SUMMARY OF DEVELOPMENT OF ENVIRONMENTAL FLOW REGIMES FOR THE CYPRESS RIVER BASIN AND CADDO LAKE WATERSHED AS OF 2012 WITH 2015 UPDATE

The recommended flow regimes or "Building Blocks" for the Cypress River Basin (See Attachment 1) and the Caddo Lake Watershed (See Attachment 2) were developed over the 7 years period from 2004 to 2011 as part of this Environmental Flows Project (Project). They were based on a process recommended by the National Academy of Sciences in a report for Texas, and the Sustainable Rivers Project, a joint effort of the U.S. Army Corps of Engineers (USACE) and the Nature Conservancy (TNC). They are based on the recommendations of a number of scientists and stakeholders, many with intimate knowledge of the system. The flow regimes were based on the best science available as well as practical limitations and the goals and interests of the stakeholders such as protections against flooding.

The Cypress Basin Flows Project was initiated in 2004 after the State of Texas made the decision that no new water rights would be granted for the purpose of assuring adequate flows in rivers, lakes and bays. Instead, the state leaders proposed in 2003 and, then, enacted a law in 2007 ("Senate Bill 3") to provide a process for protecting some state water for environmental flows in Texas. Not all river basins in Texas were, however, scheduled for the environmental flows process. The Cypress, Sulphur, Red and Canadian River basins were not, and funding for Senate Bill 2 processes in those basins has never been provided by the Texas Legislature. Senate Bill 3 did, however, provide that, for those basins not scheduled, voluntary efforts through consensus building could proceed to develop environmental flow recommendations.

In 2004, in anticipation of the passage of such a law, the Caddo Lake Institute (CLI) and TNC initiated such a voluntary process for the Cypress Basin with assistance from the U.S. Army Corps of Engineers, Northeast Texas Municipal Water District and others.

The goals of the Project have generally remained the same since 2004, although with some modifications as additional opportunities to expand the work have become available. The current goals are:

* Official State Recognition of the Need to Establish and Protect the Recommended Environmental Flows Regimes Developed in this Project: The Project is seeking a state-approved reservation of water for these flows regimes for the Cypress Basin and inclusion of these regimes as co-equal goals for water as the water needed for cities, industries and agriculture in the regional and state water plans.

* A New Release Rule for Lake O' the Pines: The Project is seeking a permanent change in the operations of Lake O' the Pines to provide releases in patterns that provide more of the recommended flow regimes downstream in Big Cypress Bayou and to Caddo Lake. (A temporary change is currently in place to allow monitoring of the impacts.)

* Additional Storage in Lake O' the Pines for Environmental Flows: The Project is seeking to implement strategies that increase storage of water in Lake O' the Pines or that otherwise help restore and maintain the recommended environmental flow regimes in the basin. (See Attachment 9 for one example.)

* A Long-Term Program of Monitoring and Adaptive Management: The Project is seeking to establish a program for monitoring conditions over the long-term to allow a periodic reevaluation of the recommended flow regimes and the expected outcomes, provide adaptive management for the Project.

Details on the process, such as agendas and reports from the workshops and other meetings are available at www.caddolakeinstitute.us/flows.html.

1 Orientation Meeting and Initial Consensus to Pursue the Project

In December 2004, CLI and TNC hosted a two-day meeting to discuss the possibilities of a project to develop and pursue sustainable flows regimes for the Cypress River Basin. Approximately 80 scientists and stakeholders participated. Facilitated by Brian Richter of TNC, the participants considered the need and options for the work. A consensus was reached that there

were or could be found adequate resources for an approach that relied heavily on volunteers working at meetings to develop recommendations based on existing data. With available resources, the testing of the Building Blocks and other research would also be pursued. It was also agreed that the process would involve scientists and stakeholders meeting together.

The process would first be used to develop Building Blocks or draft environmental flow regimes based on the ecological needs, without consideration of the practical limitations or other needs for the water. Thus, the Building Blocks would not be constrained by physical or legal limitations or broader goals of stakeholders. Such limitations, interests and goals of stakeholders, and issues of implementation would then be used to revise the Building Blocks to develop the final recommended environmental flow regimes for the Project, similar to what are called "environmental flow standards" in the Senate Bill 3 (SB 3) process. (A summary of the SB 3 process is provided in Attachment 7.) Details on work at the orientation meeting can be reviewed at www.caddolakeinstitute.us/dec04.html.

The basic process for developing Building Blocks is shown in Figure 1 below.

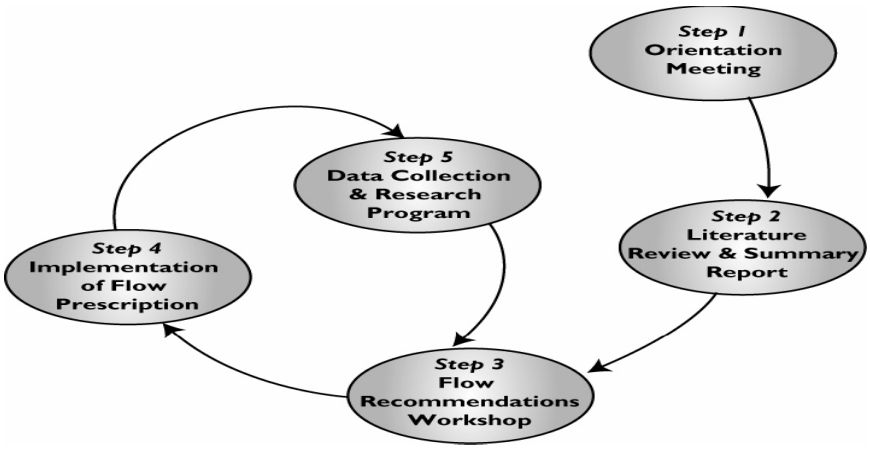


Figure 1 Flow regime development with adaptive management

1.1 Identifying Scientists and Stakeholders

One of the first steps, initiated even before the orientation meeting, was identifying scientists and stakeholders. The areas of desired scientific expertise that were identified included 1) hydrology and hydraulics, 2) biology, 3) water quality, 4) connectivity and 5) fluvial geomorphology.

Recruiting the scientists needed for the work was a three-step process. The first step was to identify institutions or individuals with a history of working in the watershed. This included people who have studied the ecology of the system and those who had conducted studies related to proposed water development projects. Next, other institutions that were likely to have an interest in this process were identified. This included local, state and federal agencies, university researchers and private consultants. Finally, the experts identified were then asked to identify others who might be needed or otherwise should be invited to participate.

The Cypress Basin has attracted scientific studies for many years. Given that Caddo Lake is Texas' only naturally-formed large lake, there have been strong interests in the basin. There were also a number of studies associated with the water projects in the basin. These included studies for existing lakes, such as Lake O' the Pines and Bob Sandlin Lake, and projects that were not completed, such as the proposal for a reservoir on Little Cypress Creek and one for a barge canal across Caddo Lake. A few of these studies included instream flow studies. All of the studies were evaluated for the work. Importantly, many of the scientists who participated in these studies were also available and assisted with the work of the Project.

Stakeholders were identified in a similar way. The process began with those known to be interested and with the obvious governmental and non-governmental organizations working in the area. That was followed up by requests that stakeholders identify other potential stakeholders to participate. A number of stakeholders not only helped set goals for the process to

add practical limits to the flow regimes, they also brought their practical experience and observations to help with the technical evaluations and development of the flow regimes. The meetings were also open to the public. In all, approximately 200 individuals have participated in one way or another. See Attachment 4 for the list of the major organizational participants.

