Cypress Basin Hydrology Update

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by

Joe Trungale
Trungale Engineering & Science

Introduction

This document is an update to the *Summary Report Supporting the Development of Flow Recommendations for the Stretch of Big Cypress Creek below Lake O' the Pines Dam*, (Winemiller et al. 2005). The original summary document was used at the first Big Cypress Bayou – Caddo Lake Flow-Ecology workshop in May 2005 to develop building block flow recommendations. Eighty-seven scientists, water managers, and local community members participated in the two-day workshop.

In addition to providing an update of the progress and proposals made since May 2005, this document presents options for moving forward in a manner which is consistent with the methodologies defined in the Texas Instream Flow Program (TIFP). This program has produced guidance documents on how the state intends to proceed with studies to determine instream flow needs. In general, the documents lay out a methodology for performing instream flow assessments to address four riverine components: hydrology and hydraulics, biology, water quality, and physical processes (geomorphology). A fifth component, connectivity, is also included.

The TIFP was reviewed and evaluated by the National Academy of Sciences (NAS) and the guidance documents are currently being revised by the state agencies. A number of the NAS recommendations are included in the Caddo Flow-Ecology process including an expanded stakeholder process, the use of a desktop tool such as The Nature Conservancy's Indications of Hydrologic Alteration (IHA) and the use of a building block approach to develop subsistence, base, high pulse and overbank flow recommendations.

This document restructures the Caddo research priorities into the TIFP format, provides an update of research activities currently underway and lays out options to move forward. The Caddo Flow-Ecology approach and the TIFP while similar are not identical. One notable issue is that the TIFP does not specifically address wetland and lake issues which are obviously of primary importance in the Caddo Lake area. One of the important developments which has taken place in the last year has been the initiation, led by the Texas Commission on Environmental Quality, of a Watershed Protection Plan (WPP) for Caddo Lake. A WPP is similar to the more well known Total Maximum Daily Load (TMDL) although the WPP provides for more flexibility than the TDML. Since TMDL's are addressed in the TIFP under the water quality sections and because many of the lake research priorities identified in the workshop might be addressed within the WPP, the WPP will be addressed in the water quality section. This oversimplification is no doubt too restrictive to the lake issues and to the WPP but is useful for the purposes of this document.

Organization

This report follows a similar structure to the original A&M report in that it includes sections on the four principle riverine components, hydrology, biology, water quality and physical processes (geomorphology). Within each section the following topics will be addressed.

- Review of summary document and research priorities. Clarify and resolve outstanding issues, supplement with newly discovered data and give status report on research priorities. As part of this update we will also include any additional information needs to help develop building block type recommendations to for Little and Black Cypress.

- Provide a status report of on-going research including methods, results, interpretation and discussion of implications on flow recommendations.
- Consistency with the methods prescribed by the Texas Instream Flow Program. There is now two years worth of studies currently underway on the instream flow. The scopes of work for these studies will be reviewed and there suitability/applicability to the Cypress/Caddo work evaluated.

The final section of this document will address connectivity. Connectivity, while sometime treated as one the five riverine components to be addressed in instream flow studies, (Annear and others, 2002) is treated some what differently in the TIFP than the other four components. Its meaning has to do with spatial and temporal connections; lateral connectivity addresses connections from headwaters to the mouth, longitudinal connectivity addresses connections from the channel to floodplain, and vertical connectivity addresses the connections between surface and groundwater. In pervious work as part of the Caddo/Cypress Flow Ecology work these issues related are scattered among the other components.

Hydrology and Hydraulics

Review of Summary document

The original scope of work between TNC and TAMU for the development of the summary document included the following tasks to address issues of hydrology and hydraulics.

Hydrology

1. Do stream gauges exist along the river, and if so, where are they located, who maintains them, and how long have they been in operation?
2. Have lake level elevations been monitored, and if so, for how long and by whom?
3. What are/were the typical seasonal patterns of natural river flow and lake level fluctuation, e.g., when do higher flows tend to occur, when do the lowest flows occur?
4. To what extent have lake levels and the base, high pulse, and overbank flows in the river changed over time in response to human influences? Have extreme low flows (i.e., subsistence flows) become more frequent or extreme?
5. What are the primary human influences on the flow regime, and where do these impacts occur? Do certain human impacts (e.g., dam construction) appear to dominate over other human influences?
6. What types of water development activities are planned for the future, and how might those developments influence river flows and lake levels?
7. How important are ground water contributions to base flows? What is the nature of hydraulic connections between river or lake stage and alluvial water table levels?

