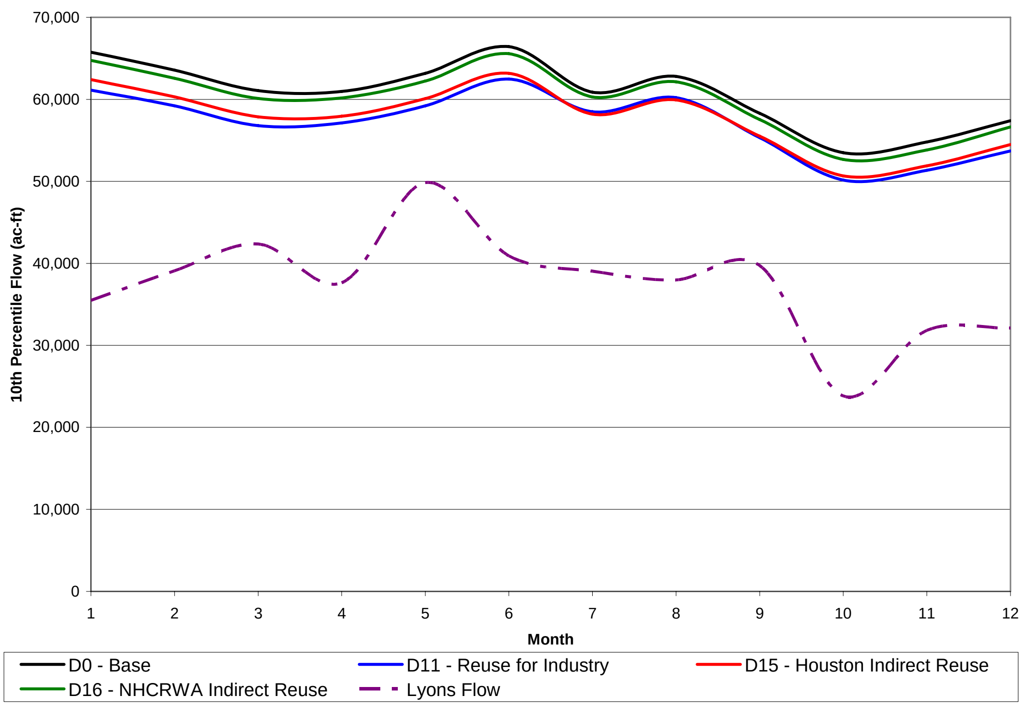
Segment: 1005 Houston Ship Channel/San Jacinto River Tidal
From the confluence of Galveston Bay with Morgan's Point in Harris/Chambers County to a point 100 meters (110 yards) downstream of IH 10 in Harris County.

Impacted by: Bacteria – impaired water body on 2006 303(d) lists

Characteristics: Tidal Stream
Water Body size: 12.0 miles

Segment 1005 Use: Aquatic Life Use
Fish Consumption Use
General Use
Recreation Use

10th Percentile Flow for Critical Strategies:



References
2006 Texas 303(d) List; dated June 27, 2007
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_303d.pdf

2006 Texas Water Quality Inventory – Basin Assessment Data by Segment
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_basin10.pdf

