Instream Flow Targets for the Trinity and San Jacinto River Basins

Senate Bill 3
Environmental Water Planning

DRAFT

Prepared for
National Wildlife Federation

Prepared by
Trungale Engineering & Science

September 30, 2007

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Executive Summary

Trinity River Basin begins north of Dallas and Fort Worth and drains 46,540 km^2 into Galveston Bay near Houston. Municipal water demands dominate water use accounting for 68% of the existing water rights in the basin. The basin includes 31 major reservoirs and many waste water treatment plants. Significant qualities of water are imported into the basin. Water development projects have altered the water quality and quantity of the Trinity River and its tributaries. The San Jacinto Basin, located on the west side of Houston, is the second most populous basin in Texas though it drains only 7,250 km^2. The shift in water supply sources from a reliance on groundwater to surface water will place new challenges to maintaining instream flows.

The protection of instream flows for Texas Rivers has been recognized by the Texas Legislature and state agencies as one of the most important natural resource priorities in the state. Instream flow regimes require flows of specific magnitudes, durations, frequencies and timing to provide aquatic habitat, transport sediments and maintain water quality to support diverse plant and wildlife assemblages. The 77th session of the Texas Legislature passed Senate Bill 2 which directed TCEQ, TPWD, and TWDB to "…conduct studies and analyses to determine appropriate methodologies for determining flow conditions in the state rivers and streams necessary to support a sound ecological environment." However the Science Advisory Committee on Water for Environmental flows, established by the 78th legislature concluded that “for evaluating environmental flows for rivers and streams, statistical desk-top methods and associated technical analyses must be enhanced to facilitate regulatory permitting actions until such time as the Texas Instream Flow Studies program is completed.” In the most recent session the Legislature passed Senate Bill 3, which sets up Bay and Basin committees “to develop environmental flow analyses and a recommended environmental flow regime for the river basin and bay system for which the team is established.”

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The science of instream flows has evolved over the last 40 years from an approach which defines a single minimum instream flow (e.g. the current Texas default methodology) to one which encompasses the full flow regime including subsistence, base, high flow pulse and overbank flows (e.g. Texas Instream Flow Studies Technical Overview). The current state of the art in instream flow science is a multi-disciplinary effort which takes into consideration hydrology and hydraulics, water quality, physical processes and spatial and temporal connectivity. The flow recommendations seek to mimic ecologically significant components of the natural hydrograph and account for seasonal and inter-annual variations.

This report develops instream flow recommendations at locations within the watershed that encompass the wide geographic diversity within the Trinity and San Jacinto Basins. Because this approach is based on an analysis of natural or, at least, less altered flow regimes these site are all at USGS gage locations which include historical hydrology which has been significantly modified. The sites represent relatively homogeneous river segments. These areas are defined by sub basin cataloging unit (USGS-HUCs) and river segments (TCEQ classified stream segments)

The recommendations are presented in the form of "Building Blocks" which define the magnitude, frequency, duration, timing and variability of the flow prescriptions for dry, normal and wet conditions. The "Building Blocks" also hypothesize the ecological outcome that should result from meeting these targets. These recommendations also suggest a number of short- to mid-term research priorities that might be undertaken in order to reduce some of the uncertainty associated with the recommendations.

While this document presents a framework for the technical approach to developing instream flow recommendations there are several steps both at the front and back ends of a flow prescription process that should be included to produce successful out come.

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At the front end a number of recommendations related to the tasks that should be performed by the two basin groups explicitly established Senate Bill 3 that will share that will develop these flow recommendations. The Basin Bay Area Stakeholder Committee (BBASC) will need to work with the Basin Bay Expert Science Team (BBEST) to define the desired ecological condition. Several useful models could be adapted to the Senate Bill 3 process and perhaps focus what can otherwise become long and contentious discussions regarding the definition of ecological health. A significant challenge for the BBEST will be to develop the recommendations on a fairly short time frame and without the benefit of targeted site specific data collection. The report provides an annotated bibliography of the major studies undertaken on in the Trinity San Jacinto Basins and links to available biological, physical and chemical data.

Once the recommendations are developed and adopted by the various committees and agencies, the recommendations will need to be implemented and the response of the system monitored. One tool that should be considered in the development of the implementation plan is the Water Availability Model (WAM) developed for the Senate Bill 1 regional planning group. This model can be used to report flows representing past, present and future conditions and, once disaggregated from a monthly to daily time step; various management alternatives should be evaluated based on their ability to meet the prescribed recommendations. Finally, if anything about instream flow planning can be said for certain about desktop instream flow recommendations, it is that they will be incomplete and imperfect. As more new information and greater understanding of the system acquired, the recommendation will need to be refined. This report concludes with specific research tasks that should be undertaken to improve the preliminary recommendations provided herein.

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Introduction

History and definitions

The science of developing instream flow recommendations to maintain a sound ecological environment has evolved over the last four decades. A number of important concepts have emerged.

Minimum flow to flow regime

Focus on single species to protection of biological diversity and integrity

Holistic studies and models to natural flow paradigm

Challenges

Long term monitoring, precautionary principle and adaptive management

Study Area

Trinity River Basin begins north of Dallas and Fort Worth and drains 46,540 km^2 into Galveston Bay east of Houston. The San Jacinto Basin, in and around Houston, is the second most populous basin in Texas though it drains only 7,250 km^2.

The Trinity and San Jacinto Basins transverse five major eco-regions.

Though the basins are almost entirely within one biotic province. (define biotic province and eco region and explain why they are important)

Water development projects have dramatically altered the water quality and quality of the Trinity River and its tributaries. Municipal water demands dominate water use accounting for 68% of the existing water rights in the Trinity and 84% in the San Jacinto.[1] Water diversions effect on aquatic health …….(decreasing base and subsistence flows)