Hydraulics

1. Has any hydraulic modeling been performed for the river? Has any flood hazard mapping been undertaken?
2. How well are relationships between river and lake stages (water elevations) and river flow understood?
3. How well are relationships between river flow and the distribution of velocities and depths in the river channel understood?
4. Is there longitudinal (upstream to downstream) connectivity in flow or are there major discontinuities (i.e., diversion dams), and if so where?
5. Has the lateral connectivity between the river and its floodplain been altered in any way?

With respect to hydrology, questions 1-5 were addressed in Winemiller et al. Question 6 has to do with water planning which is largely done through the Senate Bill 1 Regional Planning process managed by the Texas Water Development Board (TWDB). The final Region D regional plan and Draft State Water Plan for 2006 are now available. As part of the State Plan, the Cypress Basin Water Availability Model (WAM) was use to model the effects of the proposed water management plan on streamflows. This model along with the existing WAM allows us to quantify change in flows between natural, current, proposed and fully permitted conditions and specifically the frequency with which the system satisfies the building block recommendations developed in 2005.

A few words of caution regarding the following results are worth noting. The WAM was not developed specifically for this type of exercise and the results are probably best viewed in reference to changes between the various runs rather than as absolute predictors of the frequency of meeting the targets. One specific challenge in this exercise relates to the fact that the various flow targets recommended assume instantaneous or daily time step while the WAM produces results based at a monthly time step. To resolve this conflict, the WAM outputs were distributed to daily values based on daily time series patterns from existing USGS gages. Table 1 presents the frequencies of meeting the building block flow targets assuming natural, current, proposed (in SB1 regional planning) and fully permitted conditions.

Table 1 Frequency of meeting Big Cypress building blocks flow targets assuming natural, current and fully permitted conditions.

	Mag	Dur	Freq	Time/Yr	StartMo	EndMo						
Lg Flood	10000	2	10	1	1	5						
Sm Flood	6000	2	2	1	1	5						
High Pulse	1500	2	1	4	1	5						
Base Flow												
Month	Dry	Avg	Wet									
1	90	268	396									
2	90	347	500									
3	218	390	536									
4	198	330	445									
5	114	150	264									
6	49	79	140									
7	13	35	70									
8	6	40	41									
9	6	40	40									
10	40	40	49									
11	90	90	94									
12	90	117	275									
Percent Excedence												
	Dry				Average				Wet			
	Natural	Current	SB1	Full	Natural	Current	SB1	Full	Natural	Current	SB1	Full
Jan	87%	62%	53%	35%	66%	43%	39%	28%	53%	38%	36%	25%
Feb	98%	72%	67%	47%	78%	59%	48%	37%	68%	54%	43%	31%
Mar	92%	69%	60%	42%	80%	62%	54%	38%	72%	58%	50%	34%
Apr	84%	66%	63%	49%	76%	60%	58%	41%	69%	57%	53%	36%
May	85%	68%	66%	46%	80%	66%	64%	42%	69%	58%	53%	37%
Jun	85%	65%	58%	42%	78%	55%	50%	35%	67%	49%	46%	31%
Jul	87%	62%	51%	35%	80%	44%	39%	23%	69%	32%	31%	19%
Aug	86%	57%	46%	43%	70%	38%	34%	12%	70%	38%	34%	12%
Sep	76%	50%	44%	37%	55%	32%	25%	14%	55%	32%	25%	14%
Oct	54%	29%	20%	10%	54%	29%	20%	10%	51%	27%	20%	10%
Nov	63%	37%	28%	16%	63%	37%	28%	16%	62%	37%	28%	16%
Dec	79%	49%	46%	27%	75%	46%	45%	26%	57%	35%	34%	18%
	High Pulse				Sm Flood				Lg Flood			
	Natural	Current	SB1	Full	Natural	Current	SB1	Full	Natural	Current	SB1	Full
	39%	37%	27%	16%	35%	2%	2%	0%	22%	0%	0%	0%

A similar analysis is presented in Table 2 which displays the frequency of meeting the various targets on Big Cypress both pre and post Lake o' the Pines.

Table 2 Frequency of meeting Big Cypress building blocks flow targets under pre and post dam conditions.