1.2 Literature Review and Summary Report

A team of professors from Texas A&M University was engaged to prepare a literature survey, summary of existing research and a synthesis of the research to be used as a basis for the Building Blocks. The A&M team was headed by Professor Kirk Winemiller. While the report covered most of the significant studies in the Cypress Basin, the decision was made, for resource reasons, to focus initial work of the Project on the Big Cypress Creek between Lake O' the Pines and Caddo Lake.

2 Flows Workshops: How the Work Was Organized

Flow regime matrices were developed and revised at four multi-day flow workshops starting in 2005. In addition, there were numerous smaller meetings to direct the research. These occurred between the dates of the full workshops.

2.1 First Workshop: May 2005

At the first workshop, held over three days in early May 2005, a first cut was made for 2 sets of Building Blocks, one for Big Cypress Bayou downstream of Lake O' the Pines and one for Caddo Lake. As part of the initial recommendations, a plan was developed to test the Building Blocks for Big Cypress Bayou, where possible, with releases from Lake O' the Pines.

The work of the first workshop was based on the A&M literature survey and summary, which reported on the historical flow conditions (including pre-dam conditions) in Big Cypress Bayou and the role of these conditions in shaping the lotic, lentic and floodplain ecosystems of this region. Over 80 scientists, water managers, and local community members participated in the first workshop. Participants worked together in breakout groups to define the dimensions of the flow component patterns including magnitudes frequencies, durations and timing for a full range of hydrologic conditions and inter and intra-annual variation. The workshop participants also identified knowledge gaps and prioritized research tasks necessary to validate or, if necessary, refine these preliminary recommendations.

2.2 Second Workshop: October 2006

The second multi-day workshop was held in October 2006 with again over 80 participants. Because of drought conditions, there had been no opportunity to test assumptions and the Building Blocks with releases from Lake O' the Pines. As a result this second workshop focused on developing Building Blocks for Little and Black Cypress Bayous.

To prepare for the work on Little and Black Cypress Bayous, a supplement to the literature survey was completed, including IHA and recurrence interval flow statistics for these streams. After some discussion of whether the Building Blocks for Black and Little Cypress could be developed by using the approach applied to the Building Blocks for Big Cypress Bayou, a consensus was reached that this approach was appropriate. Building Blocks recommendations were developed; however, there was also extensive discussion as to whether these numeric regimes could meet both the scientific objectives and the goals of other participants. Thus, the concept of "narrative" standards was initiated, though not fully developed.

2.3 Third Workshop: December 2008

A third multi-day workshop was held in December 2008 with about 75 participants. The results of the research that had occurred after the second workshop led to several refinements of the preliminary flow regime matrices. The participants also decided to make a significant adjustment to the form of the flow recommendations on the unregulated sites on Little and Black Cypress by adopting a narrative approach for Black Cypress and hybrid (part Building Block, part narrative) approach for Little Cypress. This decision was motivated by the recognition that the wetlands associated with Caddo Lake have very high resource value and the concern expressed at the second workshop that the limited high-flow events defined by the Building

Blocks might not be satisfactory to maintain the ecological health of these streams that currently experience largely unaltered flow regimes, given the reduced level of pulse flows available from Lake O' the Pines. (See Attachment 6.)

At this third workshop, the group also made recommendations for developing Building Blocks for ungaged tributaries based on drainage area adjustment. Having reached consensus on the scientific basis for the flow recommendation and the Building Blocks for most of the basin, the work began to focus on the two next steps: 1) developing strategies that might be needed to assure sufficient water to satisfy the flow recommendations where not currently met and 2) applying the practical limitations, legal restrictions and stakeholder goals to the Building Blocks to develop the recommended environmental flow regimes.

2.4 Fourth Workshop – December 2011

A fourth multi-day workshop was held in December 2011 with between 60 and 70 participants. The participants considered the results of several studies conducted between 2008 and 2011 including 1) a study funded through the Sustainable Rivers Project to quantify areas inundated at a range of in-bank and overbank flows, 2) a TCEQ Clean Rivers Program special study that included mesohabitat mapping and fish sampling during low and subsistence flow levels and 3) studies conducted as part of the Watershed Protection Plan (WPP) process that was focused on water quality issues. The workshop also heard updates on the Texas regional water planning process and water supply issue concerns raised by Louisiana stakeholders.

While a number of modifications to the flow regime recommendations were considered, including changes to high-flow release to meet targets for inundation of select wetland habitat types, the participants decided not to make any changes to the Building Blocks values. They did agree that changes may be required based on additional studies that were recommended before the next workshop. Next, a consensus was reached that attainment frequency targets should attempt to mimic attainment frequencies observed under more natural flow conditions.

The participants then discussed implementation issues and recommended the Building Blocks as the recommended environmental flow regimes, choosing not to revise the Building Blocks based on implementation issues and stakeholders goals, except in refining the narrative standards for Little and Black Cypress Bayou. The participants recognized that practical limitations, such as the maximum release rate from Lake O' the Pines, meant that the recommended flow regimes could not be achieved in some cases. Again, strategies for achieving the recommended regimes were discussed.

The workshop participants also discussed issues related to the impacts of changes in operations at Lake O' The Pines, the complexities of implementing narrative standards within the state water right laws and research needed before the next workshop to address such issues.

With the consensus reached on the recommended environmental flow regimes, at least until the next workshop, the USACE and NETMWD agreed to change their operations of Lake O' the Pines to implement the flow regimes for Big Cypress Bayou downstream of the lake for 5 years to the extent they could do so. In exchange, the participants agreed to seek resources for a number of tests or monitoring projects to determine if the impacts of changes in operations could be detected, and if so, whether they supported the recommendations and the expected outcomes that are the basis of the Building Blocks.

Much of the rest of workshop time was focused on developing the initial set of indicators to start more formally the short and long-term monitoring needed for adaptive management. Again, priorities for research were also set.

3 Building Blocks: Where the Numbers Came From

3.1 Big Cypress Bayou

The initial Building Blocks for Big Cypress Bayou, developed in May 2005, are presented in Figure **Error! Reference source not found.**2. The flows portrayed in this figure include magnitudes, duration and seasonal timing as well as a prediction of the ecological outcome that would be expected if the flow conditions were attained.