[1] Water for Texas 2007

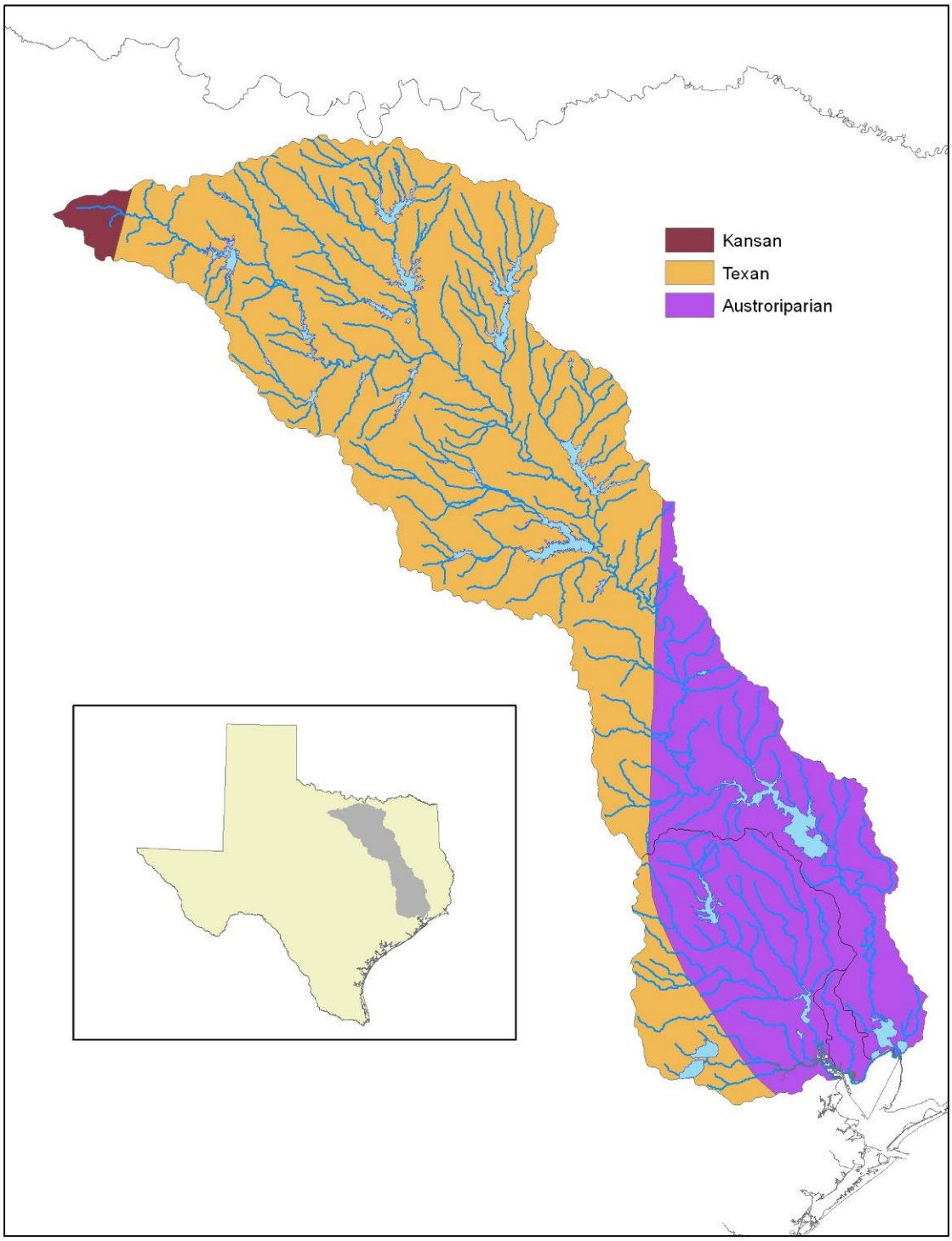

Figure 1 Ecoregions

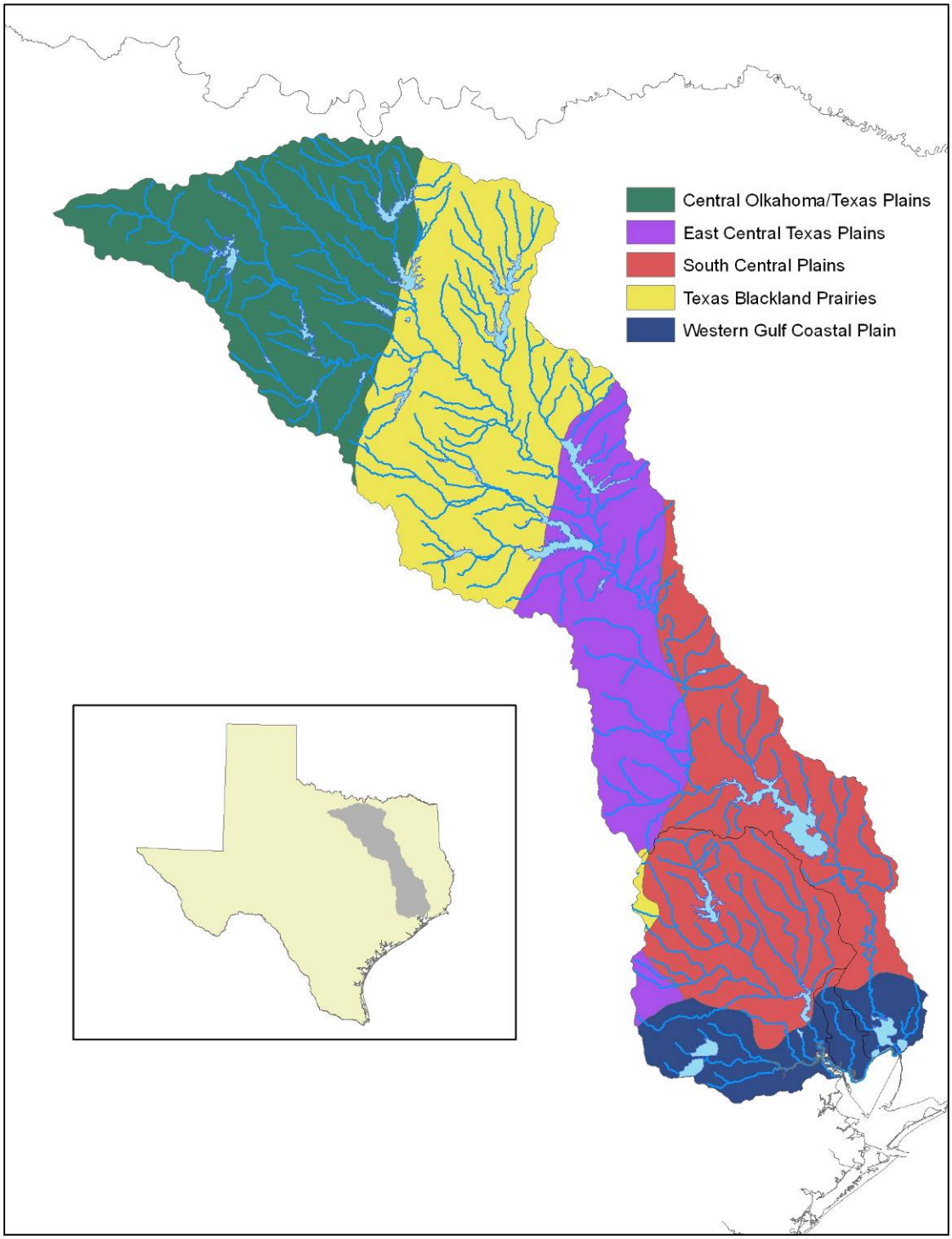

Figure 2 Biotic Provinces

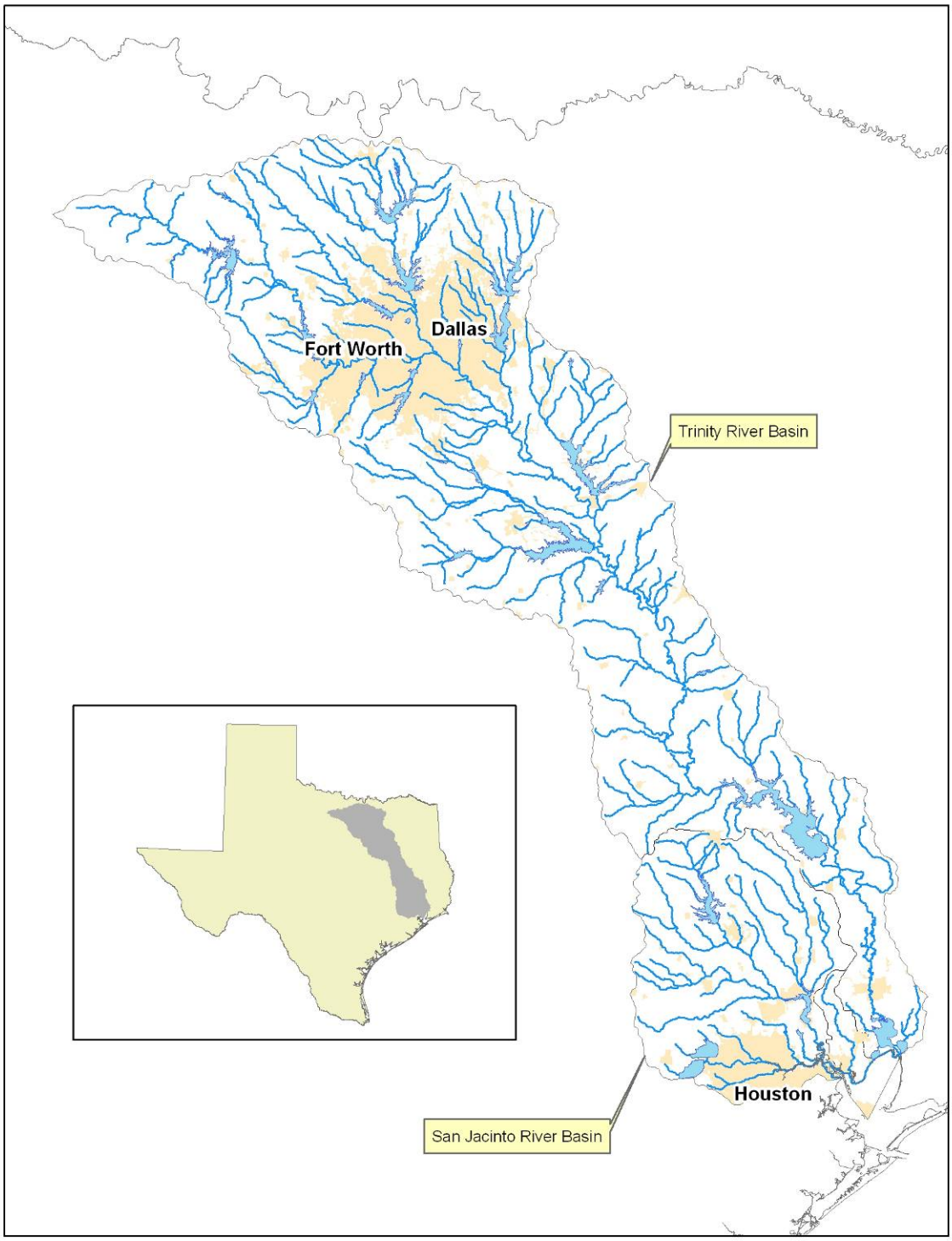

Figure 3 Trinity and San Jacinto Basins

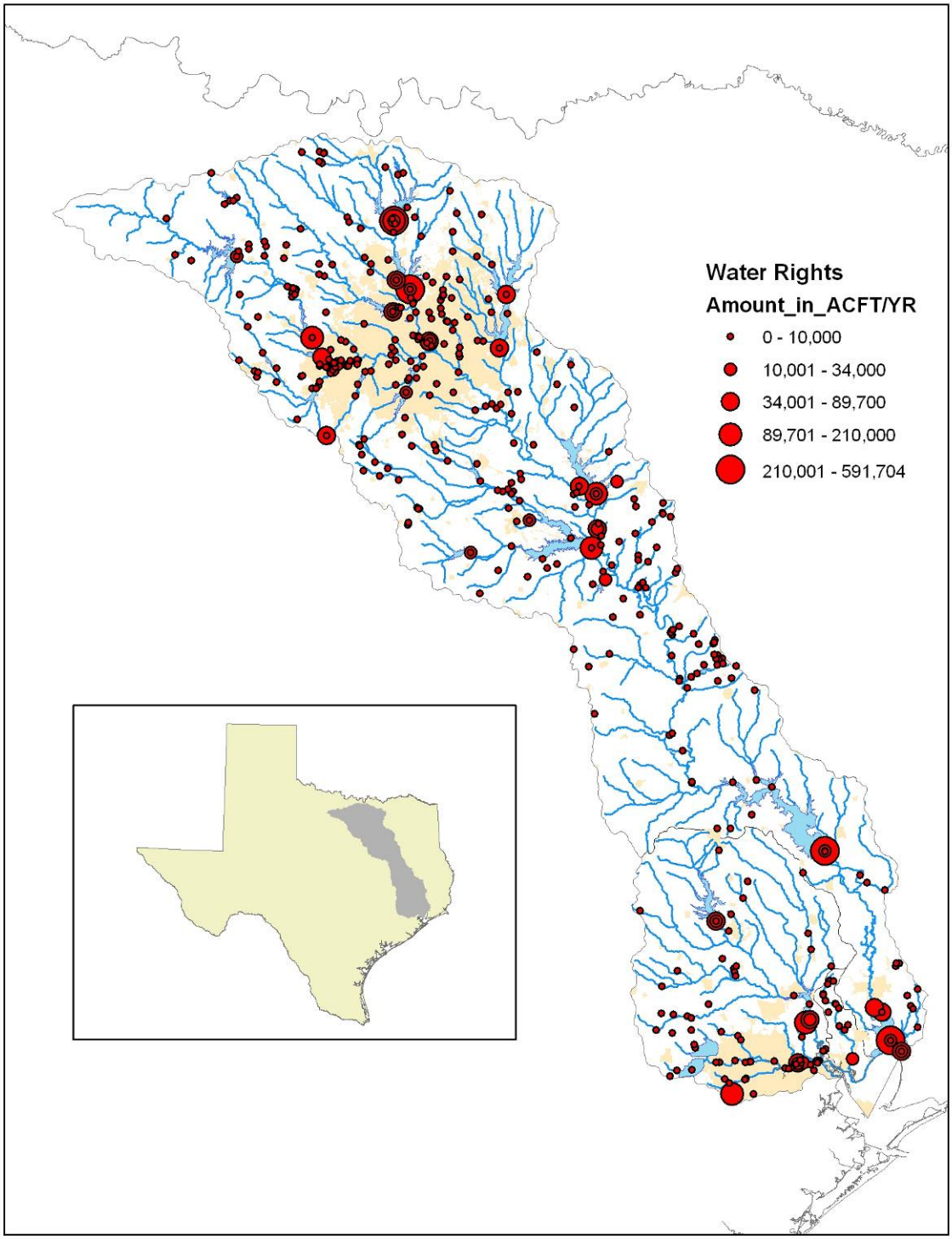

Figure 4 Water Rights in the Trinity and San Jancito Basins

There are 33 major reservoirs in the Trinity basin, 6 in the San Jacinto basin and 1 in the costal Trinity – San Jacinto watershed. Most of them were constructed in the mid and later 1900's

(Table 1). Reservoirs impact on aquatic health …. (Connectivity, moderating extreme events elevating low flow and decreasing high flow)

Table 1 Major Reservoir in the Trinity and San - Jacinto Basins

Basin	Name	Constructed	Capacity
Trinity	AMON G CARTER LAKE	1956	28,589
	ANAHUAC LAKE	1952	35,300
	ARLINGTON LAKE	1957	45,710
	BARDWELL LAKE	1965	54,900
	BENBROOK LAKE	1952	88,250
	BRIDGEPORT LAKE	1932	386,420
	CEDAR CREEK RESERVOIR, HENDERSON COUNTY	1965	679,200
	EAGLE MOUNTAIN LAKE	1934	190,460
	FAIRFIELD LAKE	1969	50,600
	FOREST GROVE RESERVOIR	1980	20,038
	GRAPEVINE LAKE	1952	188,550
	HALBERT LAKE	1921	7,420
	HOUSTON COUNTY LAKE	1966	19,500
	JOE POOL LAKE	1986	181,200
	KIOWA LAKE	1968	7,000
	LAVON LAKE	1953	456,500
	LEWISVILLE LAKE	1954	640,986
	LIVINGSTON LAKE	1968	1,750,000
	LOST CREEK RESERVOIR		11,961
	LYNCHBURG RESERVOIR	1976	4,700
	MOUNTAIN CREEK LAKE	1937	25,720
	NAVARRO MILLS LAKE	1963	63,300
	TERRELL CITY LAKE, NEW	1955	8,712
	NORTH LAKE	1957	17,000
	RAY HUBBARD LAKE	1968	490,000
	RAY ROBERTS LAKE	1987	799,600
	RICHLAND-CHAMBERS RESERVOIR	1987	1,181,866
	TRINIDAD LAKE	1925	6,200
	WALLISVILLE LAKE	1980's	51,600
	WAXAHACHIE LAKE	1956	13,500
	WEATHERFORD LAKE	1957	19,470
	WHITE ROCK LAKE	1910	10,740
	WORTH LAKE	1914	38,130
Trinity-San Jacinto	CEDAR BAYOU GENERATING POND	1972	19,250
San Jacinto	ADDICKS RESERVOIR	1948	200,800
	BARKER RESERVOIR	1945	209,000
	CONROE LAKE	1973	430,260
	HOUSTON LAKE	1954	146,700
	LEWIS CREEK RESERVOIR	1969	16,400
	SHELDON RESERVOIR	1943	5,420

Significant qualities of water are both transported between reservoirs within the basins and imported into the basin through interbasin transfers. Interbasin transfers impact on aquatic health ….(import non-natives and elevate base flows).

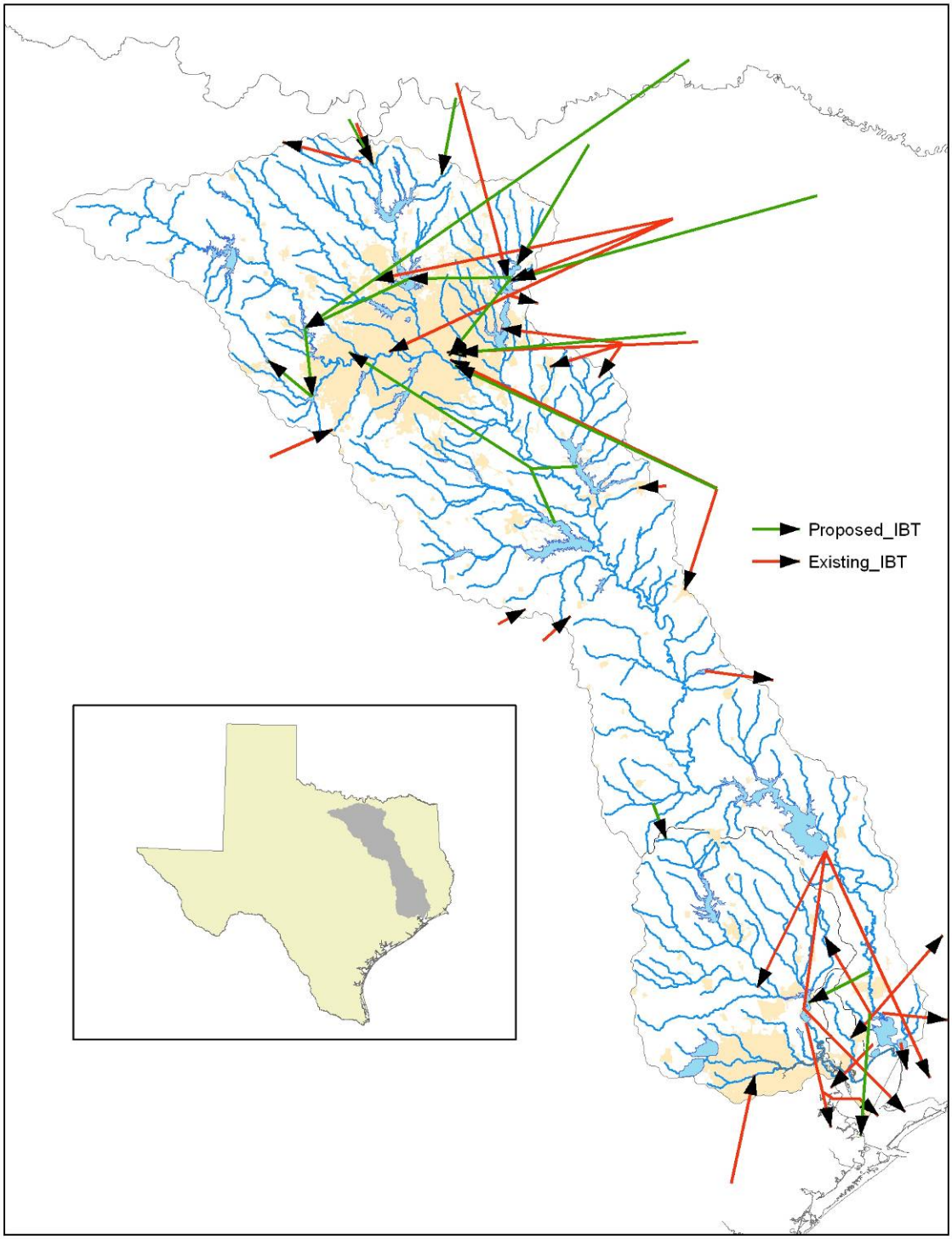

Figure 5 Interbasin Transfers (IBTs) in and out of the Trinity and San Jacinto Basins

Water originating within the basin and water that is imported into the basins is treated and discharged is treated and discharged back into the rivers. This is particularly significant in the

DFW area were seven large waste water treatment plants have significantly altered the quantity and quality of flows in the upper Trinity River.

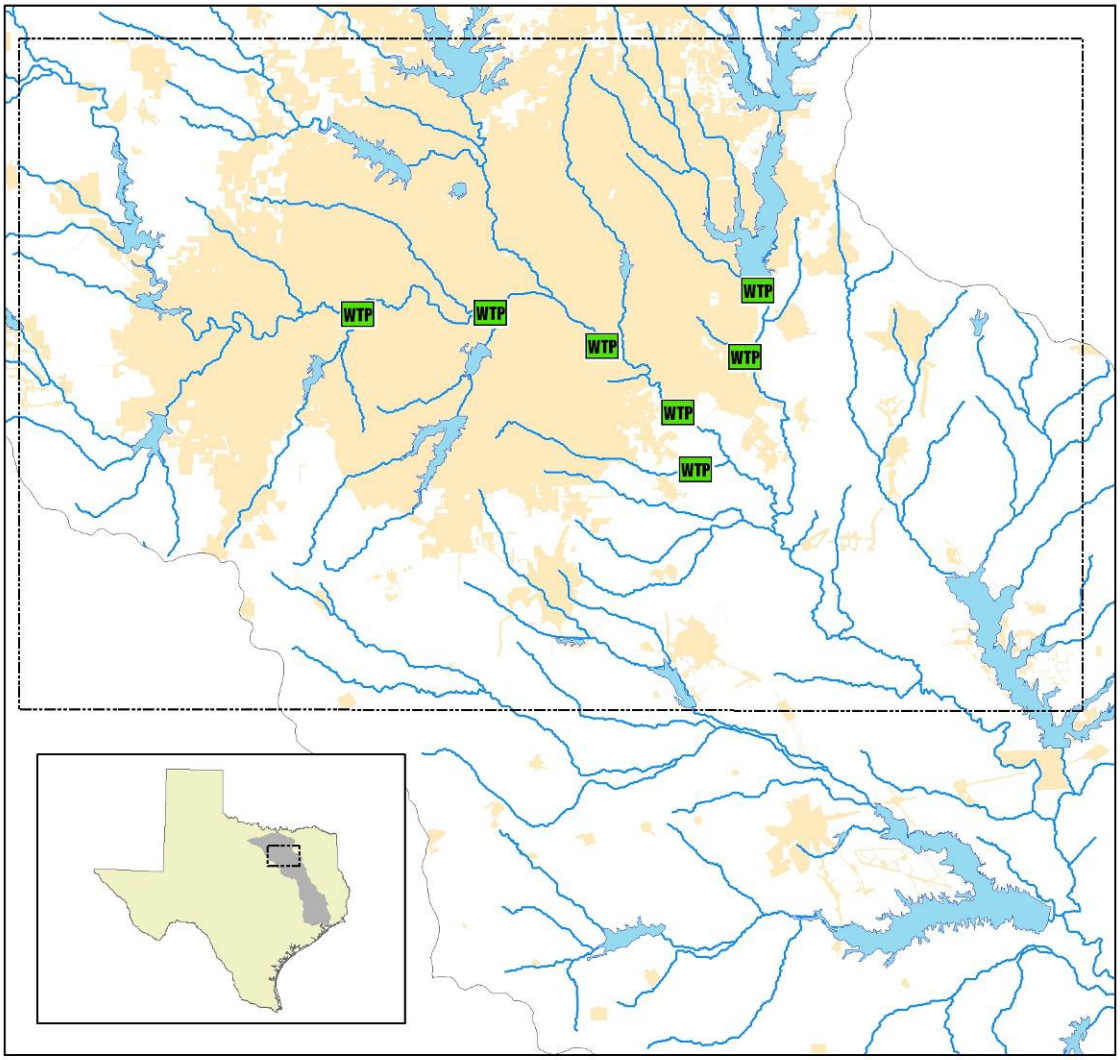

Figure 6 Major Wastewater Treatment Plants in the Dallas Fort Worth Metroplex

Need information about levees…..

The shift in water supply sources from a reliance on groundwater to surface water will place new challenges to maintaining instream flows.