	Magnitude	Duration	Frequency	Time/Year	StartMo	EndMo
Large Flood	10000	2	10	1	1	5
Small Flood	6000	2	2	1	1	5
High Pulse	1500	2	1	4	1	5
Base Flow						
Month	Dry	Avg	Wet			
1	90	268	396			
2	90	347	500			
3	218	390	536			
4	198	330	445			
5	114	150	264			
6	49	79	140			
7	13	35	70			
8	6	40	41			
9	6	40	40			
10	40	40	49			
11	90	90	94			
12	90	117	275			
Percent Excedence						
	Dry		Average		Wet	
	Pre	Post	Pre	Post	Pre	Post
Jan	93%	69%	71%	62%	60%	55%
Feb	99%	85%	77%	76%	62%	66%
Mar	86%	79%	75%	73%	65%	65%
Apr	85%	68%	76%	60%	69%	53%
May	91%	57%	84%	52%	69%	44%
Jun	82%	81%	67%	64%	50%	54%
Jul	80%	97%	55%	64%	41%	46%
Aug	70%	100%	28%	54%	28%	52%
Sep	53%	89%	24%	57%	23%	53%
Oct	28%	56%	28%	56%	25%	46%
Nov	44%	49%	43%	48%	35%	41%
Dec	74%	66%	60%	61%	44%	57%
	High Pulse		Small Flood		Large Flood	
	Pre	Post	Pre	Post	Pre	Post
	44%	35%	44%	0%	31%	0%

Question 7 under hydrology has to do with vertical connectivity (groundwater). Groundwater surface water interactions continue to be a poorly understood concern. The current Region D plan proposes satisfying most of the future unmet demands from groundwater therefore, this issue will likely require continued effort.

The questions under hydraulics also are largely related to connectivity (lateral and longitudinal). Several studies, undertaken to model the relationships between flow, stage and habitat (Questions 2-3), are described in Winemiller et al. The issue of lateral connectivity and effect of the dams (Question 4) is also addressed in Winemiller et al. With respect the questions related to longitudinal connectivity (Questions 1 & 5) the Corps of Engineers (COE) Fort Worth district is currently undertaking an effort to collect cross sectional survey data to support the development of a HEC-RAS flood simulation model.

Review of 2005 Workshop Research Priorities

During the 2005 flows workshop, several research priorities related to hydrology were identified. The first issue arose in response to the lack of a satisfactory water budget

Hydrology:

1. Develop correlation between old and new Jefferson flow gauging sites
2. What was the pre-dam duration of small floods?
3. How much gain/loss (from ground water, ET, and diversions) of water between Lake o' the Pines and Caddo Lake?
4. Assessment of floodwater accumulation (flood magnitude-frequency relationships) and backwater hydraulics below confluence of Little Cypress and Black Cypress

detailing the relationship between releases from Lake o' the Pines to flows into Caddo Lake. A critical component to this understanding is a reliable measure of flow in Big Cypress and of the various inputs and output to the creek as it flows into Caddo Lake. The desire to correlate with or reestablish an old gage near Jefferson may have arisen due to some confusion regarding the gages on Big Cypress. Historically there have been two gages on Big Cypress Creek:

- 107346000 Big Cypress Ck nr Jefferson, TX - This is a stage and discharge gage operated by the USGS located just below Lake of the Pines with a period of record from 8/1/24 to present. The data available from the USGS website is missing the period from 1/1/60 to 9/30/70 (Lake O the Pines ~Aug 1959). The data for the missing years is available in hard copy, not digital format.

- Cypress River at Jefferson, Tex – This is a wire-weight stage recorder (does not include discharge records) that was operated by NWS until about 1978. It is located on the Hwy 59 Railroad Bridge on the downstream end of Jefferson. The data is available in hard copy, not digital format.

The desire to correlate the old and new Jefferson flow gauging stations arose, based on the confusion that the old gage was a discharge gage on the HWY 59 bridge and the new gage was the USGS gage below Lake O the Pines. We are now of the opinion that correlating the old Hwy 59 stage only gage to the stage and flow gage below Lake of the Pines would be marginal and that the underling impetus for this task, to develop an accurate water balance for Caddo Lake is best served by the establishment of a new gage on Big Cypress below the confluence with Little Cypress (see ongoing work below).