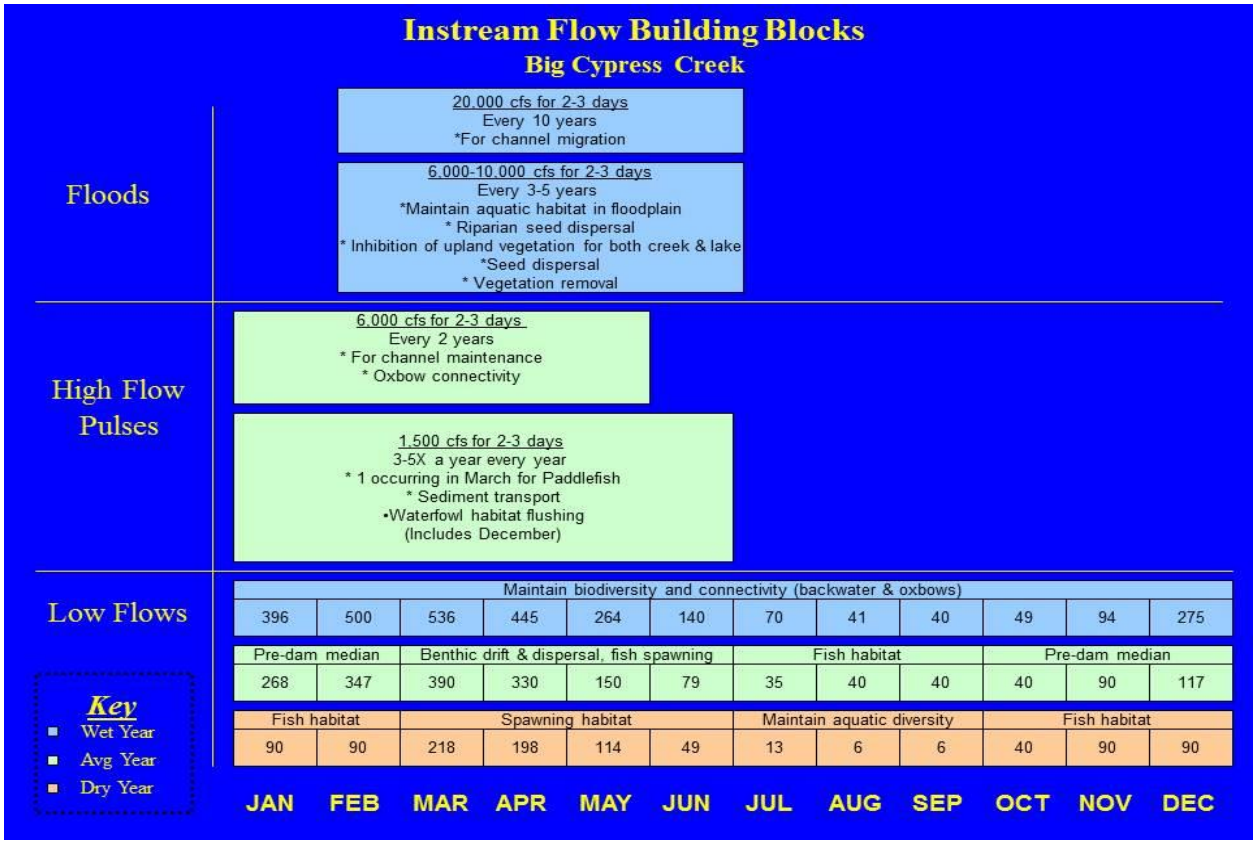


Figure 2. Initial Building Blocks for Big Cypress Bayou, May 2005 with low flows specified by month.

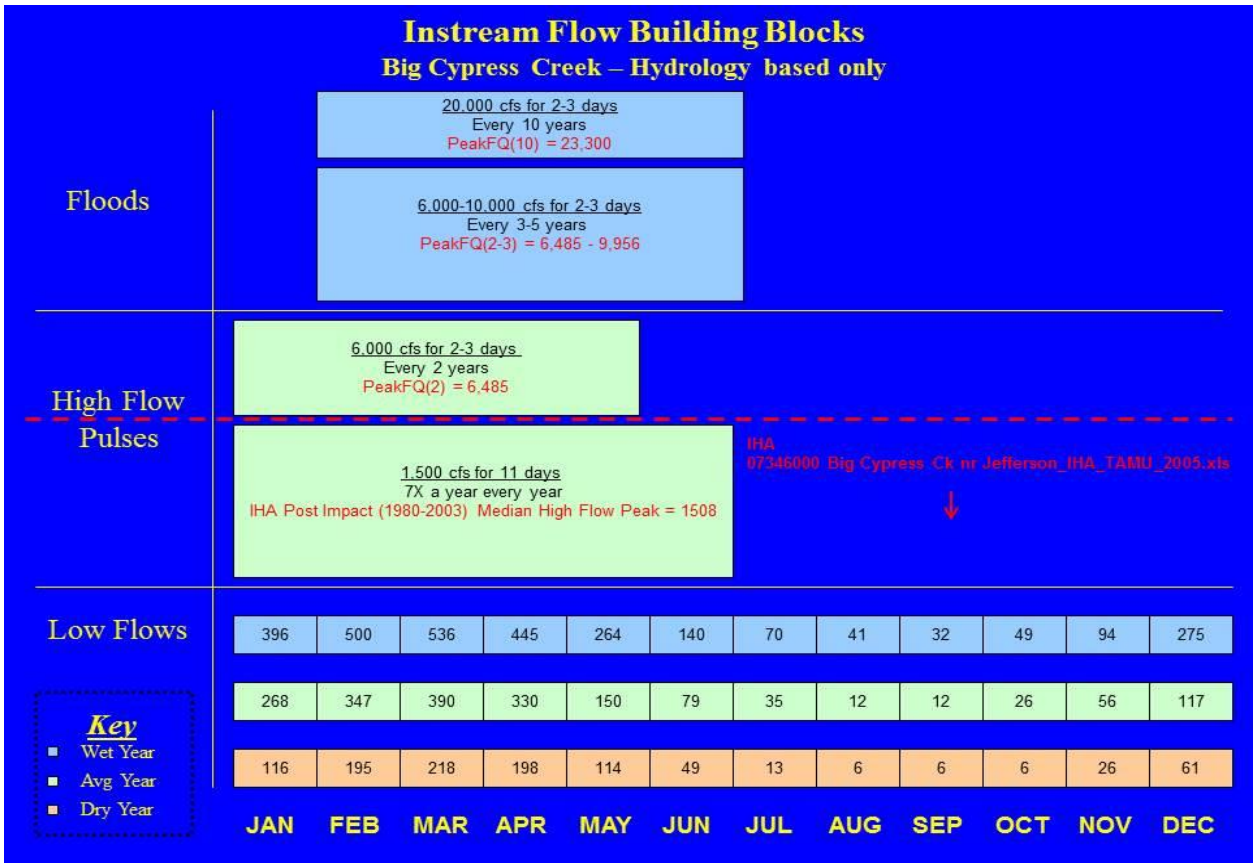


Figure 1. Initial Building Blocks for Big Cypress Bayou, May 2005. Statistics from hydrologic analysis only.

Most of the numeric values in Figure 2 come from calculations made using either the IHA software or a software tool developed by the USGS, called PeakFQWin, to calculate the flow rate of specified flood recurrence intervals. The values produced based solely on statistical analysis of historical hydrology are presented in Figure 3.

As can be seen by comparing Figure 3 with Figure 2 the preliminary low flow magnitudes were generally calculated using IHA with several months (Dry Year October – February, Average Year August - November) and modified based upon an overlay of fish habitat simulation modeling performed by the USFWS and USACE (Cloud 1984, USACE 1994).

The high pulse for December - June of 1500 cfs was based on post-dam, high-flow pulses. Workshop participants decided that the post-impact flow period was the appropriate period upon which to base the magnitude, but considered the pre impact period for the discussion on frequency and duration.

Based on analysis of pre-dam flow data, historical durations and frequencies of these high-flow events were somewhat larger than what is recommended by this matrix, however the participants in these discussions felt that fish and other mobile aquatic and amphibious organisms would be able to move into or out of secondary channels and oxbow lakes fairly quickly (e.g., during a single day) during these high-flow pulses. The duration of these events was set at 2 to 3 days to allow for some ramping time on the rising and falling limbs of these high-flow pulses. They also agreed that necessary sediment transport could also occur during these short pulses.

After some discussion about the fact that the median duration of high-flow pulses was 11 days during the pre-dam period, workshop participants agreed that the high-flow pulse duration deserved close attention during the implementation and adaptive management phase of the project. Similarly, because high-flow pulses occurred with a median frequency of 7 times per year in the pre-dam period, the number of pulses to be targeted should be closely examined.

The 6,000 cfs target for channel maintenance is based upon the assumption that the pre-dam, 2-year flood magnitude approximates the bankfull discharge level. It is well established in the geomorphic literature that the bankfull discharge is the level at which the majority of sediment transport occurs, and is, thus, a primary determinant of channel geometry. An accurate determination of the bankfull discharge level was identified as a top-priority research need. Based upon this research, the flow magnitude and necessary recurrence interval for this Building Block were later refined.