Aquifers/Springs (map)

Natural and Anthropogenic Physical features (Geomorphology)

Streams, precipitation flow, (Hydrology)

Water Quality

Biology

Alterations, Impacts, Threats, Challenges. (Past to Present) (Present to Future) (What will it mean to try to make the future look more like the past in a highly impacted system)

The Science of Instream Flows

The science of instream flows provides a number of approaches to developing flow recommendations for the protection of a sound ecological environment. The most simple, quick and inexpensive approach assumes some percentage of normal flows would be sufficient to protect the aquatic ecosystem. In Texas the default method employed is referred to as the Lyon's method. This approach was developed in the 1970s and 80s and produces a minimum flow that is calculated as a percentage of historical median flows. The Lyon's targets were developed based on another method called the Tenant method, developed in the Western United States. The Tenant method is a wetted perimeter, visual inspection approach. In developing this method, data are collected at dozens of streams, stream health is evaluated, and relationships are developed between a percentage of the average annual flow and river health; for instance 40% of the mean average flow is a minimum flow and 60% is a healthy flow. In 1978, TPWD biologists visited a single site on the Guadalupe River and determined that 40% of the monthly median flow in the winter and 60% of the monthly median flow in the summer provides a good wetted perimeter. This rule of thumb has become enshrined in TCEQ guidance and has become the default starting point when deciding on the instream flow needs of any stream in Texas. There is value in this

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method in that it provides some level of instream flow protection and this protection has some relationship to the hydrology of the stream, however this approach was never intended for the purpose for which it is now used and is now far from the state of the art of instream flow science.

Over the last 20-30 years the myth of a minimum flow has been rather thoroughly discredited as aquatic ecologists have come to recognize that a varied flow regime that mimics natural historical patterns and that maintains adequate sediment loadings is the key to sustaining fish and wildlife resources. A far more comprehensive and scientifically defensible approach to setting instream flow targets is a comprehensive instream flow study. In 2001, the 77th Texas Legislature instructed the three primary water agencies in Texas, the Texas Water Development Board (TWDB), the Texas Parks and Wildlife Department (TPWD) and the Texas Commission on Environmental Quality (TCEQ) to develop a program to conduct these studies on Texas Rivers. This program is currently underway but the completion can be time consuming and costly.

A middle path between these two approaches to developing instream flow recommendations is to develop recommendations based on the natural flow paradigm. There is broad consensus within the scientific community that healthy river systems require a range of flow conditions, i.e. a flow regime, rather than a single minimum flow target. These flow regimes are critical for specific ecosystem functions including the maintenance of habitat, water quality, channel and riparian structure, and flood plain connectivity. (Figure 7)

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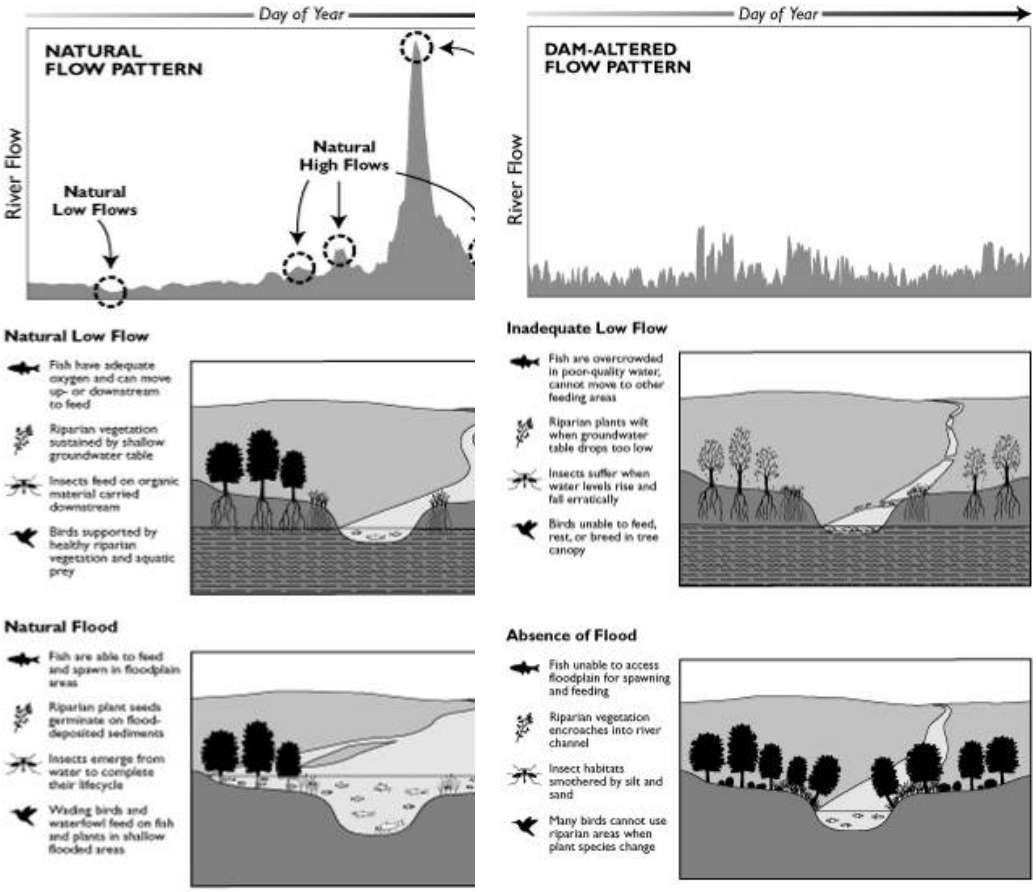
Figure 7 Ecosystem functions supported by natural flows



Graphic from "Rivers for Life: Managing Water for People and Nature" Postel, S. and B. Richter (Island Press 2003)

In this report pre-development flows are used to identify ecologically meaningful hydrologic components of the natural flow regime that should be preserved in order to maintain a healthy ecological community. This flow regime includes flows of certain magnitude, frequency, duration, timing and flow variability.

Ecosystem flow components are described in the Texas Instream Flow Program Technical Guidance document. While the program outlined in that document proposes to develop these flow recommendations with site-specific studies, the components are similar to those developed as part of the Corps of Engineers-Nature Conservancy Sustainable Rivers Program. The first step in the Sustainable Rivers Program is to conduct an extensive literature review of hydrologic, biological, geomorphic, water quality and connectivity issues. Once all of the readily available

data are assembled, a multidisciplinary team of specialists in hydrology, fluvial geomorphology, water quality and aquatic and terrestrial ecology review this information and an over the course of two to three days make preliminary flow recommendations and develop a list of research priorities. These recommendations are then tested within an adaptive management context in which the response of the ecosystem to the recommended flows is monitored and the recommendations refined as more is learned about the system. The general approaches taken and lessons learned from previous applications of this process are used in this report to make specific base, high pulse and subsistence flow recommendations for the Trinity and San Jacinto Basins.

Building Blocks Methodology

Base Flows

Base flow conditions are the flows experienced by the river during normal times i.e. when not flooding or experiencing severe drought. The flow targets are largely defined by requirements for aquatic habitats (e.g. runs, riffles, pools). Base flows are reasonably synonymous with the flows that are developed via the Lyons approach. The base flow targets developed in this study improve on the Lyons approach in two ways. First, by applying a base flow separation analysis to the daily data series and second by providing for interannual variation by developing base flow targets for wet, normal and dry periods. For each gage, the base dry, normal and wet magnitudes are first set at the 25th, 50th and 75th percentile low flow values.[2] (Describe IHA, Ecosystem Flow Components, Base Flow Separation, Refer to Ritcher comments in NAS document page 124-125) These preliminary estimates were then examined within the context of the estimates for gauges located upstream and downstream and in some cases adjusted appropriately. Subsequent field studies will need to be conducted to validate these estimates to be sure that that these flows provide desirable habitat conditions. These studies may include hydraulic habitat modeling to

[2] This is the convention that have been in other applications of the IHA program both nationally and in Texas.

quantify the changes in mesohabitats at differing flow rates and biological surveys to determine habitat preferences, potentially variable by season or life stage, of select individual species or species guilds.

The theoretical basis for selecting these values rests on the assumption that providing these base flows will provide the habitat, both physical and chemical, that the native biota has evolved to exploit. The validity of this assumption will vary by location. Habitat is created by the intersection of many factors including the amount of water in the stream, the physical shape of the channel and available substrates and the ambient water quality. If, as is the case in many areas of the Trinity and San Jacinto, the geomorphology of the channel has been substantially modified, either by long term changes in flow regime or structural modification resulting in channelization of the river, it might be argued that restoring the base flow components of the natural flow may not be the most effective approach to maintaining the ecological health of the stream. Similar arguments could be raised in situations in which ambient water quality or composition of the biological community has been significantly modified. The counter to this view is that flow is the master variable the most effective way to restore these other influences is to provide critical components of the flow regime including the high and low flow components.

High Flows

Overbank and high flow pulses are necessary to maintain physical habitat through transport and redistribution of sediments and to provide for longitudinal connectivity between the river and the flood plain. High flow pulses are events which normally occur several times every year for several days while overbank flows are less frequent events which may only occur every several years. The high flow pulse represents higher than base flow events though flows that would still remain in channel, but mobilize smaller sediments, scour encroaching riparian vegetation and generally provide a flush of fresh water during low flow periods. High flow pulses may also

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provide cues for migration and spawning for fish. The flood flow events would presumably include overbank flows which are valuable in connecting the stream to its flood plan. Connectivity between the river and flood plan is necessary for the health of riparian and terrestrial vegetation by recharging the water table and for the river by providing a source of sediments and nutrients. These infrequent flood events are also critical to forming and maintain the channel geomorphology. Finally many aquatic species exploit the greater food availability in the flood plan at specific life stages or certain times of the year.

Most commonly sited references related to bankfull flows refer to effective discharge which is the flow that, on average, moves the majority of the sediment in a channel and is responsible for maintaining equilibrium channel geometry. This effective discharge is also believed to correspond to the bankfull discharge, which is the flow at which the water begins to leave the channel and spread out over the flood plain. Thus this flow is also needed to sustain the floodplain and riparian vegetation. Much attention is given to empirical studies by Leopold, Wolman and Miller (1964) which suggest that bankfull and effective discharges correspond to the 2 year recurrence interval flow although a range between the 1.2 and 4 year recurrence interval flows is often sited. Ultimately, these rule of thumb estimates will need to be verified by field studies which measure sediment transport and overbanking connectivity, however in this report the results of the recurrence interval flow calculations are be compared to available published estimates of flood stage at various locations along the rivers. (Consider using power functions A. Chin Caddo Study to estimate flows for sediments – if there is time).

The 1.2 to 4 year recurrence interval flows were estimated using the USGS PeakFQ which performs statistical flood-frequency analyses of annual-maximum peak flows (annual peaks) following procedures recommended in Bulletin 17B of the Interagency Advisory Committee on Water Data (1982). Flood stage values are given by the National Whether Service (NWS). These

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elevations are then converted into flow rates by comparing the stage provide by NWS with the stage given by the USGS.

These will set the magnitudes which will be incorporated into IHA to determine timing, frequency and duration. Application of these estimates will require information about existing structural modifications to the river, specifically for flood control and in contrast to the base flow recommendations, which are derived from pre development flow regimes, the high flow recommendations consider both pre and post development conditions.

Low Flows

The primary objective of subsistence flows is to maintain water quality criteria typically defined by water chemistry parameters such as temperature and dissolved oxygen. The secondary objective is to provide refugia from which aquatic populations can re-colonize once drought conditions subside. Other important effects of low flow include the purging of drought intolerant invasive species and the germination of riparian vegetation in the low flow channel.

Ambient water quality in the Trinity and San Jacinto basins has been significantly modified by urbanization in general and water discharge superficially. Up until the late 1980's degraded water quality conditions was the major factor controlling the fishery in the upper Trinity basin. Improvements to treatment plants have had a dramatic effect and as a result rather healthy fishery has emerged in areas practically devoid of fish previously. The high aquatic life use score for the Trinity is maintained by maintaining the water quality. Increased quantities of water discharged into the Trinity as a result of imports for other basin has elevated the low and base flow conditions of the river. Owing to these major modification and the need for the river to assimilate high waste water return flows presents a challenge to the adoption of the natural flow as a guiding paradigm. A return to the very low flow conditions to the pre development period would, in many areas, not support water quality standards upon which waste water discharge permits are

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based. However the benefits of low flows in balancing competitive, ruderal invasives with more stress tolerant natives must also be considered. Perhaps even more that the high flow components, the subsistence flow recommendation should consider current water quality threats before advocating a return to a more natural low flow regime. In Texas the default approach to setting the subsistence flow recommendation is to calculate the 7Q2 (the 2 year recurrent mean seven day low) based on recent flow rates. In any case subsistence flows are flow which should be experienced very rarely, during severe drought, rather than in normal conditions. (Method set magnitude based on 7Q2 estimate frequency, duration, timing based on IHA)

Representative Locations

The above methodology has been applied to the Trinity and San Jacinto Basins at XX locations. These sites were selected to provide a broad geographic coverage of the diverse physical, chemical and biological conditions within the Trinity and San Jacinto Basins. Since the proposed methodology relies heavily on an analysis of the natural flow regime, the sites were constrained to those for which sufficient periods of pre-development flow records are available. The process of selecting sites began by first subdividing the basins into smaller, more homogeneous sub-watersheds. This was accomplished using the USGS Hydrologic Unit Code 8-ditgit cataloguing units (Figure 8). Hydrologic Units generally define homogenous areas and are bonded at there downstream end by confluences with major tributaries. The Trinity Basin contains 12 HUCS, the San Jacinto 4 and there is one costal basin HUC which drains directly into Galveston Bay. At a minimum one site was selected for each HUC.

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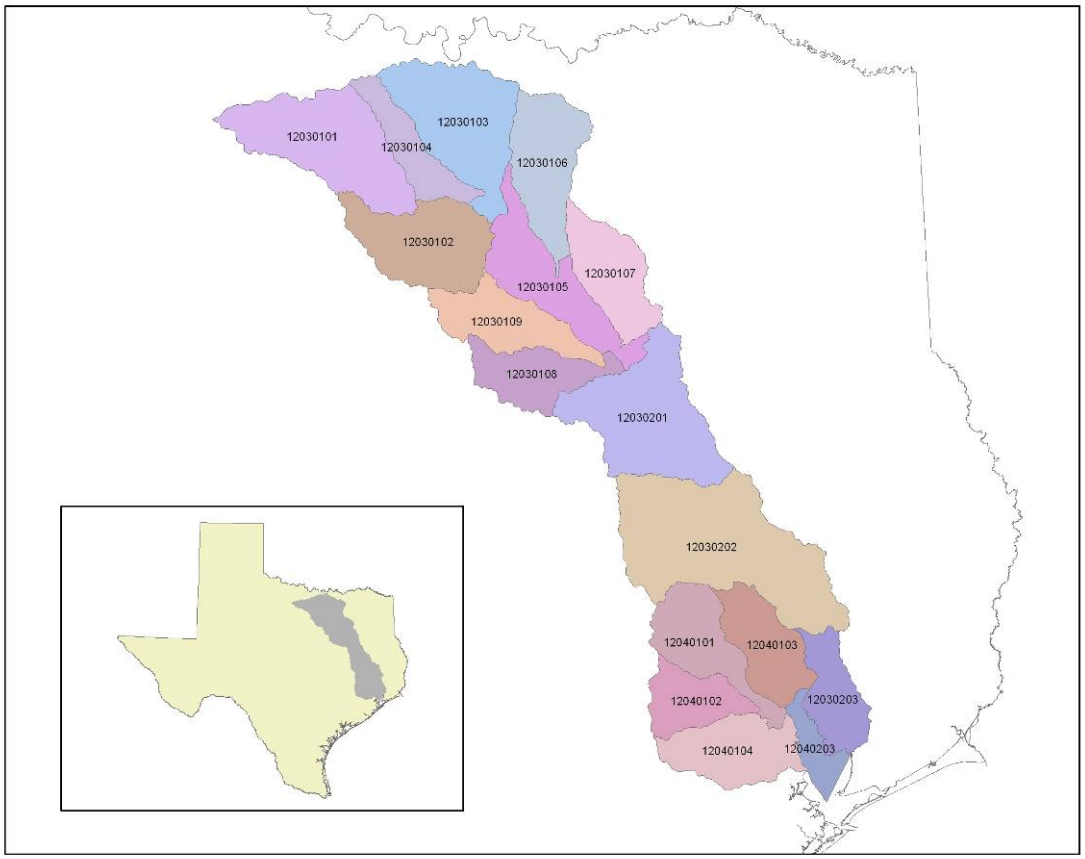
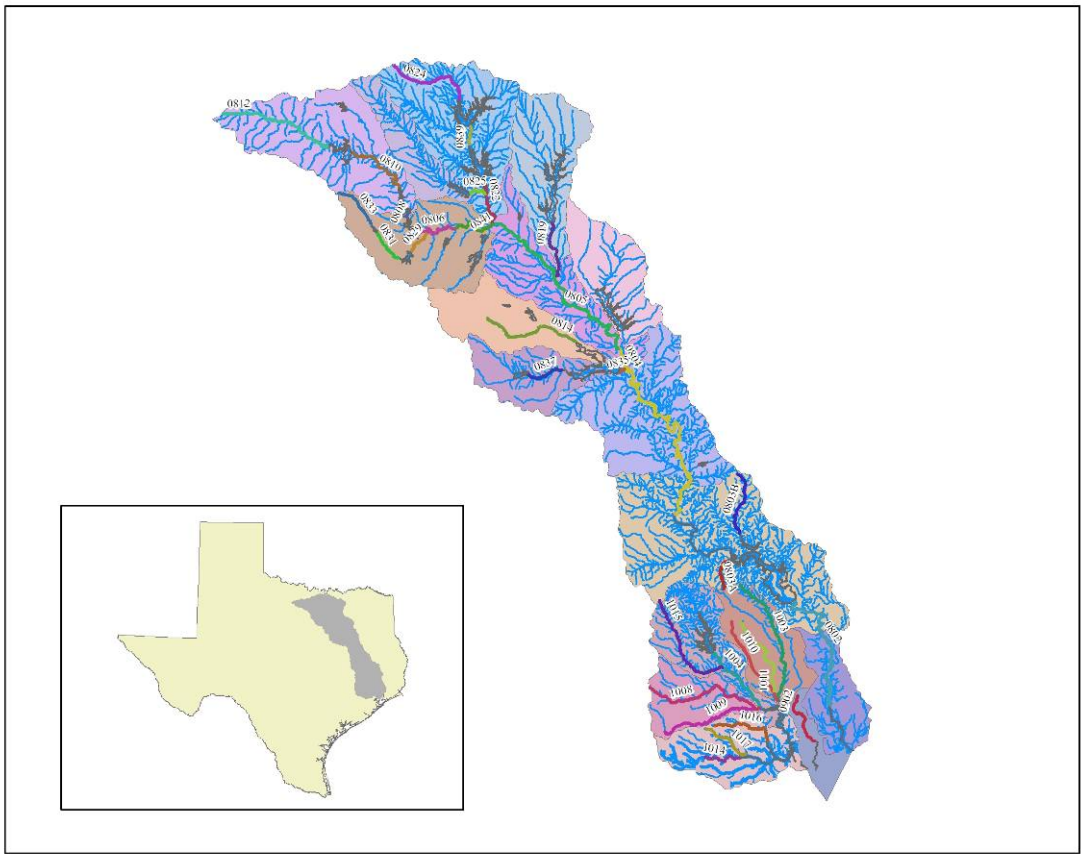