The second question, which was not elevated to one of the priority issues, was addressed to some extent in Winemiller et al., yet it raises an additional concern which may or may not have been part of the original discussion. The magnitude of a small flood, and in fact all of the Environmental Flow Components, are reported by the IHA program based on default criteria (Figure 1).

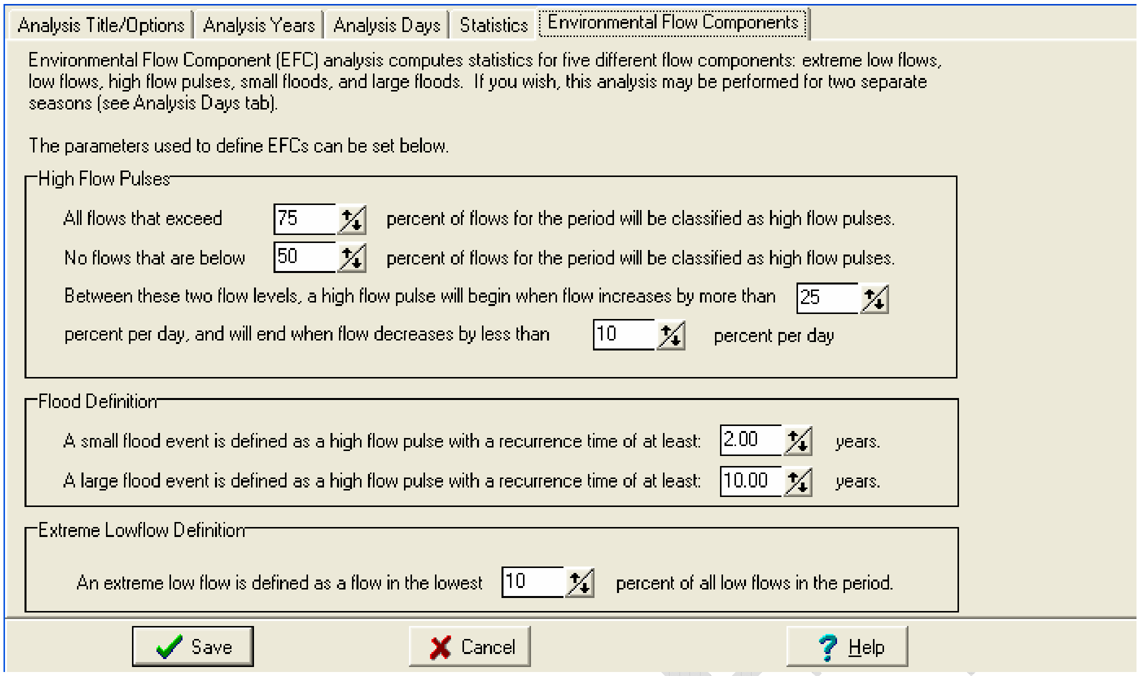


Figure 1 Environmental Flow Components default criteria in IHA

These criteria could likely be improved (calibrated) to our basin based on site specific data.

Issues 3 and 4 are connectivity issues that will be discussed in the connectivity section.

Site Specific Information on Little and Black Cypress to support Building Blocks Flow Recommendations

Although Winemiller et al. includes some analysis of the hydrology of Little and Black Cypress, they present a complete IHA analysis for Big Cypress only. A more complete analysis of Black and Little Cypress is included below. Since the flow regime of these tributaries has not been significantly altered no attempt is made to compare two different time periods. During the first Caddo Lake/Cypress Basin flows workshop in 2005, base flows for dry, average and normal years were based largely on the 25th, 50th and 75th percentile monthly low flow statistics generated by the IHA program. The high flow pulse and flood flows were largely based on the 2 and 10 year recurrence interval flows. The magnitude, frequency, duration, timing and rate of change of these values were modified based on references to site specific studies and professional judgment. The basic statistical analysis to develop similar building blocks for Little and Black Cypress is presented below and in Appendices B-D.

High Flows

High flow events, greater than around 500 cfs, have occurred historically in spring usually between February and April. In the Little Cypress, the1-day maximum peak flows are typically between 3,000 -7,000 cfs but can exceed 20,000 cfs in wet years (Figure 2). In the Black Cypress the 1-day maximums are on the order of 2,000-5,000 cfs (Figure 3). These high flow events last from 8-20 days and occur 3-8 times each year.