Somewhat less frequently (i.e., at 3-5 year intervals), a flow of 6,000-10,000 cfs would be needed to provide additional ecological benefits including riparian seed dispersal, maintenance of aquatic habitats in the floodplain, and maintenance of riparian vegetation diversity. Even less frequently (10 year intervals), a flood of 20,000 cfs would be needed to drive channel migration across the floodplain. '

Since the first flows workshop, the Building Blocks for Big Cypress have been refined based on additional data that had been collected and the environmental flow (overlays) analysis which considered other riverine science disciplines including water quality, ecology and geomorphology. Although the consensus has been to adopt the preliminary regimes, it is important to emphasize, as the preceding discussion points out, that some of these values had already been modified from a purely hydrologic analysis in considering the other riverine disciplines as part of the literature survey and summary report. Nonetheless, the subsequent additional flow analysis did result in the modification of several recommended flows.

In Figure 4, the values in red are those that were not calculated as part of the hydrologic analysis using IHA or PeakFQWin, but are refinements and adjustments to the Building Blocks based on the application of overlay analysis. Some of these adjustments were made in the development of the preliminary Building Blocks by considering the information presented in the literature survey, while others were modified based on the analysis that has been performed subsequently.

Regarding low flows, the workshop participants decided to adopt a slightly more conservative approach to ensure that for dry conditions in Big Cypress Bayou during July through September flows are adequate to protect water quality. The workshop participants decided to adopt the 7Q2 flow value developed by the state water quality standards and permitting system equal to 8.4 cfs for this segment of Big Cypress Bayou until additional data or analysis indicates another value should be used. This is higher than the low flow proposed in the original Building Block of 6 cfs. (Note the 7Q2 for this site has recently been

recalculated and in Procedures to Implement the Texas Surface Water Quality Standards the TCEQ reports the 7Q2 for this site at 18 cfs).

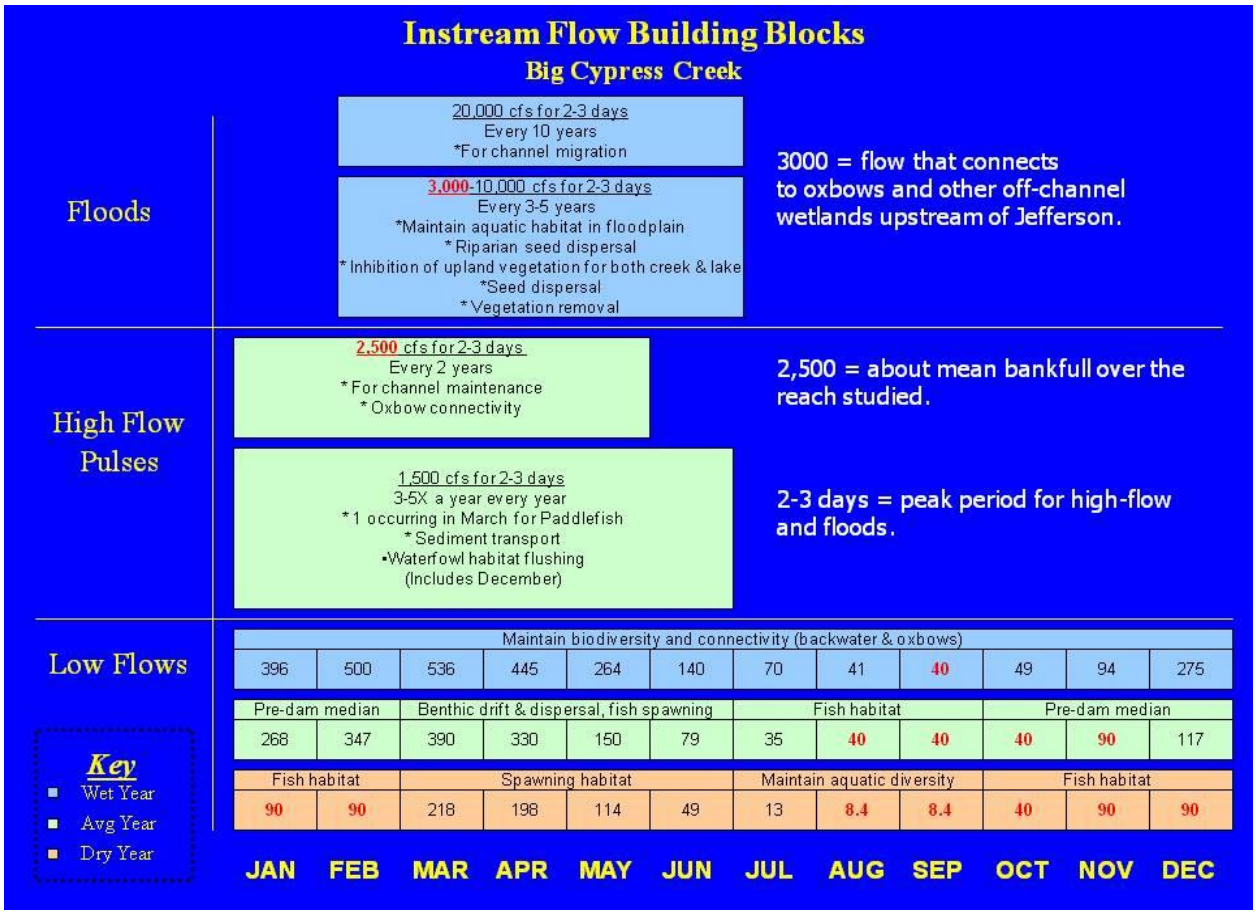


Figure 2. Big Cypress Bayou Flow Regime Recommendation.

A simple one-dimensional instream habitat analysis based on data collected in earlier instream flow studies was performed in preparation for the third flows workshop. Generally the workshop participants agreed that the results of this analysis confirmed the basic framework of developing a range of low-flow recommendations based primarily on historical pre-development flow records to provide variability in stream habitat conditions. Although the area of some habitat types would be relatively lower than others, this approach was assumed to be reflective of the natural habitat conditions of the stream, which the recommendations are intended to protect.

One conclusion from the analysis was that habitat in the lower reach of Big Cypress Bayou is less sensitive to changes in flow than in the upper reach. This is due to the fact that Big Cypress Bayou has been channelized and deepened downstream of Jefferson. While flow recommendations derived from a pre-development period of record appear to be supportive of ecological functions in river segments that have not experienced significant structural modifications (e.g. Big Cypress upstream of Jefferson and the unregulated tributaries), these flows may not be sufficient to restore this variability to a segment that has undergone significant structural modifications. The workshop participants agreed that this type of habitat evaluation is useful in providing insight into what the low-flow recommendations would produce, however there was also some reluctance to make adjustment to the Building Blocks based on biological data and habitat models that are 15 to 25 years old, without first providing a more recent validation of these results.

Fieldwork and other analysis were performed by USGS to evaluate the preliminary high-flow recommendations for Big Cypress Bayou. The analysis of observed high-flow releases from Lake O' the Pines by the USGS resulted in changes to the recommendation for pulse flows for Big Cypress Bayou. This analysis indicated that bankfull flows occur below 3,000 cfs. In addition, the flows needed for bankfull conditions in the upper reach (above Jefferson) are lower than the flows needed in

the lower reach (below Jefferson). While valuable wetland resources depend on overbank flows in the lower segment, it is clear that for the near future these events will be driven by inflows from the unregulated Black and Little Cypress Bayous. The workshop participants decided to change the larger high-flow pulse from 6,000 cfs to 2,500 cfs, to provide a good approximation of bankfull flow in the upper reach. The lower flood flow was then changed to a range from 3,000 to 10,000 cfs from the prior range of 6,000 to 10,000 cfs to reflect that there was good connectivity occurring at flows as low as 3,000 cfs.