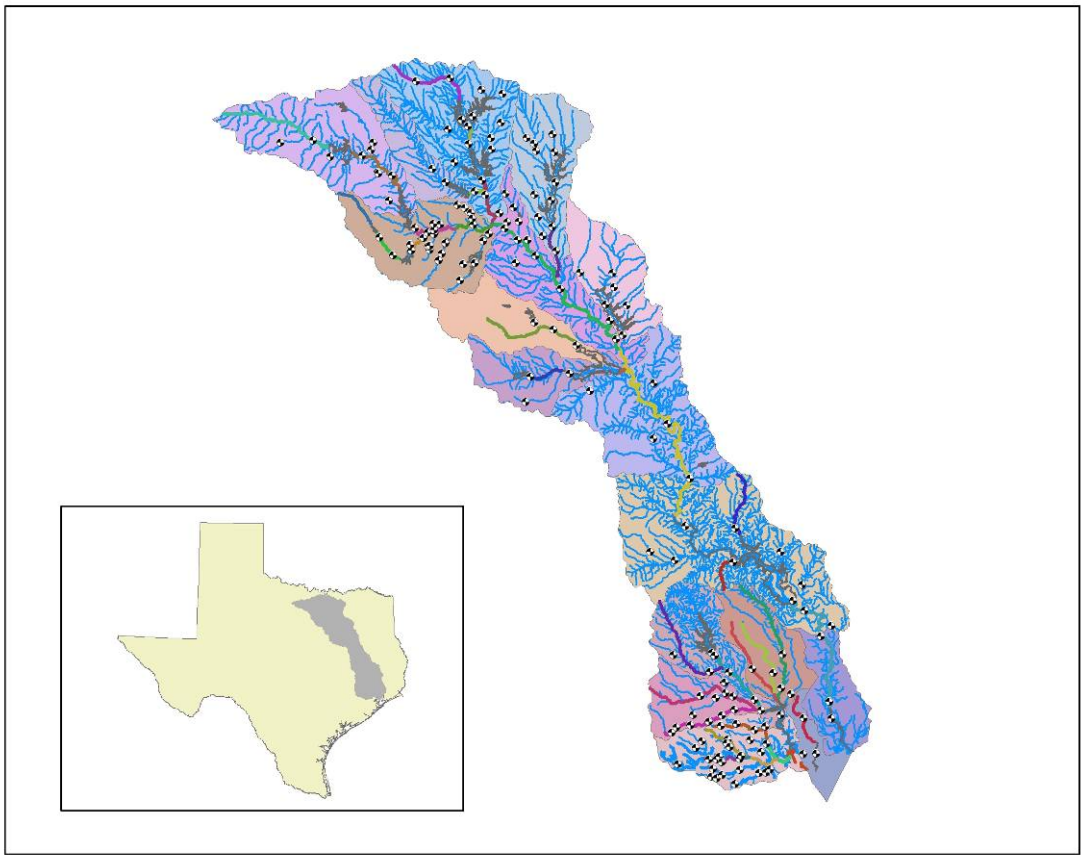
Figure 8 Hydrologic Unit Codes

TCEQ classified stream segments were then overlaid on each HUC. The official TCEQ Stream Segments for the State of Texas are listed in Title 30, Chapter 307 of the Texas Administrative Code (TAC), also known as the Surface Water Quality Standards. These are streams and waterbodies that have been individually defined by the TCEQ and assigned unique identification numbers. Intended to have relatively homogeneous chemical, physical, and hydrological characteristics, a segment provides a basic unit for assigning site-specific standards and for applying water quality management programs of the agency. The stream segments generally fall with in one of these HUCs, that is they do not cross HUC boundaries though many HUCs include more than one segment. Segments are typically split within a single HUC by either reservoirs or confluences with major tributaries. The availability of multiple segments with a single HUC allows for some redundancy which can be used to infer general patterns or perhaps adjust

recommendation for sites with limited historical data based on analysis of nearby gages with longer records.



For each segment there is typically a long term USGS stream flow gage. Ideally such a gauge would include flow data extending back in time to a period prior to major development including upstream impoundments, diversion or return flows.



Finally major disturbances, typically in channel reservoirs or point source diversions (would like to have information on structural modifications levees channelization data) were identified and the date of impact determined.

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Basin	Name	Constructed	Capacity
Trinity	AMON G CARTER LAKE	1956	28,589
	ANAHUAC LAKE	1952	35,300
	ARLINGTON LAKE	1957	45,710
	BARDWELL LAKE	1965	54,900
	BENBROOK LAKE	1952	88,250
	BRIDGEPORT LAKE	1932	386,420
	CEDAR CREEK RESERVOIR, HENDERSON COUNTY	1965	679,200
	EAGLE MOUNTAIN LAKE	1934	190,460
	FAIRFIELD LAKE	1969	50,600
	FOREST GROVE RESERVOIR	1980	20,038
	GRAPEVINE LAKE	1952	188,550
	HALBERT LAKE	1921	7,420
	HOUSTON COUNTY LAKE	1966	19,500
	JOE POOL LAKE	1986	181,200
	KIOWA LAKE	1968	7,000
	LAVON LAKE	1953	456,500
	LEWISVILLE LAKE	1954	640,986
	LIVINGSTON LAKE	1968	1,750,000
	LOST CREEK RESERVOIR		11,961
	LYNCHBURG RESERVOIR	1976	4,700
	MOUNTAIN CREEK LAKE	1937	25,720
	NAVARRO MILLS LAKE	1963	63,300
	TERRELL CITY LAKE, NEW	1955	8,712
	NORTH LAKE	1957	17,000
	RAY HUBBARD LAKE	1968	490,000
	RAY ROBERTS LAKE	1987	799,600
	RICHLAND-CHAMBERS RESERVOIR	1987	1,181,866
	TRINIDAD LAKE	1925	6,200
	WALLISVILLE LAKE	1980's	51,600
	WAXAHACHIE LAKE	1956	13,500
	WEATHERFORD LAKE	1957	19,470
	WHITE ROCK LAKE	1910	10,740
	WORTH LAKE	1914	38,130
Trinity-San Jacinto	CEDAR BAYOU GENERATING POND	1972	19,250
San Jacinto	ADDICKS RESERVOIR	1948	200,800
	BARKER RESERVOIR	1945	209,000
	CONROE LAKE	1973	430,260
	HOUSTON LAKE	1954	146,700
	LEWIS CREEK RESERVOIR	1969	16,400
	SHELDON RESERVOIR	1943	5,420

The date of impact was combined with the period of record available at each of the gages to determine the pre-development flow regime for each site.

HUC	HUC Name	Main River Segment(s)	Seg	RES_NAME	IMPOUND	site	station	Start	End	Years
12030101	Upper West Fork Trinity	West Fork Trinity River	812			8042800	W Fk Trinity Rv nr Jacksboro, TX	1956	2007	52
12030101	Upper West Fork Trinity	Brushy Creek		LAKE AMON G. CARTER	5/31/56	8043950	Big Sandy Ck nr Chico, TX	1936	1955	20
12030101	Upper West Fork Trinity	West Fork Trinity River	810	LAKE BRIDGEPORT	4/1/32	8043500	W Fk Trinity Rv at Bridgeport, TX	1924	1930	7
12030102	Lower West Fork Trinity	Clear Fork	831	LAKE WEATHERFORD	3/31/57	8046000	Clear Fk Trinity Rv nr Aledo, TX	1947	1956	10
12030102	Lower West Fork Trinity	Clear Fork	829	BENBROOK LAKE	9/29/52	8047500	Clear Fk Trinity Rv at Ft Worth, TX	1924	1951	28
12030102	Lower West Fork Trinity	West Fork Trinity River	806	LAKE WORTH	6/30/14	8048000	W Fk Trinity Rv at Ft Worth, TX	1920	1951	32
12030102	Lower West Fork Trinity	West Fork Trinity River	841	LAKE ARLINGTON	3/31/57	8049500	W Fk Trinity Rv at Grand Prairie, TX	1925	1956	32
12030103	Elm Fork Trinity	Elm Fork Trinity River	824			8050300	Elm Fk Trinity Rv nr Muenster, TX	1956	1973	18
12030103	Elm Fork Trinity	Elm Fork Trinity River	839	LAKE RAY ROBERTS	6/30/87	8050500	Elm Fk Trinity Rv nr Sanger, TX	1949	1984	36
12030103	Elm Fork Trinity	Elm Fork Trinity River	822	LEWISVILLE LAKE	11/1/54	8053000	Elm Fk Trinity Rv nr Lewisville, TX	1949	1953	5
12030104	Denton	Denton Creek				8053500	Denton Ck nr Justin, TX	1949	2007	59
12030104	Denton	Denton Creek	825	GRAPEVINE LAKE	7/3/52	8055000	Denton Ck nr Grapevine, TX	1947	1951	5
12030105	Upper Trinity	Trinity River	805	DFW Reservoirs	11/1/54	8057000	Trinity Rv at Dallas, TX	1902	1953	52
12030106	East Fork Trinity	East Fork Trinity River				8058900	E Fk Trinity Rv atnear McKinney.txt	1949	2007	59
12030106	East Fork Trinity	East Fork Trinity River	819	LAVON LAKE / LAKE RAY HUBBAI	9/14/53	8062000	E Fk Trinity Rv nr Crandall, TX	1949	1952	4
12030105	Upper Trinity	Trinity River	805	LAVON LAKE / LAKE RAY HUBBAI	9/14/53	8062500	Trinity Rv nr Rosser, TX	1924	1952	29
12030107	Cedar	Cedar Creek				8062800	Cedar Ck nr Kemp, TX	1963	2007	45
12030107	Cedar	Cedar Creek		CEDAR CREEK RESERVOIR	7/2/65	8063000	Cedar Ck nr Mabank, TX	1938	1964	27
12030108	Richland	Richland Creek	837	NAVARRO MILLS LAKE	3/15/63	8063500	Richland Ck nr Richland, TX	1939	1962	24
12030109	Chambers	Chambers Creek	814			8064500	Chambers Ck nr Corsicana, TX	1939	1984	46
12030201	Lower Trinity-Tehuacana	Trinity River	804	RICHLAND-CHAMBERS RESERVC	7/2/65	8065000	Trinity Rv nr Oakwood, TX	1923	1964	42
12030202	Lower Trinity-Kickapoo	Trinity River	803	RICHLAND-CHAMBERS RESERVC	7/2/65	8065500	Trinity Rv nr Midway, TX	1939	1964	26
12030202	Lower Trinity-Kickapoo	White Rock Creek	803B			8066100	White Rock Ck nr Trinity, TX	1965	1985	21
12030202	Lower Trinity-Kickapoo	Bedias				8065800	Bedias Ck nr Madisonville, TX	1967	2007	41
12030202	Lower Trinity-Kickapoo	Menard				8066300	Menard Ck nr Rye, TX	1965	2007	43
12030203	Lower Trinity	Trinity River	802	LAKE LIVINGSTON	10/31/68	8066500	Trinity Rv at Romayor, TX	1924	1967	44
12040101	West Fork San Jacinto	West Fork San Jacinto River	1004	LAKE CONROE	1/31/73	8068000	W Fk San Jacinto Rv nr Conroe, TX	1924	1972	49
12040101	West Fork San Jacinto	Lake Creek	1015			8067900	Lake Ck nr Conroe, TX	2002	2004	3
12040102	Spring	Spring Creek	1008			8068500	Spring Ck nr Spring, TX	1939	2007	69
12040102	Spring	Cypress Creek	1009			8069000	Cypress Ck nr Westfield, TX	1944	2007	64
12040103	East Fork San Jacinto	East Fork San Jacinto River	1003			8070000	E Fk San Jacinto Rv nr Cleveland, TX	1939	2007	69
12040103	East Fork San Jacinto	Caney Creek	1010			8070500	Caney Ck nr Splendora, TX	1944	2007	64
12040103	East Fork San Jacinto	Peach Creek	1011			8071000	Peach Ck at Splendora, TX	1943	2007	65
12040104	Buffalo-San Jacinto	Buffalo Bayou	1014	BARKER RESERVOIR	2/3/45	8074000	Buffalo Bayou at Houston, TX	1936	1944	9
12040104	Buffalo-San Jacinto	Greens Bayou	1016			8076000	Greens Bayou nr Houston, TX	1952	2007	56
12040104	Buffalo-San Jacinto	White Oak Bayou	1017			8074500	Whiteoak Bayou at Houston, TX	1936	2007	72
12040104	Buffalo-San Jacinto	Brays Bayou				8075000	Brays Bayou at Houston, TX	1936	2007	72
12040104	Buffalo-San Jacinto	Sims Bayou				8075500	Sims Bayou at Houston, TX	1952	2001	50
12040203	North Galveston Bay	Cedar Bayou	902			8067500	Cedar Bayou nr Crosby, TX	1971	2007	37

Instream Flow Recommendations

In addition to the calculation of basic instream flow statistics for the subsistence, base and high flow components, the application of this methodology includes putting these estimate in a spatial context, in other words verifying that the recommendations make sense as on an upstream to down stream gradient. A the most general level this include the mainstem Trinity below Dallas, areas above and within the DFW metroplex, the various major tributary watersheds and finally the sites in the San Jacinto and San Jacinto-Trinity coastal basin.