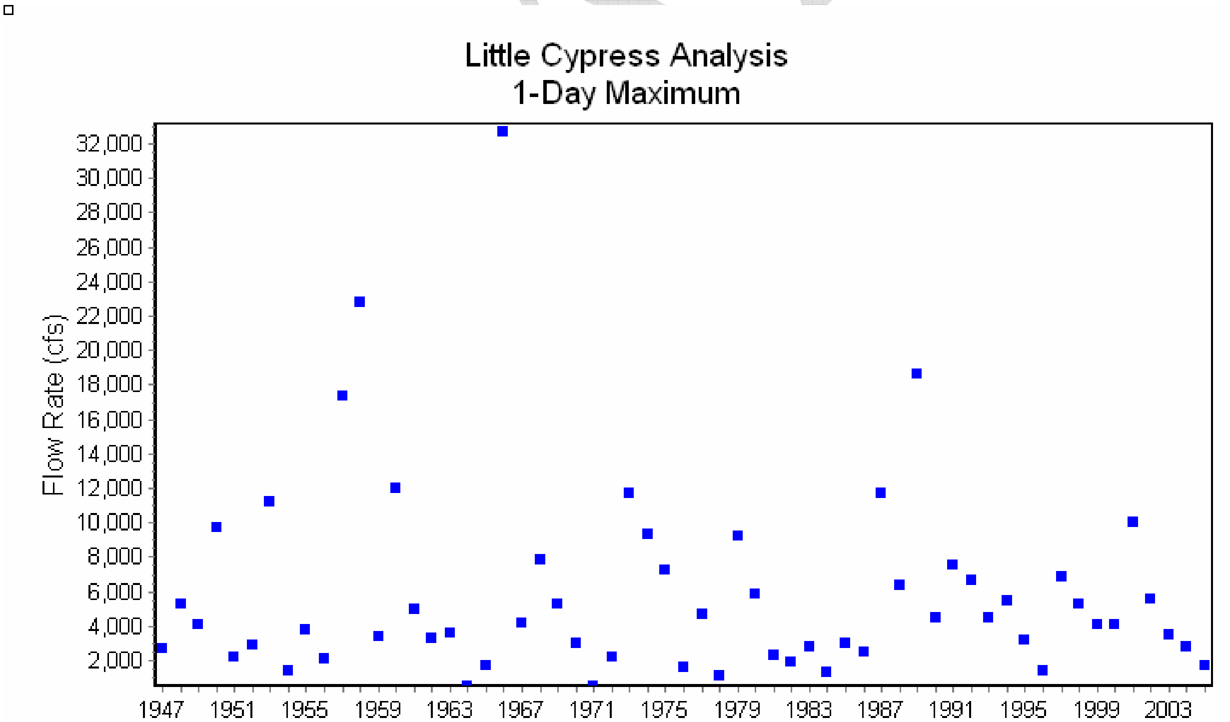


Figure 2 Annual peak flows for Little Cypress Creek at Jefferson