At the fourth flows workshop, the results of a wetland inundation study were presented that suggested that high-flow pulses of magnitudes of 2,354 and 5,866 cfs are required to inundate 75% of the bald cypress swamp and flooded forest habitat types, respectively. Literature reports suggest that these habitat types should be inundated for approximately 2 months every year for the swamp habitat and 2 weeks every other year for the flooded forest habitat type. A review of historical data, however, revealed that flows of these magnitudes and for these durations occurred very rarely in the historical record. Since the role of the inundation is to keep the soil saturated for these durations, the extended inundations that were suggested by the review may not be needed to protect these forested areas. A better understanding of persistence of soil saturation after shorter duration pulses was identified as a high priority issue for the next round of study. No changes were made to the regime recommendation at this time.

A couple of issues are worth noting if one attempts to replicate the values calculated for Big Cypress. PeakFQWin program reports flows for a range of recurrence intervals do not include the 3-year recurrence interval. This figure was calculated in a spreadsheet using the same formulas as are used in the USGS program.

Also, the pre-impact period of record, used to make preliminary determinations for low flows, was 1924 through 1956; however, streamflow data on Big Cypress actually began on August 1, 1924. For the days from January 1 – July 31, 1924, the IHA software automatically filled in data for the missing dates using the flow on the first day in the record. This does not provide the correct data. The program could have either been run based on water year rather than calendar years (starting on October 1924) or it could have been started on January 1, 1925. The error results in an underestimation of the statistics for the months of January through July, however given that there were 33 years of data this error is not considered significant. Some further review may be needed in the future.

3.2 Caddo Lake

Caddo Lake received special attention because of its location at the bottom of the Cypress Basin. It also has been designated as a “Wetland of International Importance” under the Ramsar Convention, now signed by 160 nations. See Attachment 3

One outcome of the first workshop was an initial finding that management of flows in Big Cypress Bayou may not need to be adjusted to benefit Caddo Lake. This was based largely upon the fact that Big Cypress contributes only about one-third of the total inflow to Caddo Lake. The other two-thirds entering Caddo Lake comes from Black and Little Cypress Bayous and other tributaries that are currently largely unaffected by dams or diversions. These relatively natural inflows from other tributaries result in a considerable rise in lake levels during floods and can provide high flows to the lower end of Big Cypress Bayou and to Caddo sufficient to inundate many of the wetland areas above and around the lake.

The dam for Caddo Lake, which is a weir, is fixed with the lowest spillway at an elevation of 168.5 NGVD. Under present conditions, the lake level will drop below that elevation during low flows, but these reduced levels of the lake do not often exceed 2 feet.

The workshop participants recommended an evaluation of the option of installing an outlet that would allow lowering lake levels for a number of purposes, including nutrient management, cypress regeneration and invasive species control. (In 2010, the U.S. Army Corps of Engineers announced a plan to begin a study that would include the feasibility of replacing the weir with a dam that includes an outlet for lowering lake levels.)

The consensus was also that nutrient levels in Caddo Lake are contributing to the undesirable abundance of aquatic plants, phytoplankton blooms and conditions of low dissolved oxygen. Thus, the participants concluded that lake flushing could

more efficiently be accomplished by drawing down the lake and that any such nutrient removal effort should be carried out adaptively, using monitoring to inform decisions about the necessary design and duration of the Project.

Another potential benefit of lake lowering would be bald cypress regeneration in areas that presently do not dry sufficiently to allow seed germination and seedling recruitment. Such a drawdown might need to occur in at least two consecutive growing seasons for this goal, and, thus, could have significant impacts on use of the lake and the local economy.

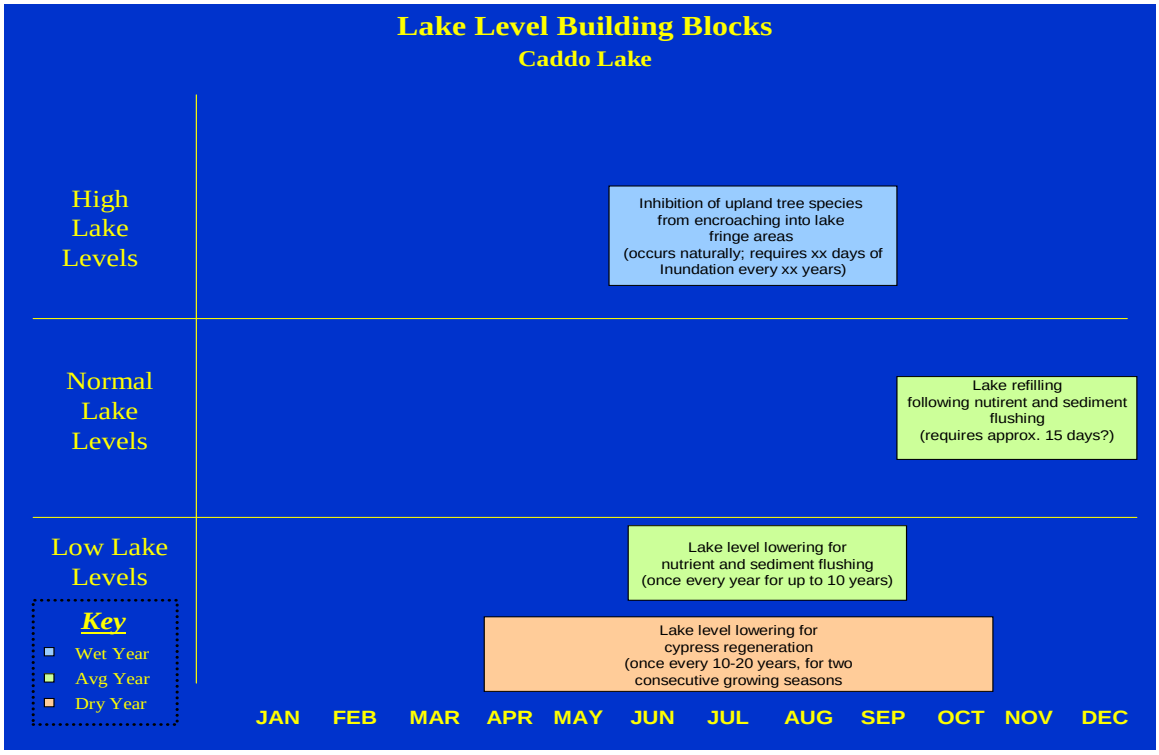


Figure 3. Initial Building Blocks for Caddo Lake, May 2005.

3.3 Little Cypress and Black Cypress Bayous

The second flows workshop held in October 2006 expanded the geographic scope of the work to include the other major gaged tributaries to Caddo Lake. There was a consensus that the Building Blocks for Black and Little Cypress could be developed by using the approach applied to Big Cypress Bayou. While the original summary report included data from the entire basin and could again be used to inform workshop participants' decisions, a supplemental report was prepared to include a hydrological analysis of the historical data from these tributary gages using the IHA software.

During the workshop, a proposal to designate of Black Cypress Bayou as an "untouchable" stream received significant discussion. The workshop participants then proposed setting a narrative flow regime on top of the Building Blocks that would assure adequate pulse and flood flows for the Bayou and to help protect Caddo Lake. The group felt that Black Cypress Bayou should remain in as pristine a state as possible to serve as: (1) a source of unregulated flows to Caddo Lake; (2) a reference state for other creeks; and (3) a refuge for biota. (In 2010, the North East Texas Regional Water Planning Group recommended that Black Cypress Bayou also be designated an Ecologically Unique Stream Segment, a designation that would prohibit state agencies from supporting the construction of any major dam on the segment.)

One breakout group also proposed that historically large flood events should also still occur on Little Cypress to maintain the wetlands associated with Caddo Lake; however, there was also a consensus that this segment does not require the same level of protection as was recommended for Black Cypress.