Mainstem Trinity below DFW

Setting

The mainstem Trinity, for the purposes of this analysis, begins downstream of Dallas at the Confluence of the West and East Forks of the Trinity. It includes 4 subwatersheds (HUC) and 4 TCEQ Classified Stream Segments. One of the stream segments (803) is classified as a reservoir segment and represents Lake Livingston which was constructed in 1968. The mainstream begins in the Texas Blackland Prairies and flows through the East Central Texas Plains and South Central Plans. The upper section is located in the Texan and lower section in the Austrioriprain biotic province.

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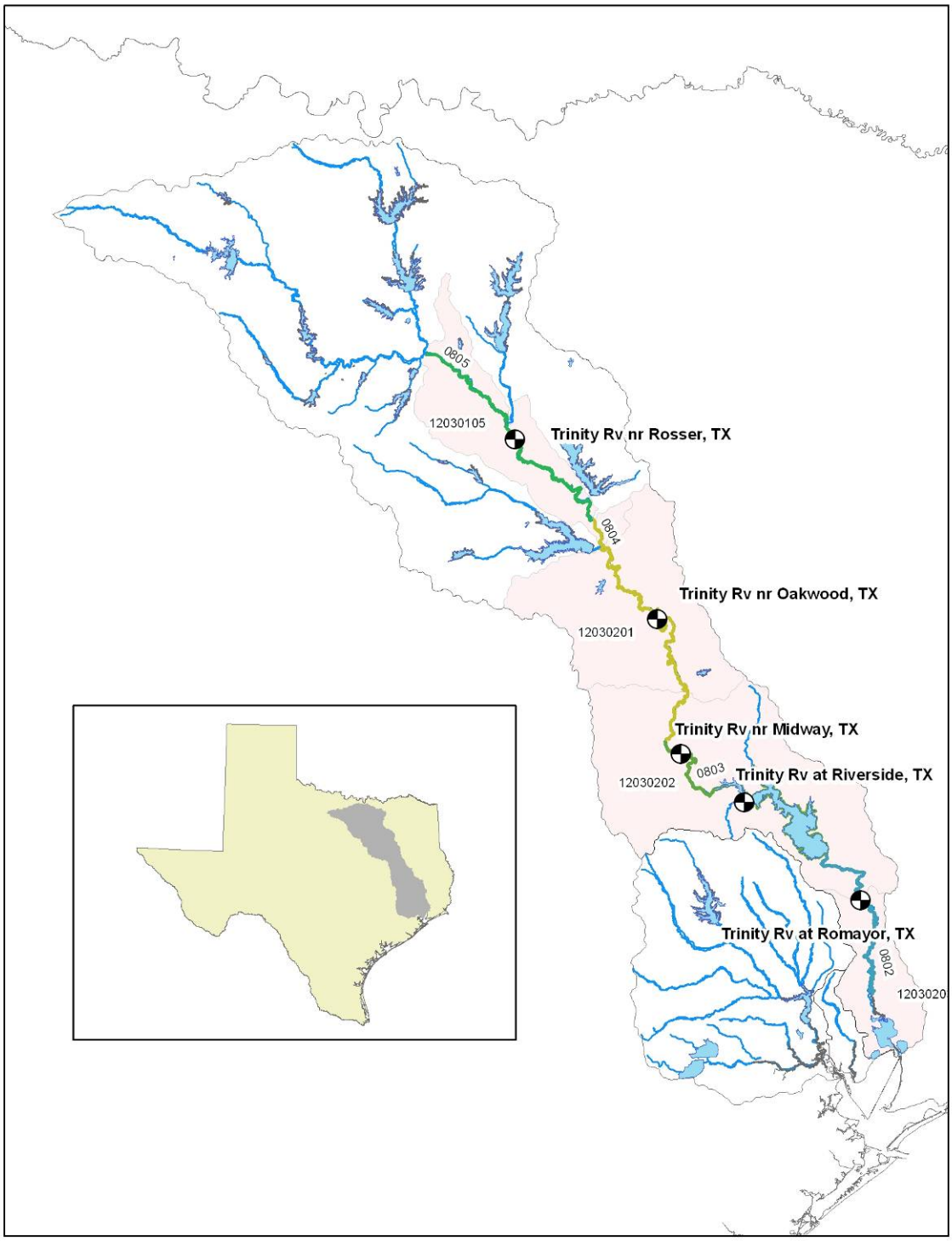

Map 1 Mainstem Setting

Pre-development Flows

There are 5 USGS gauges on the mainstem of the Trinity River with long records of predevelopment streamflow.

	Gage	Name	Period of Analysis
1	8062500	Trinity Rv nr Rosser	1939-1951 (13 years)
2	8065000	Trinity Rv nr Oakwood	1924-1963 (40 years)
3	8065500	Trinity Rv nr Midway	1940-1963 (24 years)
4	8066000	Trinity Rv at Riverside	1924-1963 (40 years)
5	8066500	Trinity Rv at Romayor	1925-1966 (42 years)

Most of the major reservoir developments effecting natural flows in the upper basin at Rosser occurred in the early 1950's include Lavon Lake (East Fork) in 1953 and Lewisville Lake (Elm Fork) in 1954. It should be noted that there were at lest 5 reservoirs constructed prior to 1950, however these are considered distant enough from Rosser or are small enough that there effect on natural flows will be ignored. Flows at Oakwood, Midway and Riverside were altered by the construction of Cedar Creek Reservoir in 1965. These sites are far enough downstream of the Elm and East Forks that much of their natural hydrology would be dictated by intervening watershed run off thus the effects of the upstream reservoirs are ignored for the period from 1950 to 1965. Finally flows at the most downstream site at Romayor were most significantly altered by the construction of Lake Livingston in 1968.

Base Flows

Base Flow recommendations for dry, normal and wet years for the 4 river segments in the mainstem of the Trinity River below Dallas were developed by examining output from the IHA. (refer to Building Block methodology). Predevelopment base flows follow predictable patterns with high spring and fall flows associated with seasons of high rain falls (Figures Below – comments on display change graph format, show tables – Building Block tables for the entire flow range will be included in an appendix in the back). The dry year estimates are about a third of the wet year recommendations.

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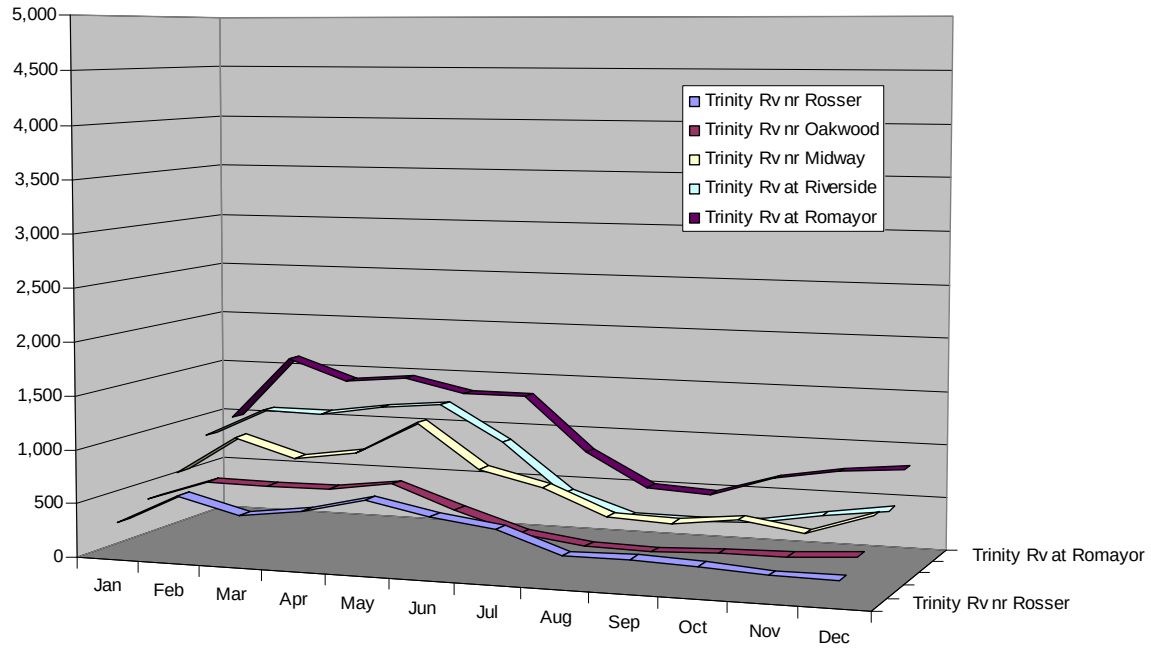

Figure 9 Dry

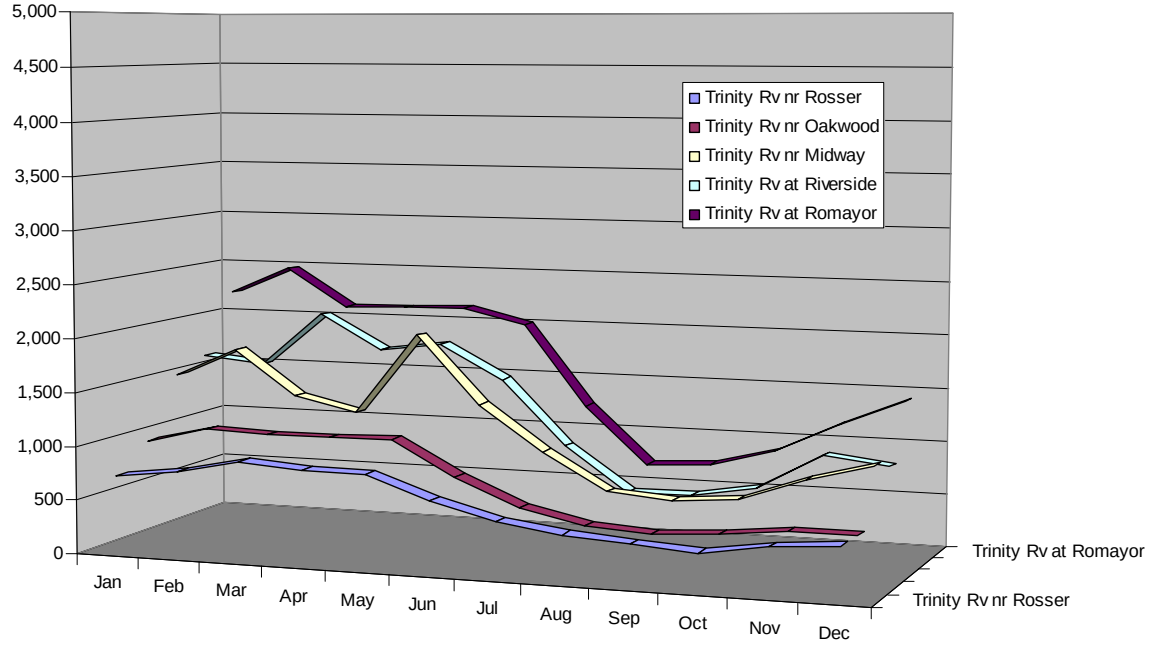

Figure 10 Normal

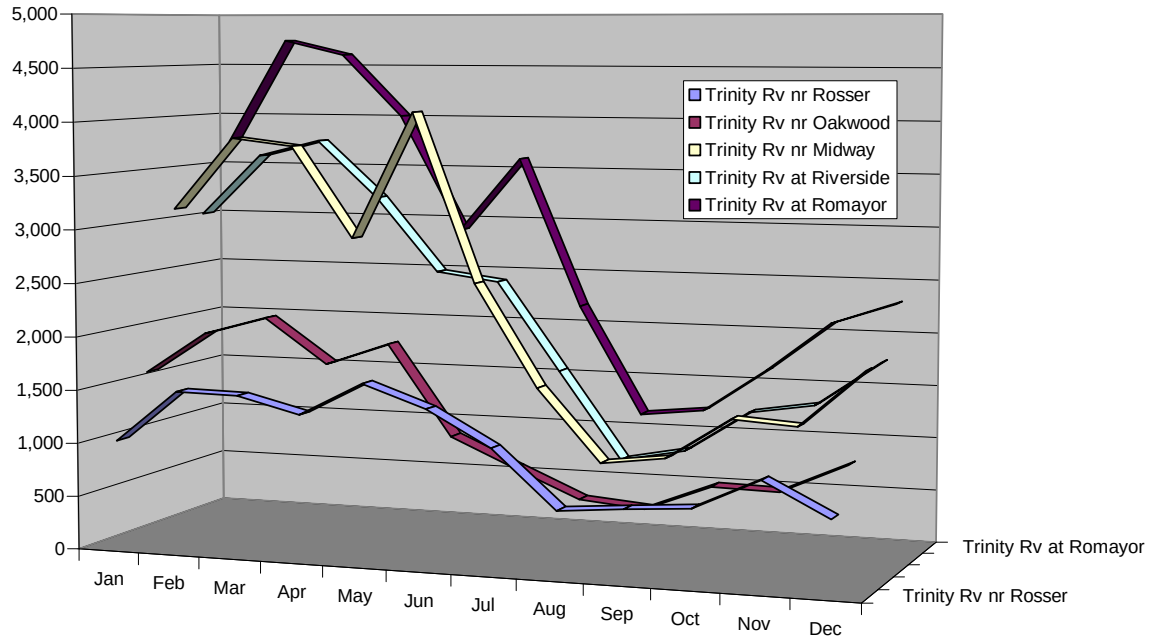

Figure 11 Wet

In two cases estimate for base flow needs for gauges further downstream are, at times, lower than gauges immediately upstream. Summer recommendations are higher at Rosser than further downstream at Oakwood similarly spring recommendations at Midway are higher than those at Riverside. This artifact is a function of slightly differing period of record upon which the stats the statistics for the different sites were generated. The Rosser gage includes only 13 years of data and does not include the severe drought of the 1950 unlike the Oakwood gauge which has a 40 year period of record.

To address this issue the gauges with the longer records (Oakwood and Riverside) where rerun in IHA with the shorter periods (1939-1951 and 1940-1963). Pairs (Rosser/Oakwood and Midway/Riverside) where then compared.

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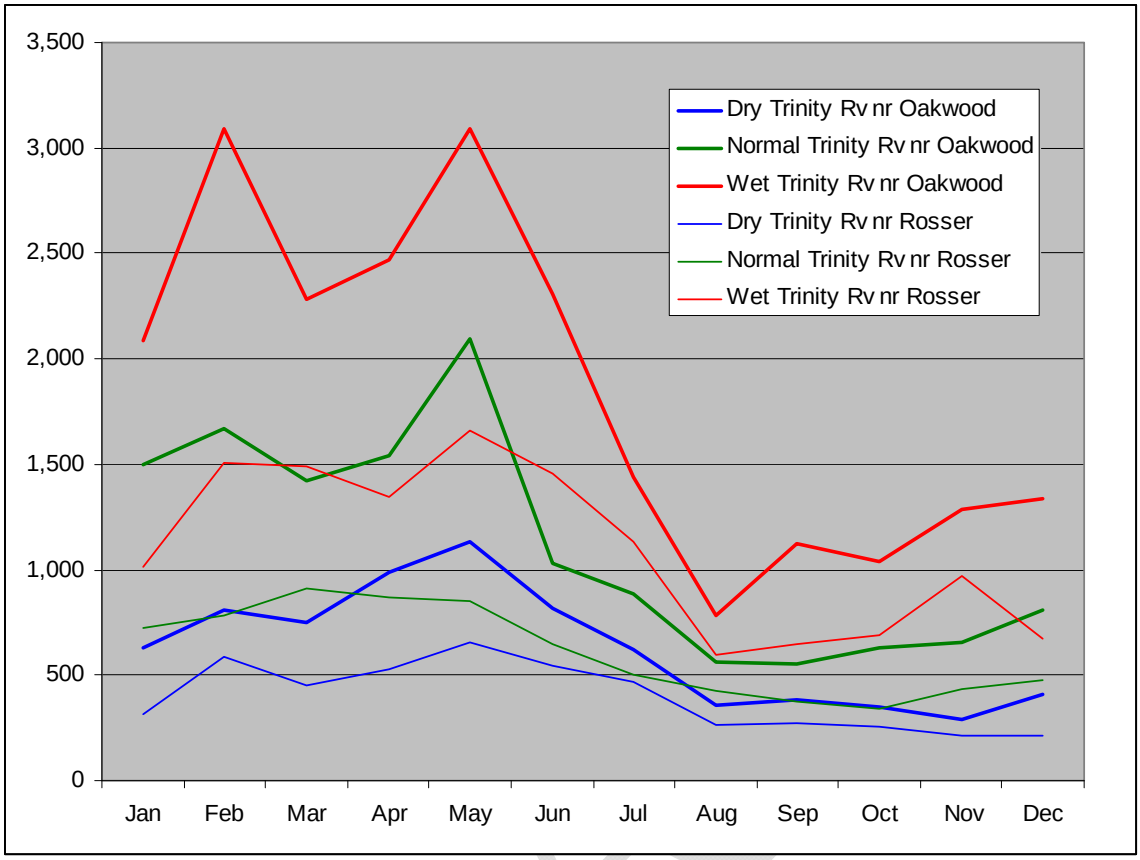

Figure 12 Oakwood Rosser

Figure 12 shows that while the seasonal flow patterns between Oakwood and Rosser are similar the flow at Rosser were generally about 50-75% of the flows at Oakwood. The actual percentages varied by month and whether the magnitudes represented dry, normal or wet conditions (Table 2).