Critical Segment - CP BRRI70

Stream: Brazos River Basin

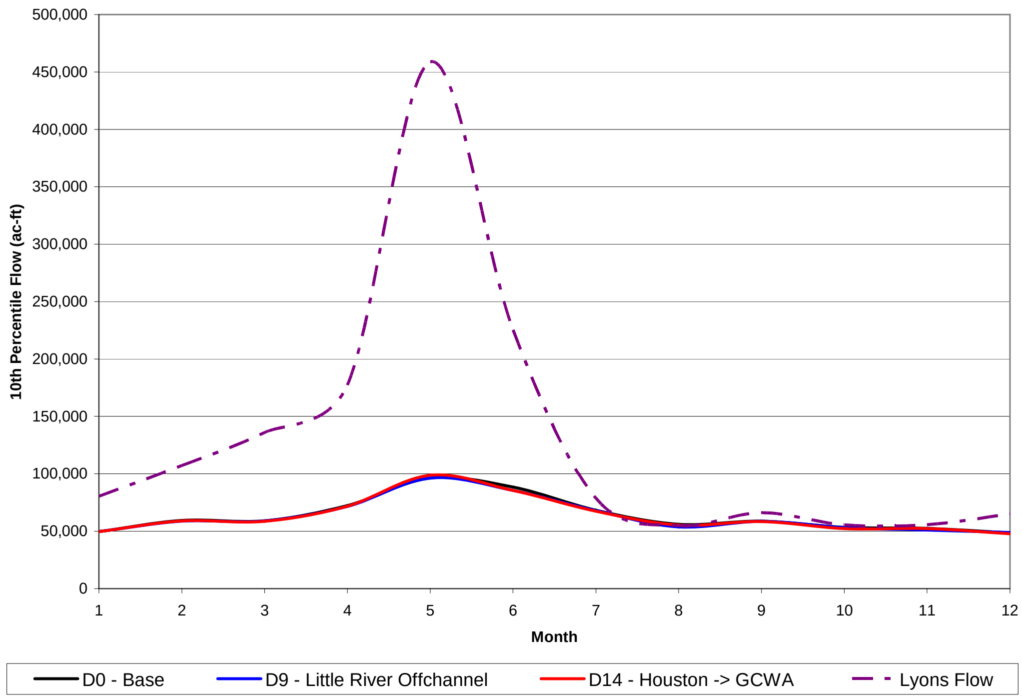
Segment: 1202 Brazos River Below Navasota River
From a point 100 meters (110 yards) upstream of SH 332 in Brazoria County to the confluence of the Navasota River in Grimes County.

Impacted by: Bacteria – impaired water body on 2006 303(d) lists

Characteristics: Freshwater Stream
Water Body size: 199.0 miles

Segment 1202 Use: Aquatic Life Use
Fish Consumption Use
General Use
Public Water Supply Use
Recreation Use

10th Percentile Flow for Critical Strategies:



References
2006 Texas 303(d) List; dated June 27, 2007
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_303d.pdf

2006 Texas Water Quality Inventory – Basin Assessment Data by Segment
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_basin10.pdf

Critical Segment - CP SRGB

Stream: San Jacinto River Basin

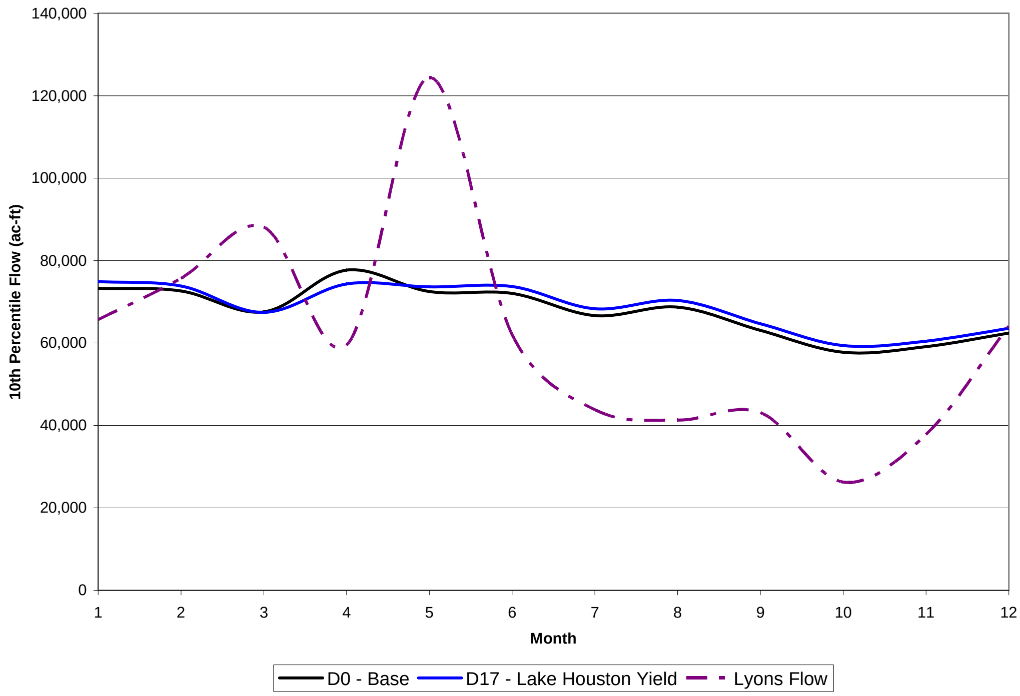
Segment: 1005 Houston Ship Channel/San Jacinto River Tidal
From the confluence of Galveston Bay with Morgan's Point in Harris/Chambers County to a point 100 meters (110 yards) downstream of IH 10 in Harris County.