There was consensus on the use of the IHA-EFC 25th, 50th and 75th monthly low-flow percentile values as reasonable starting values for the low flows in Black and Little Cypress. There was also discussion of augmenting the IHA-derived

monthly percentiles with values developed in the Physical HABitat SIMulation (PHABSIM) study conducted by the USFWS (USFWS 1984). The recommended flow from PHABSIM for Black Cypress in September was 75 cfs while the monthly median flow was 3 cfs and for Little Cypress the PHABSIM study recommended a September flow of 75 cfs while the median was 11 cfs. Stipulating an August and September low flow of 75 (7 to 20 times greater than the median flow) would change the creeks from ones that frequently had intermittent flow during the dry season to ones that had consistent elevated low flows. Therefore, the flows suggested by that study were not adopted in the Building Blocks.

The workshop participants recognized that very low flows, specifically the 25th percentile flows for August through October, might result in a series of disconnected pools. Thus, in order to maintain the connectivity between pools, they proposed that the absolute minimum flows for Little and Black Cypress should not be less than 5 and 4 cfs, respectively.

While there was a consensus to follow the Big Cypress approach for the high-flow pulse target at the 2-year flood, there was again considerable discussion about what this flow represents, e.g., whether it reflected the bankfull flow or the effective discharge. Based on the USGS's preliminary analysis on Big Cypress, it was felt that the 2-year flood may overestimate the physical bankfull flow. Therefore, the lower bound on the 95th percentile confidence interval of the 1.5-year flood as calculated using PeakFQWin, which in Big Cypress was close to the bankfull observed by the USGS, was selected as a lower range and an upper range, to ensure that the water will get up steep banks in some areas.

A consensus was reached to develop Building Blocks for large floods in a manner similar to the approach used for the Building Block for Big Cypress. For Big Cypress, a Building Block for a large flood stipulated that a flood of 20,000 cfs (approximately 10-year recurrence interval) should occur once every ten years on average. Thus, for Little and Black Cypress, floods of approximately 13,000 and 8,000 cfs for 2 to 3 days every 10 years were proposed for late winter or spring.

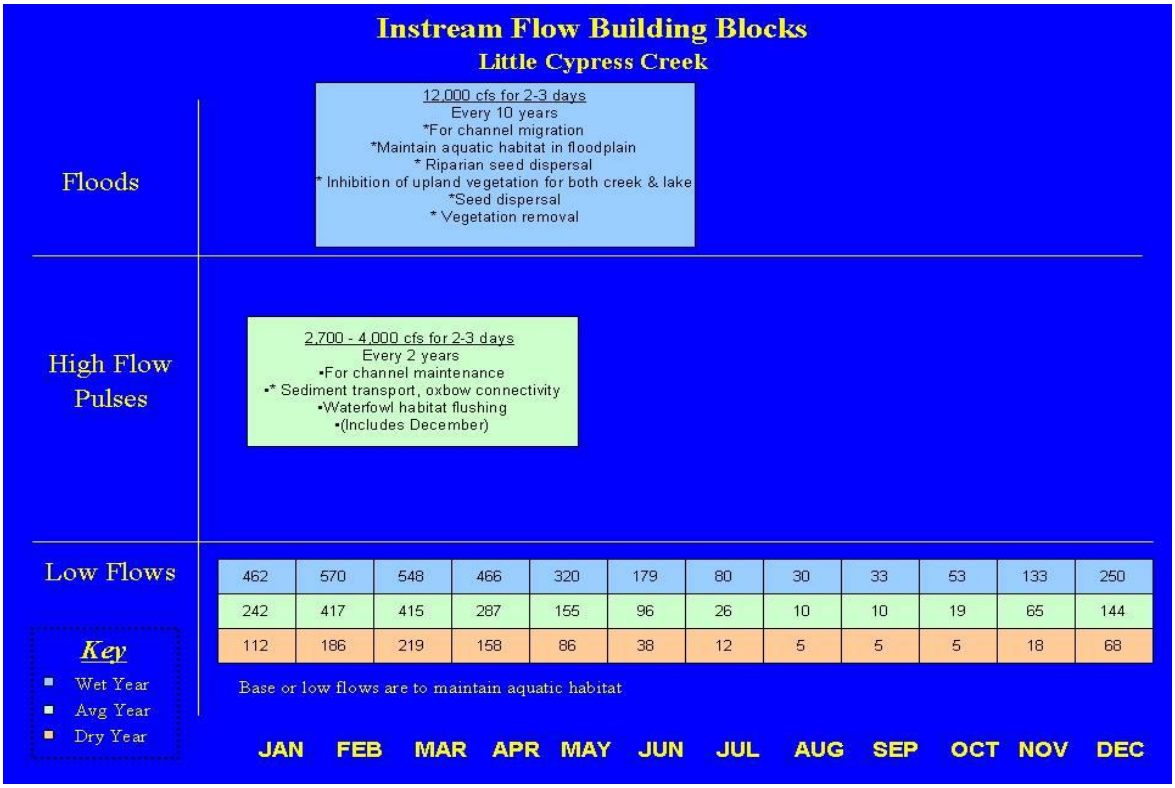


Figure 4. Initial Building Blocks for Little Cypress Bayou, October 2006.

The Building Blocks were originally developed in the 2006 workshop, and, since then, no changes have been made. Instead, the later workshops focused on how to develop the narrative flow regimes and standards in a way that would work with TCEQ's water rights systems. Discussions with TCEQ will continue. The narrative approach is discussed further below.

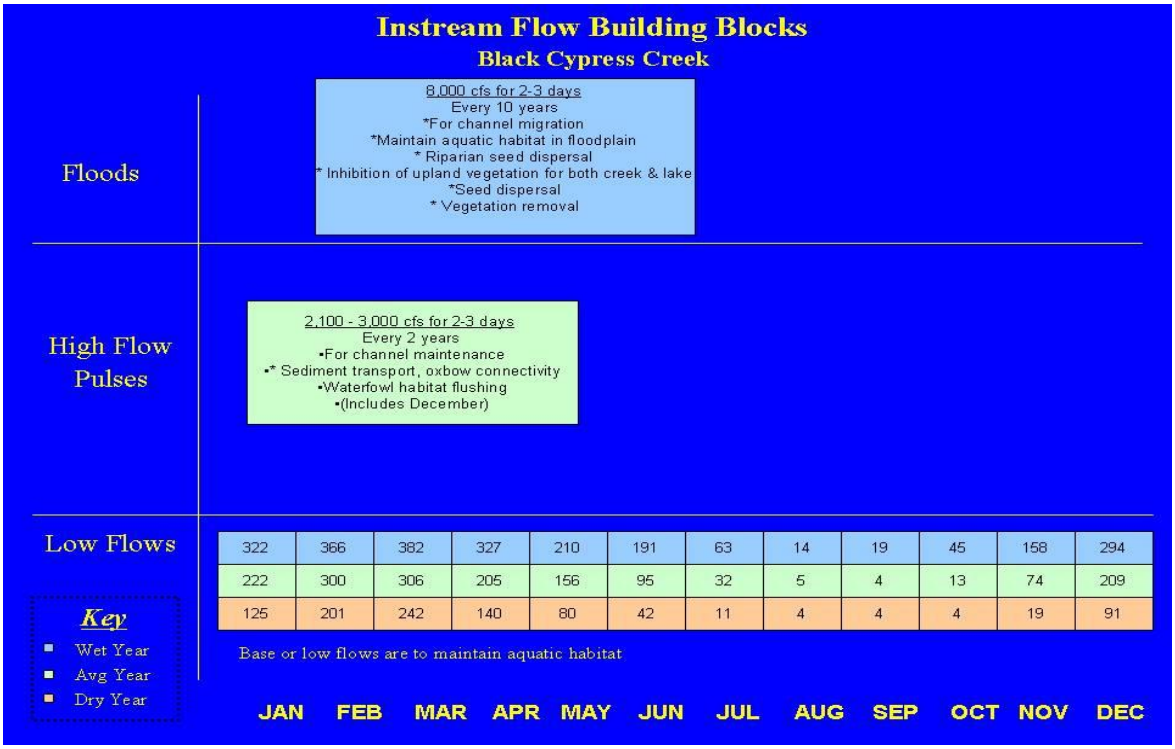


Figure 5. Initial Building Blocks for Black Cypress Bayou, October 2006.