Table 2 Rosser as a percent of Oakwood

	Rosser POR								
	Trinity Rv nr Oakwood			Trinity Rv nr Rosser			Rosser as a percent of Oakwood		
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Jan	628	1495	2089	314	720	1015	50%	48%	49%
Feb	807	1670	3088	590	784	1505	73%	47%	49%
Mar	750	1420	2280	449	907	1493	60%	64%	65%
Apr	991	1540	2466	525	866	1345	53%	56%	55%
May	1133	2095	3095	654	856	1658	58%	41%	54%
Jun	816	1030	2310	546	651	1453	67%	63%	63%
Jul	625	884	1440	466	505	1130	75%	57%	78%
Aug	354	559	786	266	424	599	75%	76%	76%
Sep	385	551	1128	273	377	650	71%	68%	58%
Oct	351	631	1036	255	337	690	73%	53%	67%
Nov	289	656	1283	215	433	975	74%	66%	76%
Dec	411	805	1340	214	475	672	52%	59%	50%

The Rosser as a percent of Oakwood this shorter time frame when predevelopment flow overlapped is then used to calculate new targets at Rosser based on the full Oakwood record.

Table 3 Rosser (Adjusted)

	Trinity Rv nr Oakwood			Trinity POR Rosser as a percent of Oakwood			Trinity Rv nr Rosser (Adjusted)		
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Jan	962	1593	2831	50%	48%	49%	481	767	1376
Feb	1102	1988	3399	73%	47%	49%	805	933	1657
Mar	1080	2155	3184	60%	64%	65%	647	1377	2085
Apr	1080	1745	2509	53%	56%	55%	572	981	1368
May	1093	1955	2773	58%	41%	54%	631	798	1486
Jun	783	1120	2314	67%	63%	63%	523	707	1456
Jul	536	861	1490	75%	57%	78%	399	492	1169
Aug	403	608	1354	75%	76%	76%	302	461	1032
Sep	361	555	932	71%	68%	58%	256	380	537
Oct	399	792	1982	73%	53%	67%	290	422	1321
Nov	464	778	1425	74%	66%	76%	344	514	1083
Dec	464	1050	2060	52%	59%	50%	242	619	1034

In the case of Midway/Riverside gauges, when the same period of record is used to generate estimates of base flow needs, Figure 13 shows that the recommends at each gauge are almost the same.

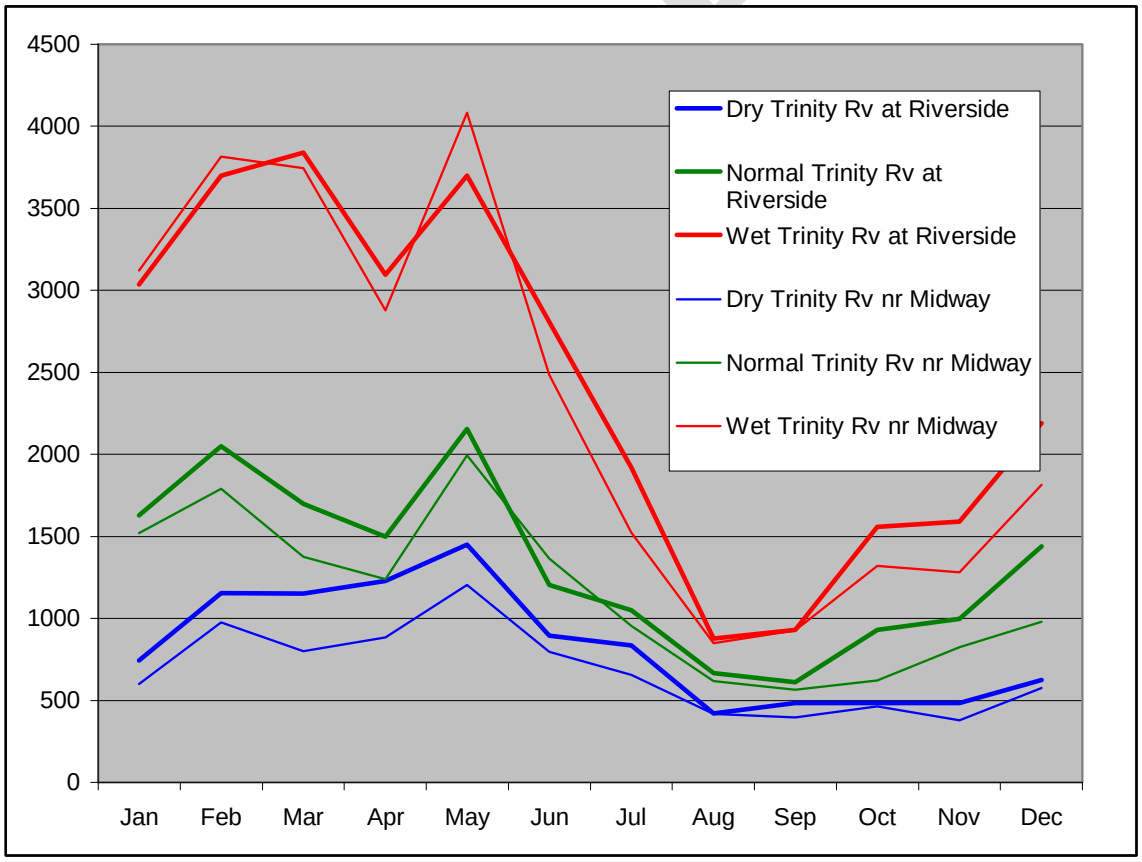

Figure 13 Riverside/Midway

These gauges are within the same HUC and TCEQ segment and there are no major tributary inflows, diversions, WWTPs or impoundments between the sites. For these reason the Midway records (with the shorter period of record) can be excluded from further consideration and the Riverside record used to define the base flow needs in this segment. As a result of the above considerations figures 9-11 can be regenerated now associated with TCEQ stream segments (Table 4)

Table 4 Mainstem Trinity Segments

Segment	Name	Description
805	Upper Trinity River	from a point immediately upstream of the confluence of the Cedar Creek Reservoir discharge canal in Henderson/Navarro County to a point immediately upstream of the confluence of Elm Fork Trinity River in Dallas County
804	Trinity River Above Lake Livingston	from a point 1.8 kilometers (1.1 miles) upstream of Boggy Creek in Houston/Leon County to a point immediately upstream of the confluence of the Cedar Creek Reservoir discharge canal in Henderson/Navarro County
803	Lake Livingston	from Livingston Dam in Polk/San Jacinto County to a point 1.8 kilometers (1.1 miles) upstream of Boggy Creek in Houston/Leon County, up to the normal pool elevation of 131 feet (impounds Trinity River)
802	Trinity River Below Lake Livingston	from a point 3.1 kilometers (1.9 miles) downstream of US 90 in Liberty County to Livingston Dam in Polk/San Jacinto County

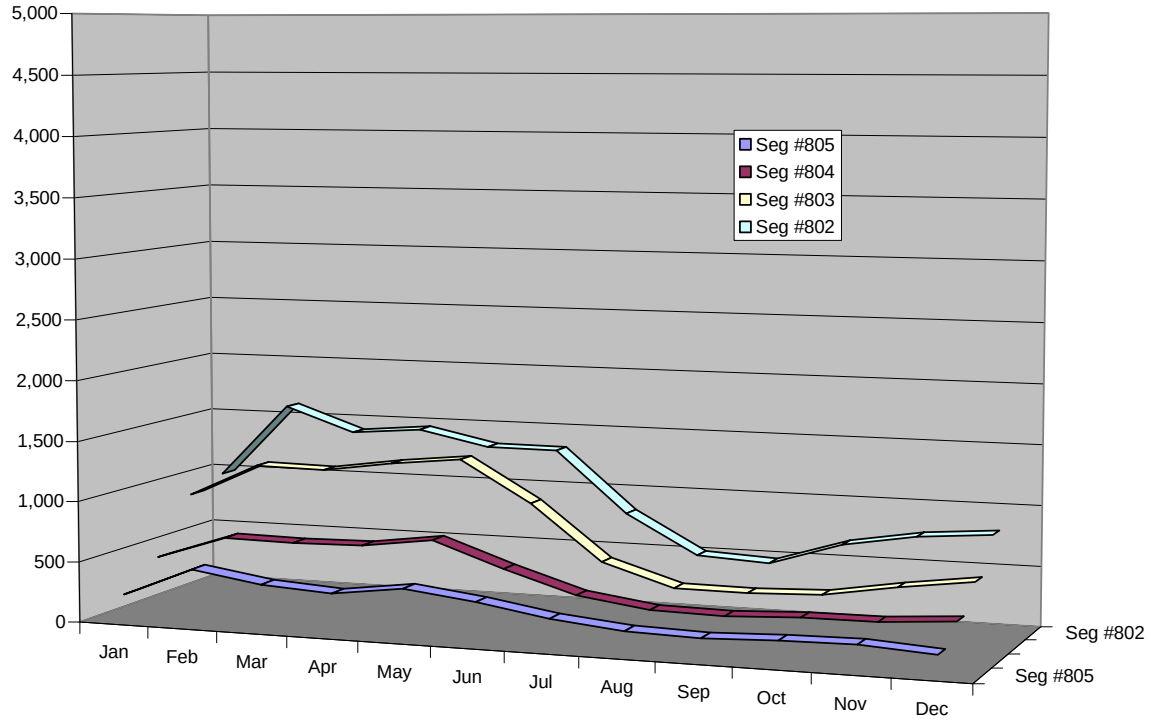

Figure 14 Dry

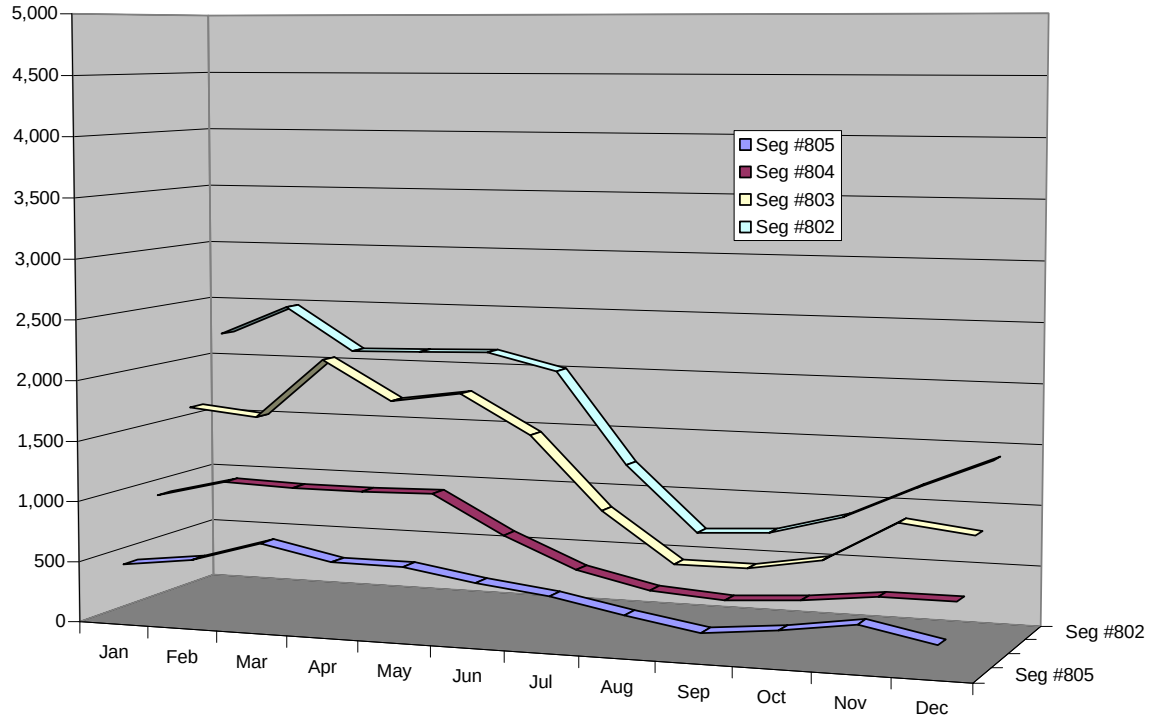

Figure 15 Normal

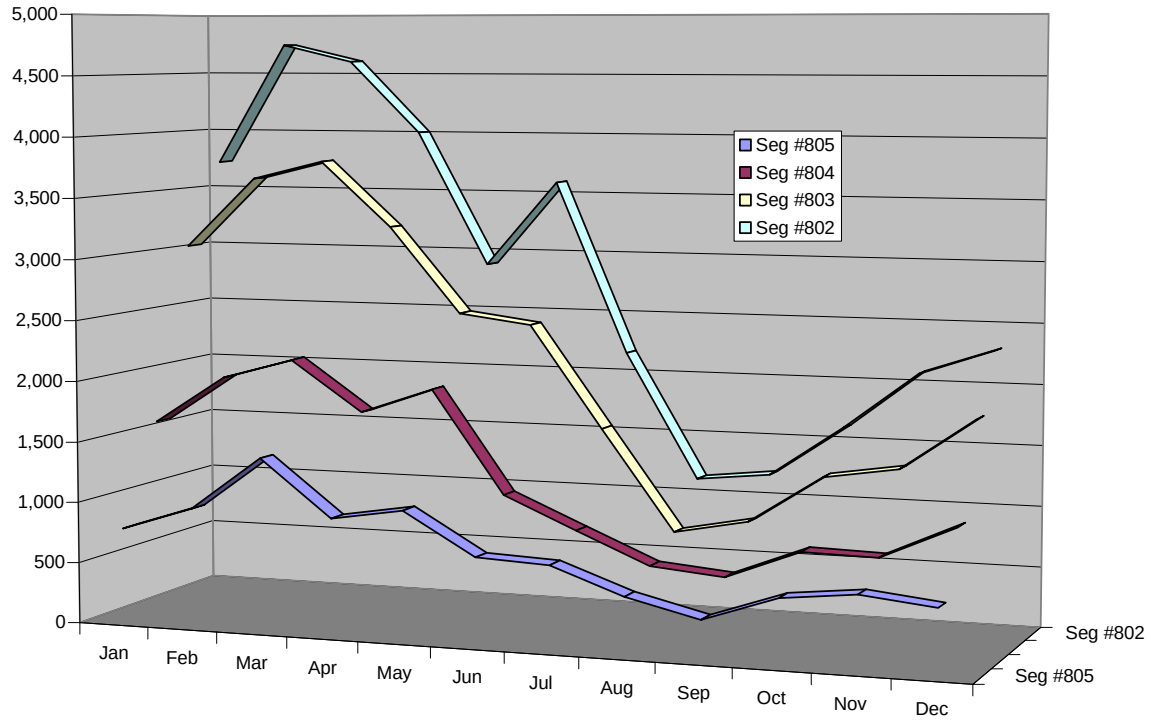

Figure 16 Wet

High Flow Pulse and Overbank Flow

The first estimates of the effective discharge and bankfull flow were made by calculating the recurrence interval flows based on peak annual flows. The USGS computer program outputs recurrence interval peak flows for 15 periods ranging from 1.005 year to 500 year recurrence flows. Table 5 presents recurrence interval flows for the 1.25, 2 and 5 year recurrence interval flows. This provides a reasonable range for the bankfull and effective discharges.