Impacted by: Bacteria – impaired water body on 2006 303(d) lists

Characteristics: Tidal Stream
Water Body size: 12.0 miles

Segment 1005 Use: Aquatic Life Use
Fish Consumption Use
General Use
Recreation Use

10th Percentile Flow for Critical Strategies:



References
2006 Texas 303(d) List; dated June 27, 2007
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_303d.pdf

2006 Texas Water Quality Inventory – Basin Assessment Data by Segment
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_basin10.pdf

Critical Segment - CP 532801

Stream: Brazos River Basin

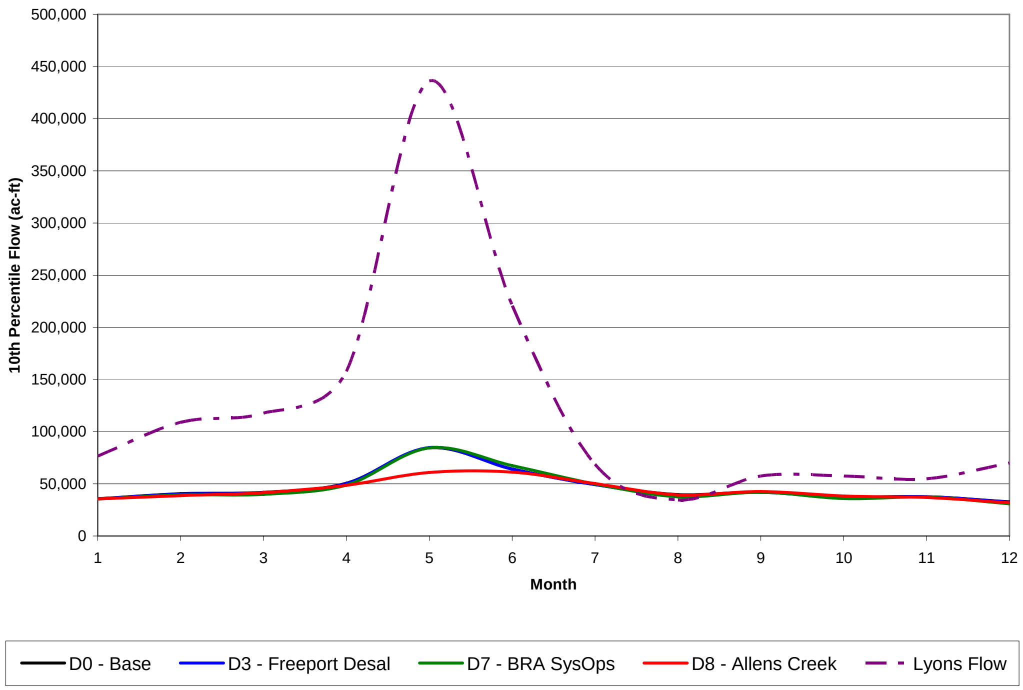
Segment: 1202 Brazos River Below Navasota River
From a point 100 meters (110 yards) upstream of SH 332 in Brazoria County to the confluence of the Navasota River in Grimes County.