2.4 Ungaged Tributaries

Concern was also raised about the lack of Building Blocks for James Bayou and a number of small streams in the basin. Because these streams do not have gages, it was agreed that the IHA approach used for Big, Little and Black Cypress Bayous could not be applied. Instead, the group agreed that flow regimes for these creeks should be based on the Building Blocks for Black Cypress Bayou with a proportional adjustment for the different sizes of the watersheds.

4 Other Issues

4.1 Attainment Frequencies

In addition to describing the flow magnitudes necessary to achieve desired ecological outcomes, any recommended flow regimes should also include the attainment frequencies at which the various flow components must be met. Although attainment targets were not explicitly defined in the first workshops, the guiding principal behind the project seemed clear; the best way to maintain a sound ecological environment is to mimic the natural flow pattern as closely as possible, including variability patterns (wet, dry and average years, seasonal) and associated duration and magnitude of flows. With that concept in mind, historical frequencies of the various recommendations were calculated as well as the predicted attainments under potential future flow scenarios. A discussion paper describing the process in determining attainment goals and the issues that need to be considered as part of this process was prepared and presented at the December 2008 flows workshop and it is included in Appendix D to the 2010 Environmental Flows Regime and Analysis Recommendation Report. Other reports, presented at the December 2008 workshop, extend further into the realm of implementation with an example of how the various flow conditions (dry, average and wet) could be triggered. Thus, a consensus was reached at the fourth flows workshop that attainment targets would seek to mimic natural attainment frequencies. These attainment frequencies differ by month as a result, in part, of the fact that some values were derived from IHA statistical analysis while some months include values based on results of other studies. Thus, the attainment frequencies should be used with the Building Blocks to complete the recommendations.

4.2 Narrative Standards

The concept of the narrative standards for the recommended environmental flow regimes for Black and Little Cypress Bayous had been discussed in the 2006 workshop, first by the scientists for the flow regime. That approach was then adopted by the stakeholders in the 2008 workshop and carried forward to the decision on the recommended environmental flow regimes in the 2011 workshop.

The confluences of Little and Black Cypress Bayou with Big Cypress Bayou are just upstream of Caddo Lake and high flows in Black and Little Cypress provide relatively high flows to the wetlands and the lake, even with the reduced flows from Big Cypress due to the existence of Lake O' the Pines. These high flows are needed for inundation of many of the wetland areas associated with Caddo Lake. Although no specific numbers or limitations were proposed by the workshop participants, a consensus was reached that a significant portion of the entire population of overbank flows, not just those at the specific magnitudes depicted in the Building Blocks, should be excluded from future diversions. Consistent with the resource values of the two tributaries, a greater level of protection was stipulated for the regionally least impacted stream, Black Cypress, than for the relatively more modified Little Cypress.

Several options exist for a quantitative approach for implementing these narrative standards based on riverine and wetland science. After the 2008 meeting, an example of an implementation approach was developed and it is provided in Appendix F to the 2010 Environmental Flows Regime and Analysis Recommendation Report.

At the 2011 workshop, the discussions of the narrative approach were reinforced by two proposals from work by the Northeast Texas Regional Water Planning Group. In its 2011 regional water plan, that Group had recommended that Black Cypress Bayou be designated as an Ecologically Unique Stream Segment and be off limits to the development of any significant reservoir. That supported the narrative approach for the pulse and flood flows for Black Cypress Bayou. The Group had also discussed a need to allow some additional appropriation of water from this river segment and proposed that no more than 1000 acre-feet of water per year be appropriated by the state in the Black Cypress watershed. A similar approach is proposed for the pulse and flood flows in the Little Cypress watershed, although more flexibility is proposed for new water rights under low-flow conditions. Thus, again most pulse and flood flows would be retained for wetland inundation and flows to Caddo Lake.

5 2015 Update

After the 2011 flows workshop, the Project has continued to focus on the four goals discussed above, but with much of the work targeted on demonstrating the value of the releases by the USACE and NETMWD from Lake O' the Pines to meet the recommended environmental flow regimes for Big Cypress Bayou. Work to determine the extent and value of inundation of wetland and other flood plain vegetation is one example discussed below. Likewise the experimental paddlefish reintroduction should provide some valuable new data.

Establishing a monitoring plan, collecting additional base line data and modeling impacts of the changed operations of Lake O' the Pines, both on the lake and downstream are also important steps that are under way. Details on much of the work described below are available at www.caddolakeinstitute.us/flows.html.

The major tasks that have been scheduled for the period of January 2012 through December 2016 involve monitoring, modeling, expanding partnerships, water policy and outreach and coordination. Examples of the work are provided below.

1. Monitoring

Extent of inundation by pulse flows created by releases from Lake O' the Pines.
Impacts on wetland and riparian vegetation along Big Cypress from the new release patterns from Lake O' the Pines.
Soil moisture and ground water along Big Cypress to determine frequency and level of pulse releases needed.
Tree rings to evaluate the historic impacts of Lake O' the Pines on wetland and other tree species.
Sediment movement to evaluate impacts of releases from Lake O' the Pines in general on sediment movement

and also on the sedimentation of new gravels bars constructed by the Corps of Engineers in 2009.
Paddlefish movement and habitat.
Bio-blitz for aquatic species in the Cypress River Basin to add to the baseline data needed for future monitoring.

2. Modeling

Impacts on Lake O' the Pines of the changes in release patterns and possible changes to storage in the Lake by USACE using its RiverWare for.
Habitat suitability for key species to determine benefits to habitats of restored base flows.

3. Expanding Partnerships

Develop long-term agreements with landowners providing access to monitoring sites along Caddo Lake and its tributaries.
Assist partner landowners with restoring and protecting riparian lands, including reconnecting wetlands and oxbow with new release flows from Lake O' the Pines.
Seek agreements with USGS-NWRC for long-term vegetation monitoring.
Seek agreements with USFWS and TPWD for long-term monitoring of aquatic species.

4. Water Policy

Work with the regional water planning group on inclusion of the recommended flow regimes as needs or goals in its 2016 regional plan.
Work with Texas agencies on a process to set aside water for the recommended flow regimes.
Coordinate water quality monitoring with Texas and Louisiana state agencies.