Table 5 Recurrence Interval flows

			Bull-17B		
Gage	Name	Period of Analysis	1.25	2	5
8062500	Trinity Rv nr Rosser	1939-1951 (13 years)	19,390	35,180	63,210
8065000	Trinity Rv nr Oakwood	1924-1963 (40 years)	21,590	38,330	68,370
8065500	Trinity Rv nr Midway	1940-1963 (24 years)	22,120	41,530	78,530
8066000	Trinity Rv at Riverside	1924-1963 (40 years)	21,270	37,390	62,310
8066500	Trinity Rv at Romayor	1925-1966 (42 years)	25,310	40,520	63,020

This assumption is checked by comparing these values with the flood stages published by the National Whether service. Only three of the five gauges with long term records have published flood stages and one of these Trinity River at Riverside is at Lake Livingston. Based on the comparisons at Rosser and Romayor (Table 6), we can conclude that the recurrence interval estimates provide reasonable estimates of bankfull flows. Some flooding would likely occur in the upper basin around 20,000 cfs and in the lower basin around 30,000 cfs. Much of the river would be out of its bank by 60,000 cfs. Although this is a fairly wide range this is not unreasonable. In natural systems bankfull will vary laterally (from upstream to downstream) and therefore some parts of the river will be out of bank and others in bank at the same flows.

Table 6 Comparison with NWS estimates

			Bull-17B			Action	Flood	Mod. Flood	Maj. Flood
Gage	Name	Period of Analysis	1.25	2	5	Stage	Stage	Stage	Stage
8062500	Trinity Rv nr Rosser	1939-1951 (13 years)	19,390	35,180	63,210	21,775	22,550	53,186	53,950
8066000	Trinity Rv at Riverside	1924-1963 (40 years)	21,270	37,390	62,310	60,053	63,700	82,000	98,850
8066500	Trinity Rv at Romayor	1925-1966 (42 years)	25,310	40,520	63,020	35,250	52,200	56,989	59,350

These estimates, 20,000-30,000 at the lower end and 60,000 at the higher end provide useful breakpoints for defining high flow pulses, small floods and large floods, the later two being overbank flows. Using default parameters, IHA estimates of median high flow pulses, small

floods and large floods are presented in Table 7. (explain the difference between annual peak flows and daily average flows)

Table 7 IHA estimates of high flow pulses, small floods and large floods

Gage	Name	Period of Analysis	High Flow Pulses	Small Floods	Large Floods
8062500	Trinity Rv nr Rosser	1939-1951 (13 years)	3,330	48,700	133,000
8065000	Trinity Rv nr Oakwood	1924-1963 (40 years)	4,923	55,700	123,500
8065500	Trinity Rv nr Midway	1940-1963 (24 years)	6,690	53,000	143,000
8066000	Trinity Rv at Riverside	1924-1963 (40 years)	8,328	47,500	106,500
8066500	Trinity Rv at Romayor	1925-1966 (42 years)	11,200	48,250	98,500

High flow pulses are clearly within bank flows, small flood are bracketed by the overbank flows from the recurrence interval flow analysis and large flows are clearly out of bank. As with the base flow estimates, there are inconsistencies which may be attributed to the deferent periods of pre-development flow records available for each site, notably the flood flows appear to peak in the middle sections rather than increasing in the downstream direction. Following the approach taken above to refine the base flow estimates and apply these five gauge records to the four TCEQ stream segments, the refined targets, by segment, are presented in (Table 8).

Table 8 High Flow Pulse, Small Flood and Large Flood targets by Segment

Segment	High Flow Pulses	Small Floods	Large Floods
805	2,000	39,000	110,000
804	5,000	43,000	110,000
803	8,000	48,000	110,000
802	11,000	48,000	110,000

(Details - threw out Midway as redundant, prorated 805 based on relationship between on Oakwood and Rosser with Rosser POR, 804 Small Flood appeared too high relative to others so averaged 805 and 803, Large Flood pattern was inconsistent moving DS so averaged all four values)

Unlike the base flow targets, which are intended to represent flows that should be meet each day of a given month with some specified frequency, (e.g. should meet normal conditions about half of the time, should not fall below dry targets more than 25% of the time and should have wet flow targets about 25% of the time), the high flow targets are not indented to be meet day in and day out. They should be met in specific seasons for a certain number of days. Based on a review of the IHA output small floods typically occurred between the months of March to October and

large floods occurred in the months of April and May. The timing of high flow pulses appear to have a spatial component with high flow pulses in the upper segments (805 and 804) most often occurring between April and October while in the lower segments between June and January. The frequency of the small and large floods is explicitly defined as an input to IHA as having a 2 and 10 year recurrence interval, as the magnitudes of theses events agree reasonably well with the estimates of overbank flows (see discussion above), these default frequencies seem reasonable. These events, from rise to fall, have rather long durations on the order of 40 days for small floods and 80 days for large floods. High flow pulses last about a week and occur approximately 10 times in most years. (Note a similar frequency and duration estimates were calculated for the Big Cypress as part of the Caddo Lake studies however aquatic scientists participating in that process felt that the ecological benefits of these pulses could be accomplished in shorter durations and with less frequency. Thus the recommendations were made that these events occur 3-5 times in normal and wet years for 2-3 days, with the proviso that these estimates deserved close attention during the implementation and adaptive management phase of the project. The LSWP recommends these types of pulses 8-10 times per year for 3-5 days.)

Subsistence flows

The starting point for determining subsistence flows is the 7Q2 which is the default water quality criteria in Texas. These values are published in the water code (Figure 30 TAC §307.10(2) - Appendix B - Low-Flow Criteria). (Table 9) shows the 7Q2 values by segment for the mainstem Trinity downstream of Dallas.

Table 9 - 7Q2 values

Segment	Gage	County	Period of Record		7Q2	Harmonic Mean	Gage Name
805	8057000	DALLAS	1966	1996	221	474.1	Trinity Rv at Dallas
805	8057410	DALLAS	1966	1996	440	816.7	Trinity Rv bl Dallas
805	8062500	KAUFMAN	1979	1996	607	1244.6	Trinity Rv nr Rosser
804	8062700	HENDERSON	1979	1996	657	1328.4	Trinity Rv at Trinidad
804	8065000	ANDERSON	1979	1996	717	1653.1	Trinity Rv nr Oakwood
804	8065350	LEON	1979	1996	811	2137.5	Trinity Rv nr Crockett
803	8065500	MADISON	1960	1970	510	1210.7	Trinity Rv nr Midway
802	8066250	POLK	1971	1996	650	1742.9	Trinity Rv nr Goodrich
802	8066500	LIBERTY	1971	1996	732	1990.2	Trinity Rv at Romayor

There are several issues that should be noted in reviewing the 7Q2 estimates. First, these values were calculated based on post development flows and therefore include the effects of flow modification caused by impoundments and waste water return flows. If the 7Q2 is calculated based on pre-development flow records, which would be more consistent with the approach taken in the other sections of this report the values would be significantly lower. In fact some segments in the Trinity basin would have 7Q2 flows at or near zero. Extreme low flow events have important ecological benefits in natural systems (see discussion above) however natural systems did not face the pollutant loads that are currently faced in the Trinity. These relatively higher flow rates may be necessary to assimilate this waste load, therefore any recommendation to lower the subsistence targets will need to carefully address the potential impact on existing waste water discharge permits.

As with the base and high flow targets there is the problem of the targets not always increasing in the downstream direction. This can be ascribed not only to the differing periods of record but also to the locations of diversion and discharge point which have modified this flow records. This is mostly a problem for segment 803 which unlike the others is based on only 10 years of data. For the sake of logical consistency this value should be adjusted to 725 cfs (average of the values at Oakwood and Romayor).

Finally, and most significantly for this report, these subsistence flow recommendations are in most cases greater than the base flow targets. This suggests that rather than include subsistence flows as part of the building blocks recommendations, these values might be used as a minimum for the base flow recommendations, that is, whenever the 7Q2 is greater than the base flow recommendation the base flow should be set to the 7Q2.

The other alternative would is to set subsistence targets based on some other rule of thumb, Hardy (2006) reference the 95th percentile low flow in several international studies.

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Building Blocks Recommendations for TCEQ Stream Segment #805

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Overbank Floods	110,000 cfs once every 10 years											
			39,000 cfs once every 2 years									
High Flow Pulses				2,000 cfs 10 times per year								
Base	774	969	1,411	952	1,047	704	676	463	320	527	591	527
	467	537	707	589	586	493	421	307	208	266	352	233
	218	462	373	336	411	340	247	186	169	192	200	162
Subsistence	80											

Wet
Normal
Dry

Base and Subsistence flows should be met for each day of the month. Flow should meet or exceed subsistence values 95% of the time, dry base 75% of the time, normal base 50% of the time and wet normal 25% of the time. High Flow Pulses and Overbank floods should be met for 3-5 days within the prescribed month or season

Building Blocks Recommendations for TCEQ Stream Segment #804

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Overbank Floods	110,000 cfs once every 10 years											
			43,000 cfs once every 2 years									
High Flow Pulses				5,000 cfs 10 times per year								
Base	1,593	1,988	2,155	1,745	1,955	1,120	861	608	555	792	778	1,050
	962	1,102	1,080	1,080	1,093	783	536	403	361	399	464	464
	436	632	622	636	712	509	331	249	239	265	270	311
Subsistence	120											

Wet
Normal
Dry

Base and Subsistence flows should be met for each day of the month. Flow should meet or exceed subsistence values 95% of the time, dry base 75% of the time, normal base 50% of the time and wet normal 25% of the time. High Flow Pulses and Overbank floods should be met for 3-5 days within the prescribed month or season

Building Blocks Recommendations for TCEQ Stream Segment #803

Overbank Floods			110,000 cfs once every 10 years									
			48,000 cfs once every 2 years									
High Flow Pulses						8,000 cfs 10 times per year						
Base	3,035	3,620	3,773	3,233	2,528	2,450	1,615	792	909	1,300	1,395	1,820
	1,640	1,580	2,090	1,765	1,850	1,530	930	520	520	620	960	890
	885	1,165	1,153	1,238	1,300	961	505	325	322	342	442	520
Subsistence	190											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Wet
Normal
Dry

Base and Subsistence flows should be met for each day of the month. Flow should meet or exceed subsistence values 95% of the time, dry base 75% of the time, normal base 50% of the time and wet normal 25% of the time. High Flow Pulses and Overbank floods should be met for 3-5 days within the prescribed month or season

Building Blocks Recommendations for TCEQ Stream Segment #802

Overbank Floods			110,000 cfs once every 10 years									
			48,000 cfs once every 2 years									
High Flow Pulses						11,000 cfs 10 times per year						
Base	3,730	4,744	4,605	4,005	2,895	3,600	2,180	1,150	1,215	1,629	2,095	2,303
	2,220	2,473	2,110	2,125	2,140	2,000	1,230	690	723	883	1,160	1,410
	988	1,605	1,403	1,454	1,330	1,328	820	503	471	658	758	806
Subsistence	300											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Wet
Normal
Dry

Base and Subsistence flows should be met for each day of the month. Flow should meet or exceed subsistence values 95% of the time, dry base 75% of the time, normal base 50% of the time and wet normal 25% of the time. High Flow Pulses and Overbank floods should be met for 3-5 days within the prescribed month or season

DFW Metroplex

Setting

The upper section of the Trinity River flows through one of the most urbanized areas of the state. Both the flow regime and the physical setting of the river have been significantly altered from their natural setting. Large waster water return flow have significantly altered the flow regime both in terms of quality and quantity. This area of the river includes parts of 2 subwatersheds

(HUCs) and 3 TCEQ Classified Stream Segments. The mainstream begins in the Central Oklahoma / Texas Plains and flows through the Texas Blackland Prairies. The section is located entirely within the Texan biotic province.

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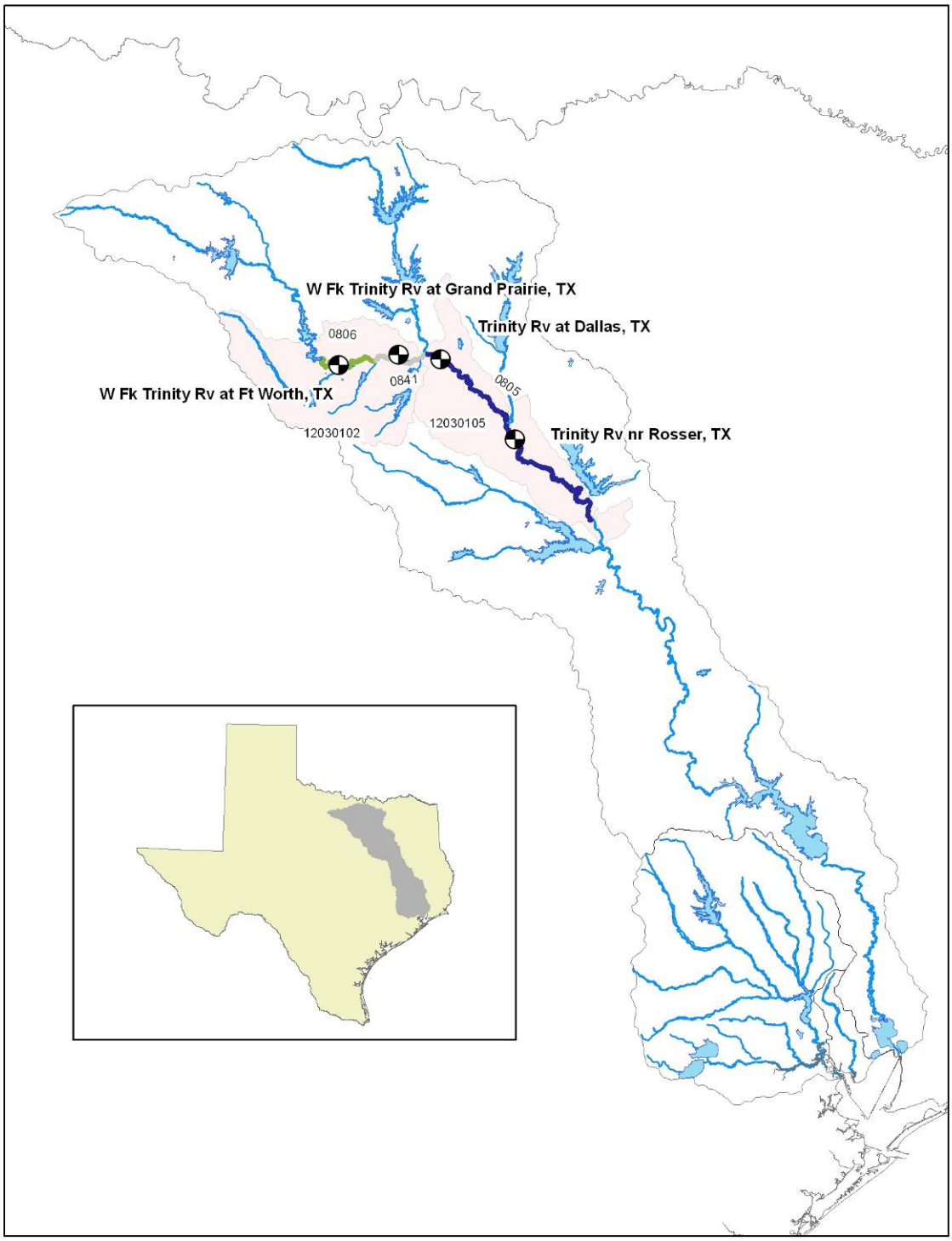

Map 2 DFW Setting

Pre-development Flows

There are three USGS gauges on this section of the Trinity River with long records of predevelopment streamflow. The flow recommendations at Rosser developed in the pervious section will also be used to develop recommendation for this section.