Impacted by: Bacteria – impaired water body on 2006 303(d) lists

Characteristics: Freshwater Stream
Water Body size: 199.0 miles

Segment 1202 Use: Aquatic Life Use
Fish Consumption Use
General Use
Public Water Supply Use
Recreation Use

10th Percentile Flow for Critical Strategies:



References
2006 Texas 303(d) List; dated June 27, 2007
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_303d.pdf

2006 Texas Water Quality Inventory – Basin Assessment Data by Segment
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/06twqi/2006_basin10.pdf

Survey Point - USGS Station 0806650 Trinity River at Romayor Bridge

Stream: Trinity River Basin

Segment: 0802 Classified Trinity River Below Lake Livingston
From a point 3.1 km (1.9 miles) downstream of US 90 in Liberty County to
Livingston Dam in Polk/San Jacinto County

Station: USGS 08066500

Characteristics: Freshwater Stream
Water Body Size 84 miles

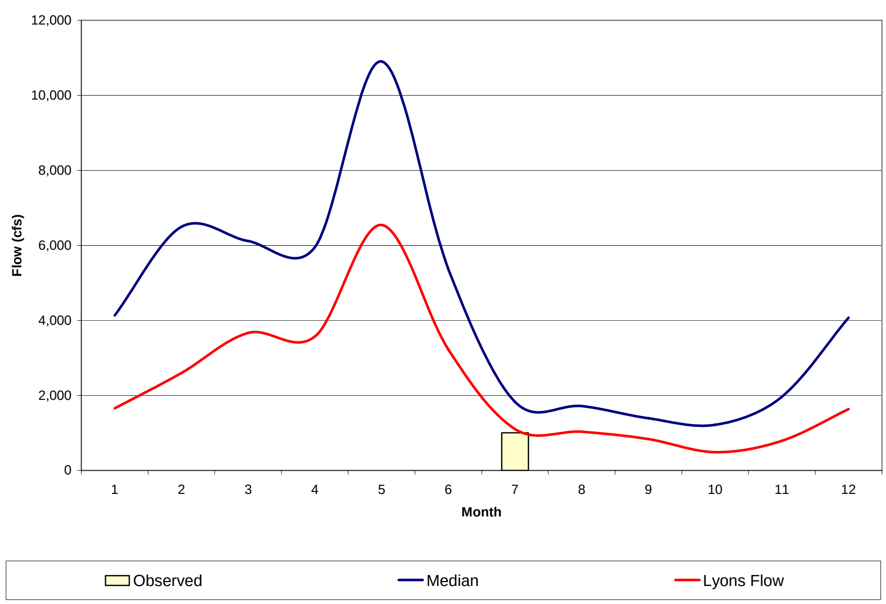
Segment 1202 Land Use: Cultivated land
Residential housing
Commercial development
Residential uses

References:
TCEQ Surface Water Quality Viewer
http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/viewer/viewer.html

2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin8.pdf

Ecologically Significant River and Stream Segment – Trinity River (Downstream of Lake Livingston)
http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1059c/trinity_river2.phtml

Observed status: At the time of observation (July 21, 2008), the Trinity River appeared to meet the definition of “Moderate” Channel Flow Status. Less than 25 percent of channel substrate was exposed. No potential wetlands and a small potential riparian corridor appeared to be present.



Survey Point - USGS Station 0806650 Trinity River at Romayor Bridge (photos)

Survey Point - USGS Station 08069000 Cypress Creek at IH 45 crossing near Westfield, TX

Stream: Trinity River Basin

Segment: 1009 Cypress Creek
From the confluence with Spring Creek in Harris County to the confluence of Snake Creek and Mound Creek in Waller County