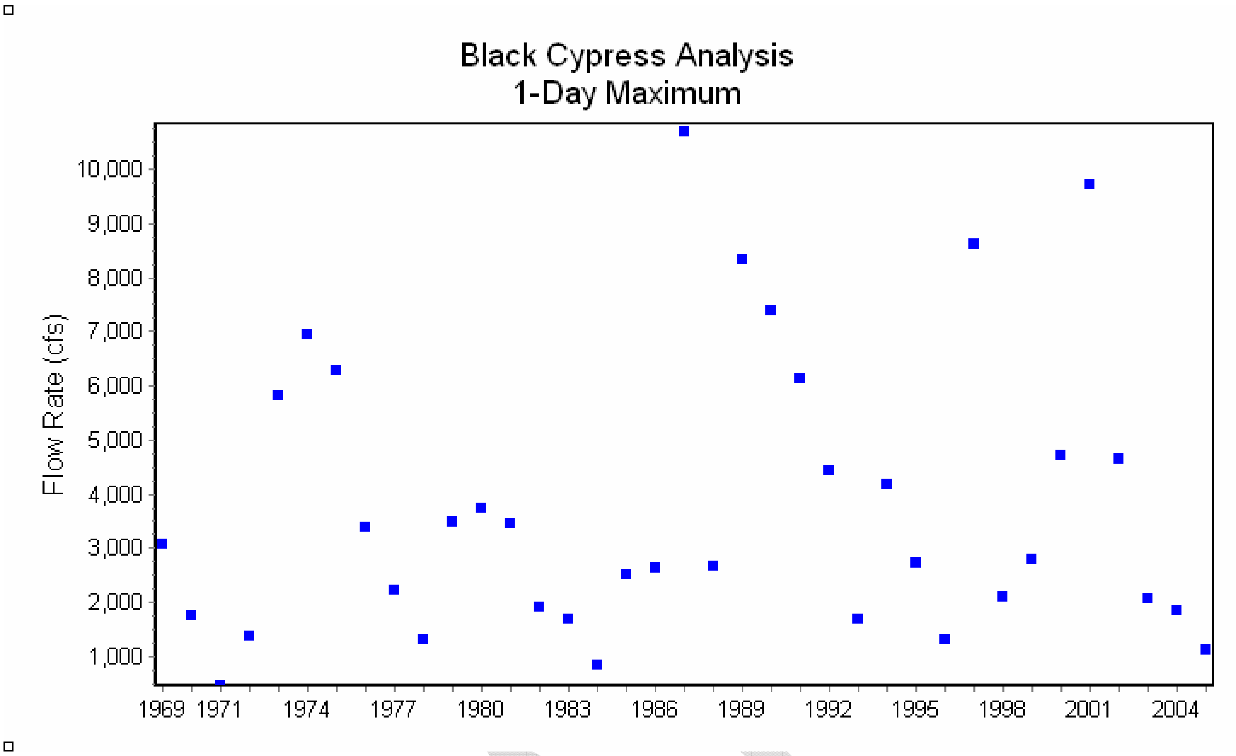


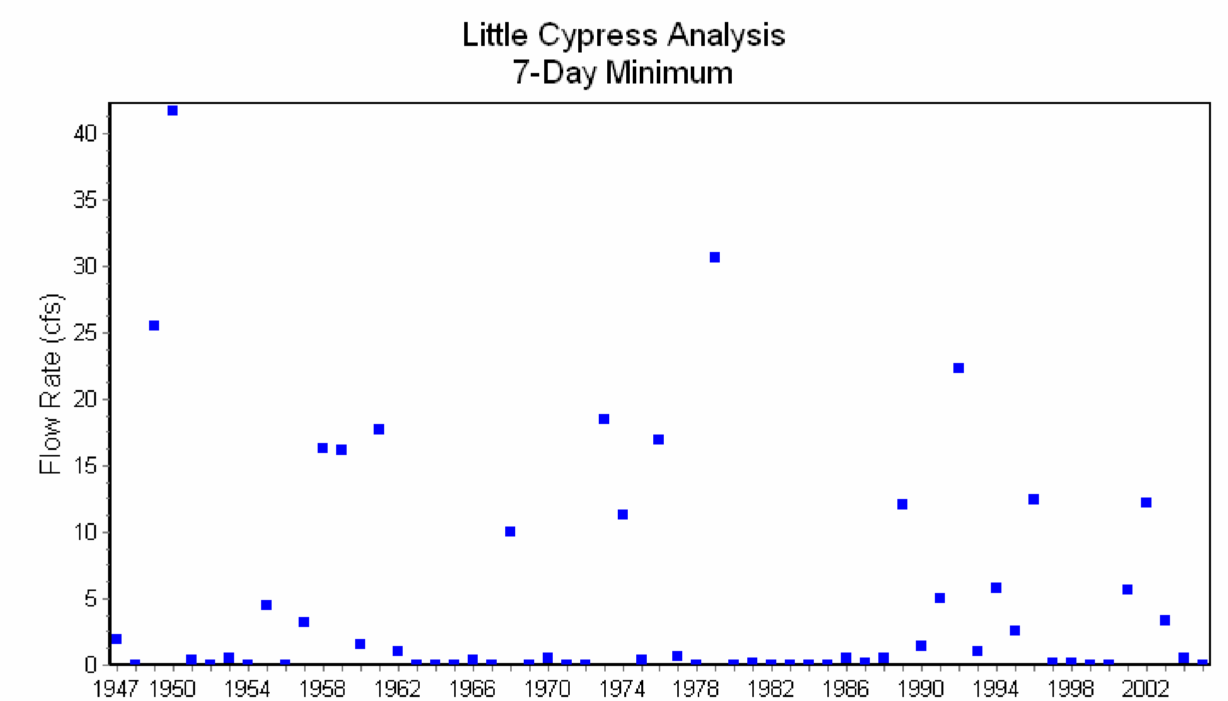
Figure 3 Annual peak flow for Black Cypress Bayou at Jefferson