Table 10 DFW USGS gauges

Gage	Name	Period of Analysis
8048000	W Fk Trinity Rv at Ft Worth	1921-1950 (30 years)
8049500	W Fk Trinity Rv at Grand Prairie	1926-1955 (30 years)
8057000	Trinity Rv at Dallas	1903-1952 (50 years)

Base

High Flow Pulse

Subsistence

Clear and West Fork Trinity

Setting

Base

High Flow Pulse

Subsistence

Elm Fork

Setting

Base

High Flow Pulse

Subsistence

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East Fork

Richland, Chambers and Cedar Creeks

San Jacinto and Costal

Conclusions

Coordination with SB2 instream flow studies.

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References

Annear, T., I. Chisholm, H. Beecher, A. Locke and 12 other authors. 2004. Instream flows for riverine resource stewardship, revised edition. Instream Flow Council, Cheyenne, Wyoming.

Bounds, R.L., and Lyons, B.W. 1979. Existing Reservoir and Stream Management Recommendations Statewide Minimum Streamflow Recommendations. Federal Aid Project F-30-R-4. Performance Report. Texas Parks and Wildlife Department, Austin, Texas. 28p.

Leopold L.B., Wolman M.G., Miller J.P. 1964. Fluvial Processes in Geomorphology. New York: Dover Publications, Inc. 522 p.

Mosier, D. and R. Ray. 1992. Instream Flows for the Lower Colorado River: Reconciling Traditional Beneficial Uses with the Ecological Requirements of the Native Aquatic Community. Austin, TX: Lower Colorado River Authority.

National Research Council, 2005 The Science of Instream Flows, A Review of the Texas Instream Flow Program, The National Academies Press, Washington D.C.

Poff, N., J. Allan, M. Bain, J. Karr, K. Prestegaard, B. Richter, R. Sparks, and J. Stromberg. 1997. The natural flow regime: A paradigm for river conservation and restoration. BioScience 47:769-784.

Postel, S. and B. Richter. 2003. Rivers for Life: Managing Water for People and Nature . Washington, D.C.: Island Press.

Richter, B., J.V. Baumgartner, R. Wigington, and D.P. Braun. 1997. How much water does a river need? Freshwater Biology 37:231-249.

Richter, B., A. Warner, J. Meyer, and K. Lutz. 2006. A Collaborative and Adaptive Process for Developing Environmental Flow Recommendations.

DRAFT

Smith, S. 2007. Determining minimum recreational instream flow requirements for a reach of the Brazos River at Glen Rose, Texas. Masters Thesis. Texas Christian University, Fort Worth, TX.

Study Commission on Water for Environmental Flows, Science Advisory Committee Report on Water for Environmental Flows, Senate Bill 1639, 78th Legislature October 26, 2004

Tennant, D. 1976. Instream flow regimens for fish, wildlife, recreation, and related environmental resources. Fisheries 1(4):6-10.

Texas Instream Flow Program. 2002 Texas Instream Flow Programmatic Workplan. Texas Parks and Wildlife Department, Texas Commission on Environmental Quality and Texas Water Development Board, Austin, Texas.

Texas Instream Flow Program 2006 Draft - Texas Instream Flow Studies Technical Overview. Texas Parks and Wildlife Department, Texas Commission on Environmental Quality and Texas Water Development Board, Austin, Texas.

TNRCC. 1995. A Regulatory Guidance Document for Applications to Divert, Store or Use State Water.

TPWD An Analysis of Texas Waterways flow levels available on-line http://world.std.com/~reichert/riverflo.htm

TWDB. 2007. Water for Texas – 2007 State water plan. Texas Water Development Board, Austin, Texas

Winemiller, Kirk O., Anne Chin, Stephen E. Davis, Daniel L. Roelke, Luz Maria Romero, and Bradford P. Wilco Summary Report Supporting the Development of Flow Recommendations for the Stretch of Big Cypress Creek below Lake O' the Pines Dam, April 2005 Texas A&M University Team:

Wurbs, R.A. 2003. Water Rights Analysis Package (WRAP) Modeling System Reference and Users Manuals. Texas Water Resources Institute, Technical Reports 255 and 256, College Station, Texas.

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Appendices

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Goal Setting

What does it mean to "mimic natural flow regime"

Rationale for the Natural Flow Regime in the Apalachicola-Chattahoochee-Flint River Basin - Mathews (1999) – maybe useful outline

Biological Condition Gradient (BCG)

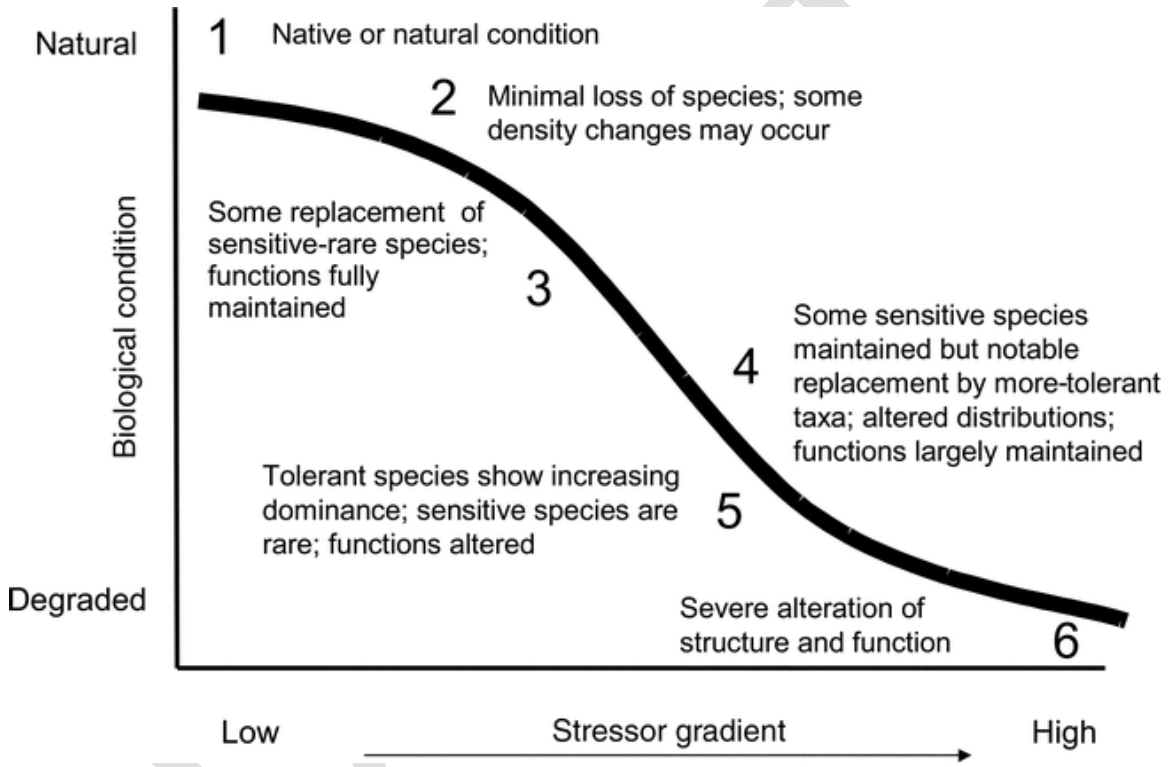
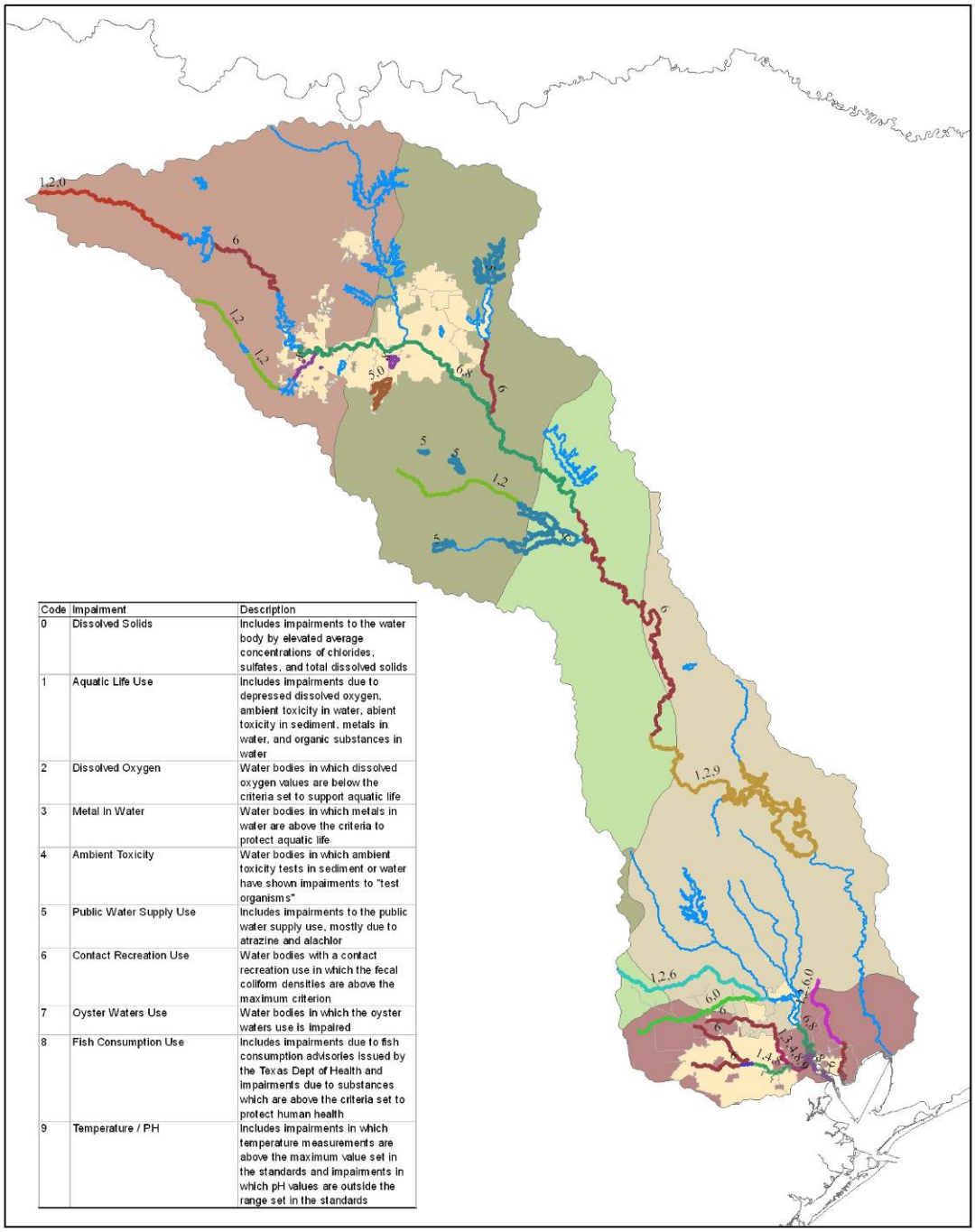


FIGURE 17 - Conceptual Model depicting stage of change in biological conditions in response to an increasing stressor gradient. (Davies and Jackson 2006)

Aquatic Life Use (ALU)



Code	Impairment	Description
0	Dissolved Solids	Includes impairments to the water body by elevated average concentrations of chlorides, sulfates, and total dissolved solids
1	Aquatic Life Use	Includes impairments due to depressed dissolved oxygen, ambient toxicity in water, abient toxicity in sediment, metals in water, and organic substances in water
2	Dissolved Oxygen	Water bodies in which dissolved oxygen values are below the criteria set to support aquatic life
3	Metal In Water	Water bodies in which metals in water are above the criteria to protect aquatic life
4	Ambient Toxicity	Water bodies in which ambient toxicity tests in sediment or water have shown impairments to "test organisms"
5	Public Water Supply Use	Includes impairments to the public water supply use, mostly due to atrazine and alachlor
6	Contact Recreation Use	Water bodies with a contact recreation use in which the fecal coliform densities are above the maximum criterion
7	Oyster Waters Use	Water bodies in which the oyster waters use is impaired
8	Fish Consumption Use	Includes impairments due to fish consumption advisories issued by the Texas Dept of Health and impairments due to substances which are above the criteria set to protect human health
9	Temperature / PH	Includes impairments in which temperature measurements are above the maximum value set in the standards and impairments in which pH values are outside the range set in the standards

Water Quality - Texas Surface Water Quality Standards

CRITERIA						
Chloride (Cl^{-1}) (mg/L)	Sulfate (SO_4^{-2}) (mg/L)	Total Dissovled Solids (TDS) (mg/L)	Dissolved Oxygen (DO) (mg/L)	pH Range (SU)	Fecal Coliform (#/100ml)	Temperature (F)

Fish - Indicators of Biologic Integrity (IBI) — Linam, Kleinsasser and Mayes (2002)

	Habitat Characteristics	Species Assemblage	Sensitive species	Diversity	Species Richness	Trophic Structure
Exceptional	Outstanding natural variability	Exceptional or unusual	Abundant	Exceptionally high	Exceptionally high	Balanced
High	Highly diverse	Usual association of regionally expected species	Present	High	High	Balanced to slightly imbalanced
Intermediate	Moderately diverse	Some expected species	Very low in abundance	Moderate	Moderate	Moderately imbalanced
Limited	Uniform	Most regionally expected species absent	Absent	Low	Low	Severely imbalanced

TABLE 11 - Characteristics of Aquatic Life Use Subcatagories (Source: Table 4, 30 TAC 307)

Macroinvertebrates - Rapid Bioassessment Protocol (RBP) - (Receiving Water Assessment Procedures Manual – TCEQ (1999)

Habitat - Habitat Quality Index (HQI)
Habitat Quality and Stream Fishes

Project Title: Refinement and Validation of Habitat Quality Indices (HQI) and Aquatic Life Use (ALU) Indices for Application to Assessment and Monitoring of Texas Surface Waters

Funding Agency: TCEQ to Texas A&M University and Baylor

Funding Period: 2005-2008

Project Management: Kirk O. Winemiller (TAMU, PI and Project Director), Ryan S. King (PI, Baylor subcontract)

Funding Summary: Total Award = $310,500 ($132,000 to Baylor)

Project Summary: The Texas Commission for Environmental Quality (TCEQ) has adopted Aquatic Life Use Standards (ALUS) that rely on indices of biotic integrity (IBIs) and habitat quality indices (HQIs) to support its responsibilities of monitoring and setting standards for surface water quality. These essential tools allow natural resource managers and regulators to

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assess the status of ecological systems for evaluation of trends and compliance with established water quality standards.

A recent analysis of the correspondence between the fish IBI and the TCEQ's HQI revealed a very low correlation between these indicators of ecological condition of streams. A variety of factors could explain this lack of correspondence, including i) errors in one or both of these metrics, ii) poor matching of spatial scales of assessment, and iii) poor correspondence between temporal dynamics of environmental disturbances and habitat or biotic responses, and iv) poor calibration of habitat indices to reflect natural conditions in specific ecoregions. The issue of scale and resolution, both in terms of space (geography, watershed position, siting within stream reach) and time (seasons, hydroperiod, time elapsed since last major disturbance) must be evaluated quantitatively in order to design and evaluate the validity and reliability of these assessment tools.

In this study, we will sample from a population of streams that have perennial surface water and lie within the Brazos and Trinity River basins within the Texas Blackland Prairies, East Central Texas Plains, and Cross Timbers ecoregions. Annual surveys will describe and evaluate key metrics of stream habitat in relation to position within stream reach, watershed, and landscape (e.g., geology/soils, topography, land use) as well as fish assemblage structure. We will determine principal relationships between stream habitat features and sources of landscape variation, as well as composition and structure of fish assemblages for use as biotic indicators of ecological status. Using quantitative methods, we will identify the most useful (sensitive, reliable) fish community and habitat metrics (individual elements, suites of elements, or aggregate variables derived from multiple elements) for creation of improved HQI and IBI for wadeable streams for these selected ecoregions.

Indicators of Hydrologic Alteration (IHA) – Flow TNC/COE

Available Data

TNC/TAMU Scope of work

Implementation

WAM

Monitoring and Adaptive Management

Define adaptive management

Research Priorities

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