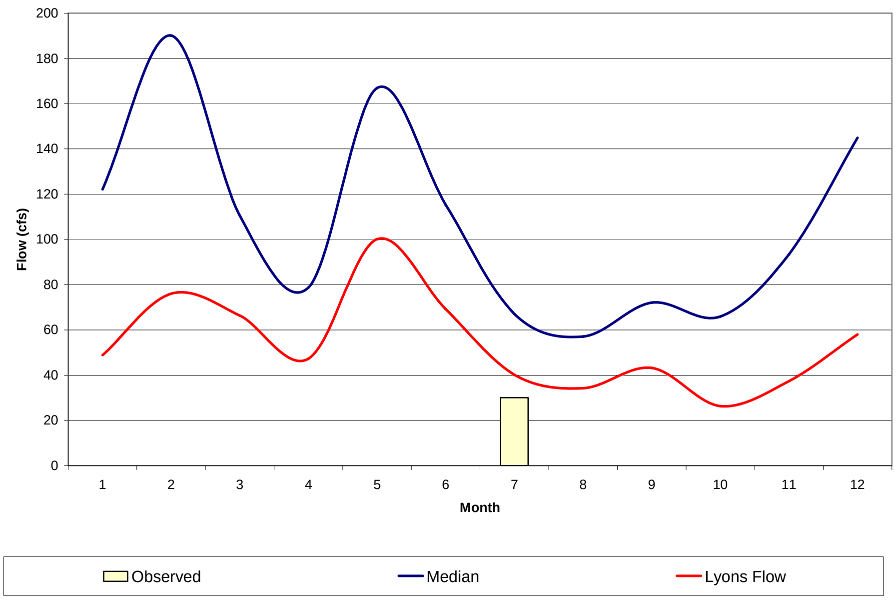
Station: USGS 08069000

Characteristics: Freshwater Stream
Water Body Size 53 miles

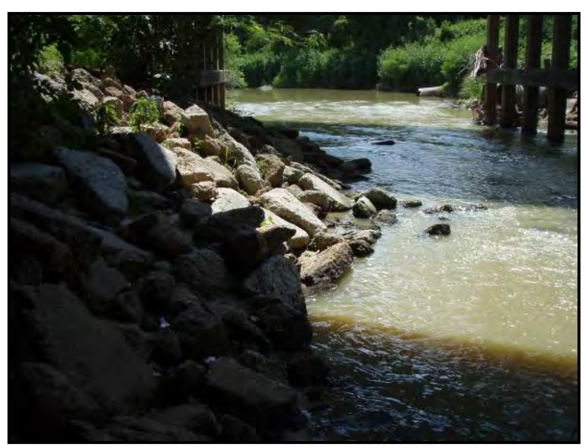
Segment 1009 Land Use: Aquatic life
General use
Public water supply
Residential uses

References:
2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin10.pdf

Observed status: At the time of observation (July 21, 2008), Cypress Creek appeared to meet the SQWM definition of "High" Channel Flow Status. Less than 5% of the channel substrate was exposed. No potential wetlands or riparian habitats were visible at the location of the USGS monitoring station.



Survey Point - USGS Station 08069000 Cypress Creek at IH 45 crossing near Westfield, TX (photos)



Survey Point - USGS 08068090 West Fork San Jacinto River above Lake Houston near Porter, TX

Stream: San Jacinto River Basin

Segment: 1004 Classified West Fork San Jacinto River
From the confluence of Spring Creek in Harris/Montgomery County to Conroe Dam in Montgomery County

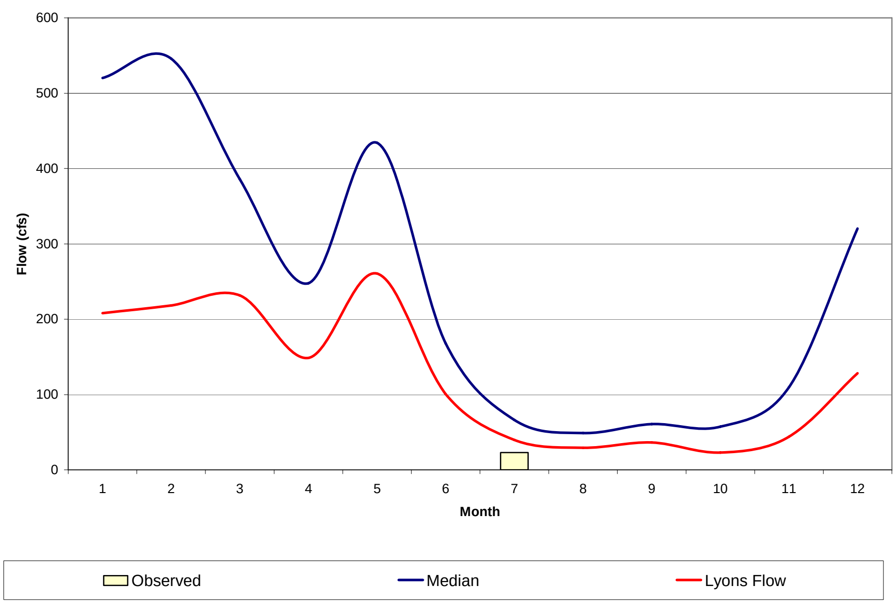
Station: USGS 08068090

Characteristics: Freshwater Stream
Body Size 40 miles

Segment 1004 Land Use: Aquatic life
General use
Public water supply use
Residential use