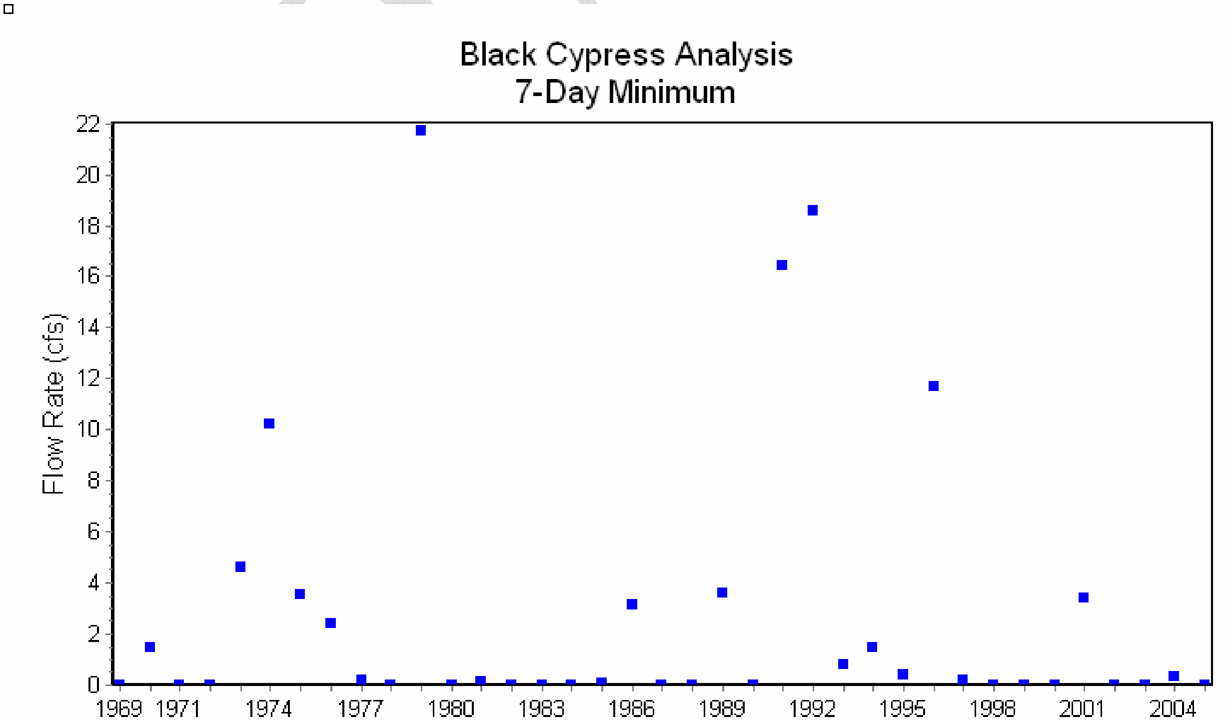
In addition to the daily maximums calculated with IHA, the USGS PKFQWin program was used to calculate recurrence intervals of instantaneous peak flows for Little and Black Cypress. Since this analysis was not presented for Big Cypress report it is included here as well. Full analysis outputs are in Appendix E.

Recurrence Interval	Big	Little	Black
1.5-year	4,207	3,031	2,270
2-year	6,485	4,389	3,263
5-year	15,040	8,955	6,199
10-year	23,300	12,930	8,376

Low Flow

Both Little and Black Cypress historically have experienced periods of very little to no flow with flows essentially zero occurring in more than one quarter of the years. The median seven day average low flow or 7Q2 are 0.53 and 0.12 for Little and Black Cypress, respectively.