References:
2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin10.pdf

Observed status: At the time of observation (July 21, 2008), West Fork San Jacinto River appeared to meet the definition of "Moderate" Channel Flow Status. Less than 25 percent of channel substrate was exposed. Small sloughs jutting off the main river channel were present near the USGS monitoring station. These sloughs are potential wetlands. Some potential riparian areas were also present.



USGS 08068090 (photos)

Survey Point - USGS 08071280 Luce Bayou above Lake Houston near Huffman, TX

Stream: San Jacinto River Basin

Segment: 1002B Unclassified Water Body - Luce Bayou
From confluence with Lake Houston (Harris County) to FM 1008 (Liberty Texas)
Luce Bayou above Lake Houston near Huffman Texas

Station: USGS 08071280

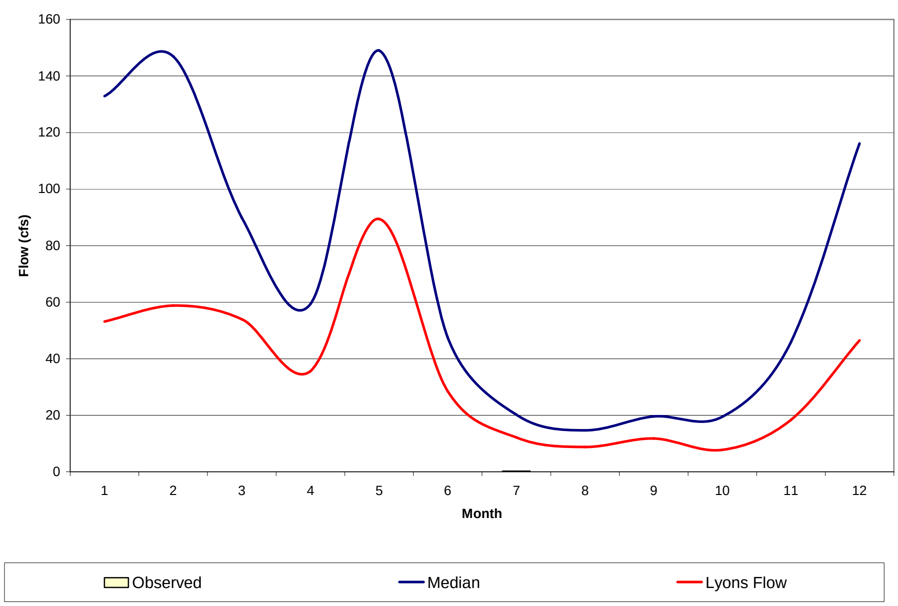
Characteristics: Freshwater Stream
Water Body Size 22.3 miles

Segment 1002B Land Use: Aquatic life
General use
Residential use

References:
TCEQ Surface Water Quality Viewer
http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/viewer/viewer.html

2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin10.pdf

Observed status: At the time of observation (July 21, 2008), Luce Bayou appeared to meet the definition of “Moderate” Flow Status. Less than 25 percent of channel substrate was exposed. Some potential fringe wetlands were present. Potential riparian habitats were present north of FM 2100 at the observed location.



Survey Point - USGS 08071280 Luce Bayou above Lake Houston near Huffman, TX (photos)






Survey Point - USGS 08067500 Cedar Bayou near Crosby, TX

Stream: Trinity-San Jacinto Coastal Basin

Segment: 0902 Classified Cedar Bayou Above Tidal
From a point 2.2 km (1.4 miles) upstream of IH 10 in Chambers/Harris County to a point 7.4 km (4.6 miles) upstream of FM 1960 in Liberty County.

Station: USGS 080067500

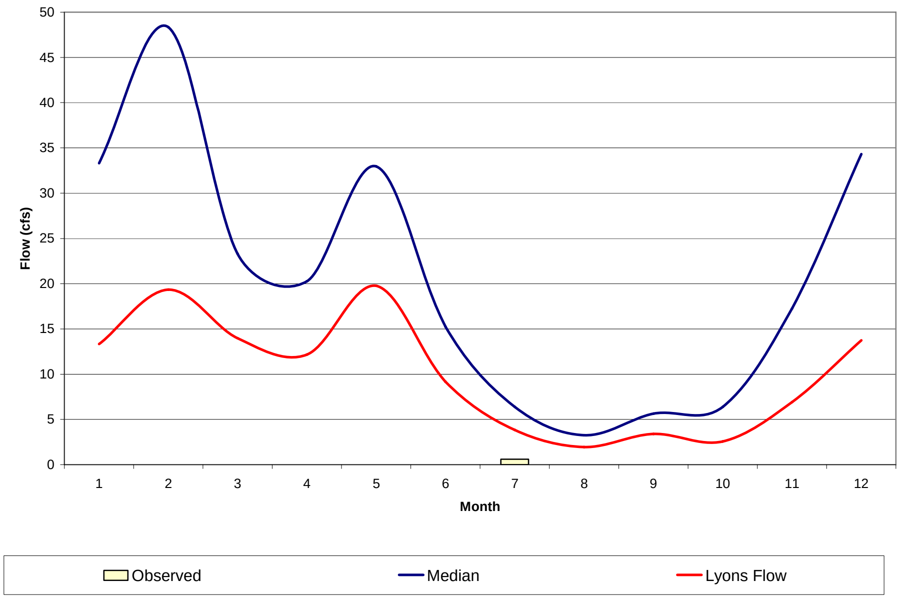
Characteristics: Freshwater Stream
Water Body Size 25 miles

Segment 0902 Land Use: Aquatic life
General use
Public water supply
Residential

References:
TCEQ Surface Water Quality Viewer
http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/viewer/viewer.html

2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin9.pdf

Observed status: At the time of observation (July 21, 2008), Cedar Bayou appeared to meet the definition of “Low” Channel Flow Status. Water filled 25 – 75 percent of the available channel and riffle substrates were mostly exposed. No potential wetlands or riparian habitats were visible.



Survey Point - USGS 08067500 Cedar Bayou near Crosby, TX (photos)

Survey Point - USGS 08116650 Brazos River near Rosharon, TX

Stream: Brazos River Basin

Segment: 1202 Classified Brazos River Below Navasota River
From a point 100 meters (110 yards) upstream of SH 332 in Brazoria County to the confluence of the Navasota River in Grimes County

Station: USGS 08116650

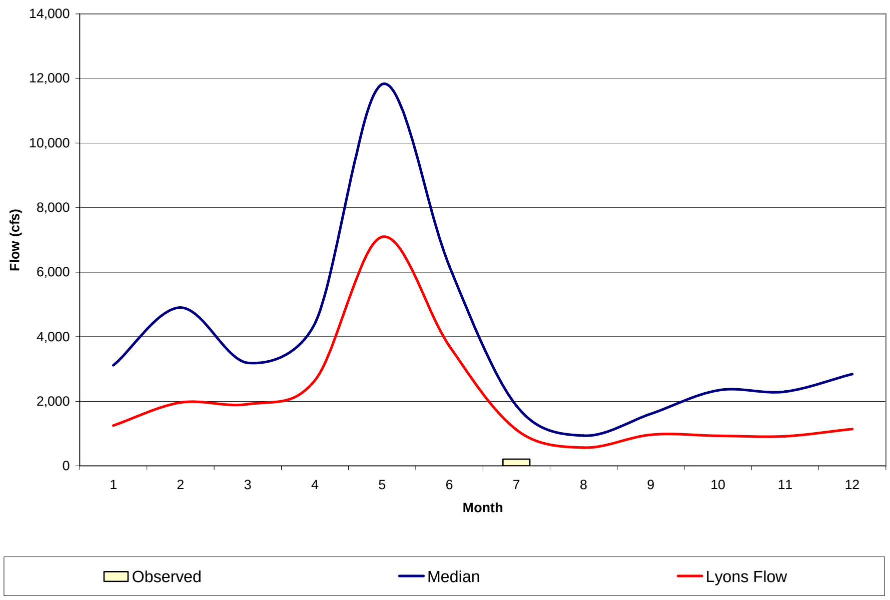
Characteristics: Freshwater Stream
Water Body Size 217 miles