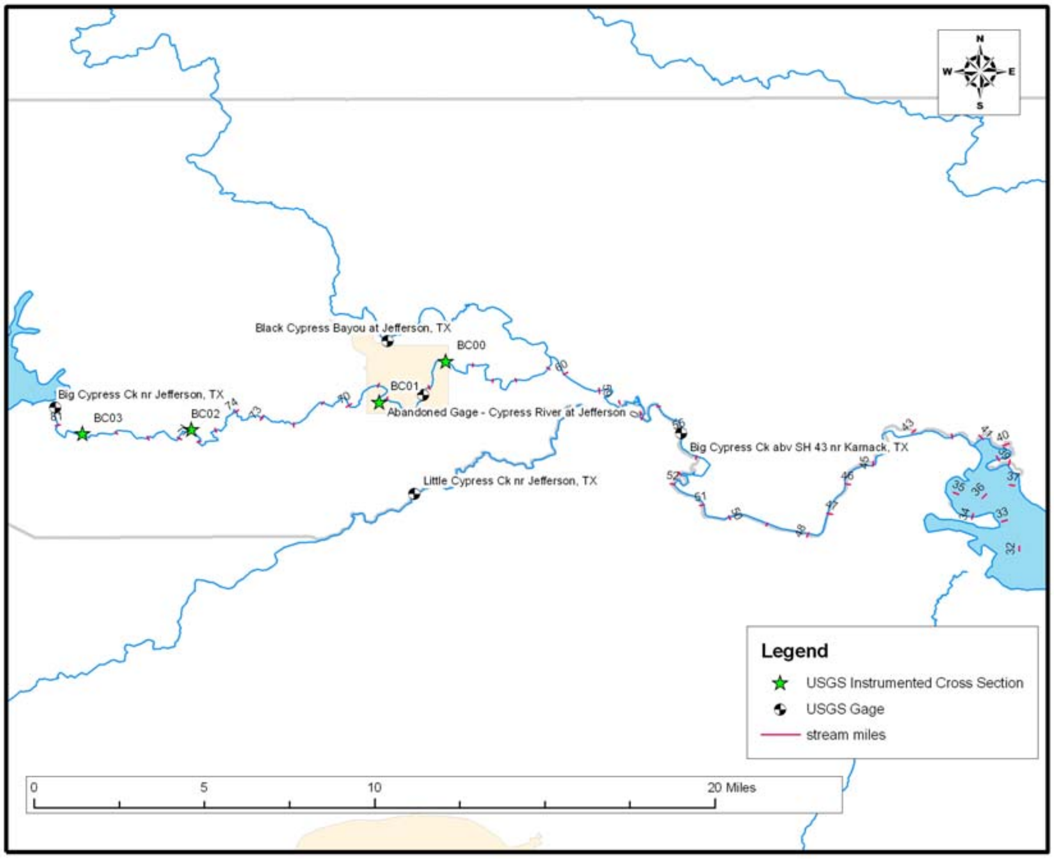


These low events also exhibit seasonal characteristics occurring most often in the late summer and early fall (Aug-Sep) about 2-4 times per year and typically lasting several weeks.

Status report of on-going work

The main tasks completed for hydrology and hydraulics have been the establishment of a new USGS gage and installation of continuous monitoring stations at which relationships between stage and discharge will be developed. The new gage, USGS gage 07346080, Big Cypress Ck abv SH 43 nr Karnack, TX was established in May 2006 and is currently reporting river stage. A rating curve will be developed over the next 1-2 years subject to flows after which time the gage will also report flow. This new gage, on Big Cypress, will allow us to better calculate a water balance into Caddo Lake.

The USGS has established four instrumented cross-sections at non-gaged locations for continuous monitoring of stage, temperature, and discharge in advance of prescribed releases. These will be used to relate flows and stage to biological and geomorphologic assessments.



Map 1. USGS permanent gages and temporary continuous monitoring stations.

Consistency with the Texas Instream Flow Program

With respect to the hydrology component, some progress has been made in using the state's Water Availability Model (WAM) to determine flow frequencies, which is consistent with some of the language within the TIFP documents. The building blocks approach and the reliance on a natural flow regime are also part of the state methodologies.

The TIFP section on hydraulics is focused on developing multi-dimensional hydrodynamic models to predict habitat and the hydrology section generally supports that development by providing guidance as to the range of flows to be analyzed. The development of a multi-dimensional habitat model has not been identified as at priority at this time, though much of the data currently being collected could be used to support the development of such a model in the future. With respect to hydraulics and hydraulic modeling, we are updating the existing 1-dimensional model (HEC-2) created by the USACOE and perhaps employing the recently developed HEC-EFM to predict responses of indicators ecological health to changes in flow.

We anticipate expanding on the hydrology work in developing a more accurate water budget for the Cypress Basin. Although the major focus with regards to hydrology has been the installation of a new gage on Big Cypress downstream of Jefferson future projects may be designed to address a groundwater gain-loss study. The TIFP is very clear that the methodologies were not intended to be a prescriptive one-size-fits-all approach.