Segment 1202 Land Use: Aquatic life use
Fish consumption
General use
Public water supply
Recreation use

References:
TCEQ Surface Water Quality Viewer
http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/viewer/viewer.html

2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin12.pdf

Observed status: At the time of observation (July 21, 2008), the Brazos River appeared to meet the definition of “Low” Channel Flow Status. Water filled 25 – 75 percent of the available channel and riffle substrates were exposed. No potential wetlands or riparian habitats were visible.



Survey Point - USGS 08116650 Brazos River near Rosharon, TX (photos)






Survey Point - USGS 08067000 Trinity River at Liberty, TX

Stream: Trinity River Basin

Segment: 0802 Classified Trinity River Below Lake Livingston
From a point 3.1 km (1.9 miles) downstream of US 90 in Liberty County to
Livingston Dam in Polk/San Jacinto County

Station: USGS 080067000

Characteristics: Freshwater Stream
Water Body Size 84 miles

Segment 0802 Land Use: Cultivated land
Residential housing development
Commercial development
Residential uses

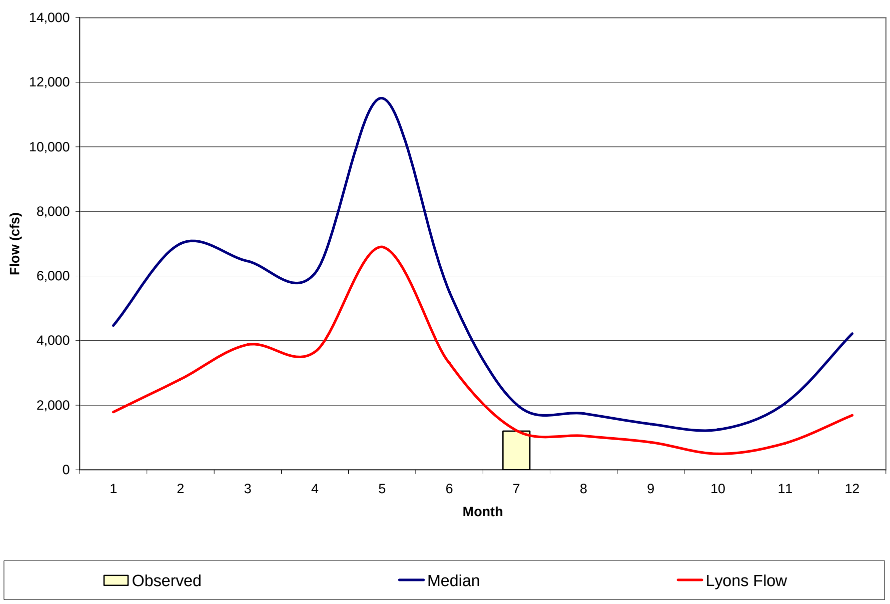
References:

TCEQ Surface Water Quality Viewer
http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/viewer/viewer.html

2008 Texas Water Quality Inventory – Basin Assessment Data by Segment (March 19, 2008)
http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_basin8.pdf

Ecologically Significant River and Stream Segment – Trinity River (Downstream of Lake Livingston)
http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1059c/trinity_river2.phtml

Observed status: At the time of observation (July 21, 2008), the Trinity River appeared to meet the definition of "Moderate" Channel Flow Status. Less than 25 percent of channel substrate was exposed. No potential wetlands and a small potential riparian corridor appeared to be present.



Survey Point - USGS 08067000 Trinity River at Liberty, TX (photos)