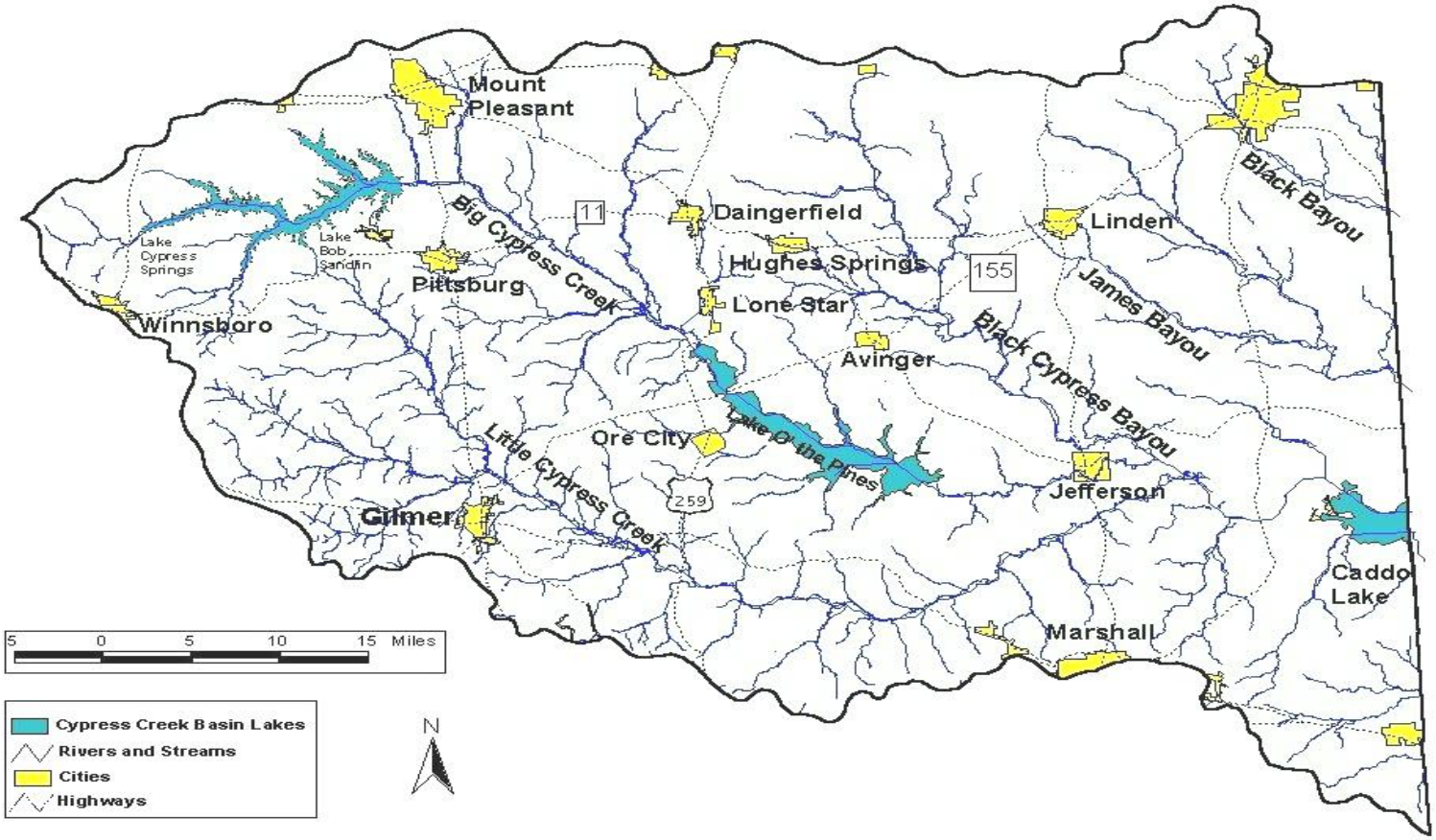
5. Outreach and Coordination

Science planning meetings to guide research and other work.
Periodic partners meetings for specific decisions on funding and coordination.
Outreach to local communities through meetings, press and other communications to advise them of developments, research, etc.
Plan for fifth multi-day flows workshop for reporting on work and for potential revisions of flow regimes and the long-term monitoring plans.

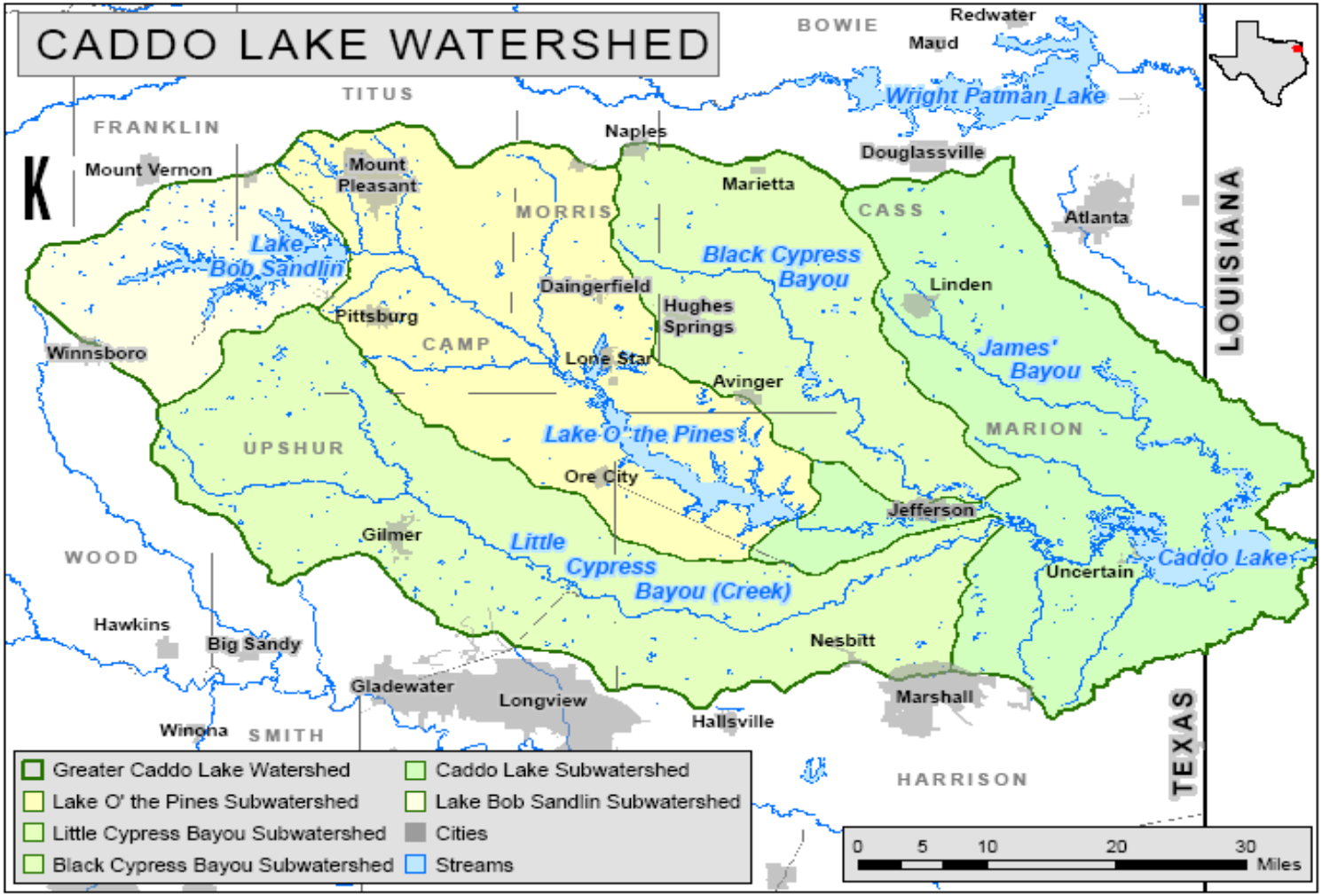
Attachments

1. Map of the Cypress River Basin in Texas
2. Map of the Caddo Lake Watershed
3. Map of Caddo Lake Watershed Designated as Ramsar Wetlands of International Importance
4. Lists of Major Participating Organizations and Individual Participants
5. Time Table for Major Activities
6. Lake O' the Pines and the Changes in Flows with Construction of the Dam
7 Key Provisions of Senate Bill 3
8. Dam and Impoundment Statistics for Caddo Lake
9. Lake O' the Pines Operating Rule Curve

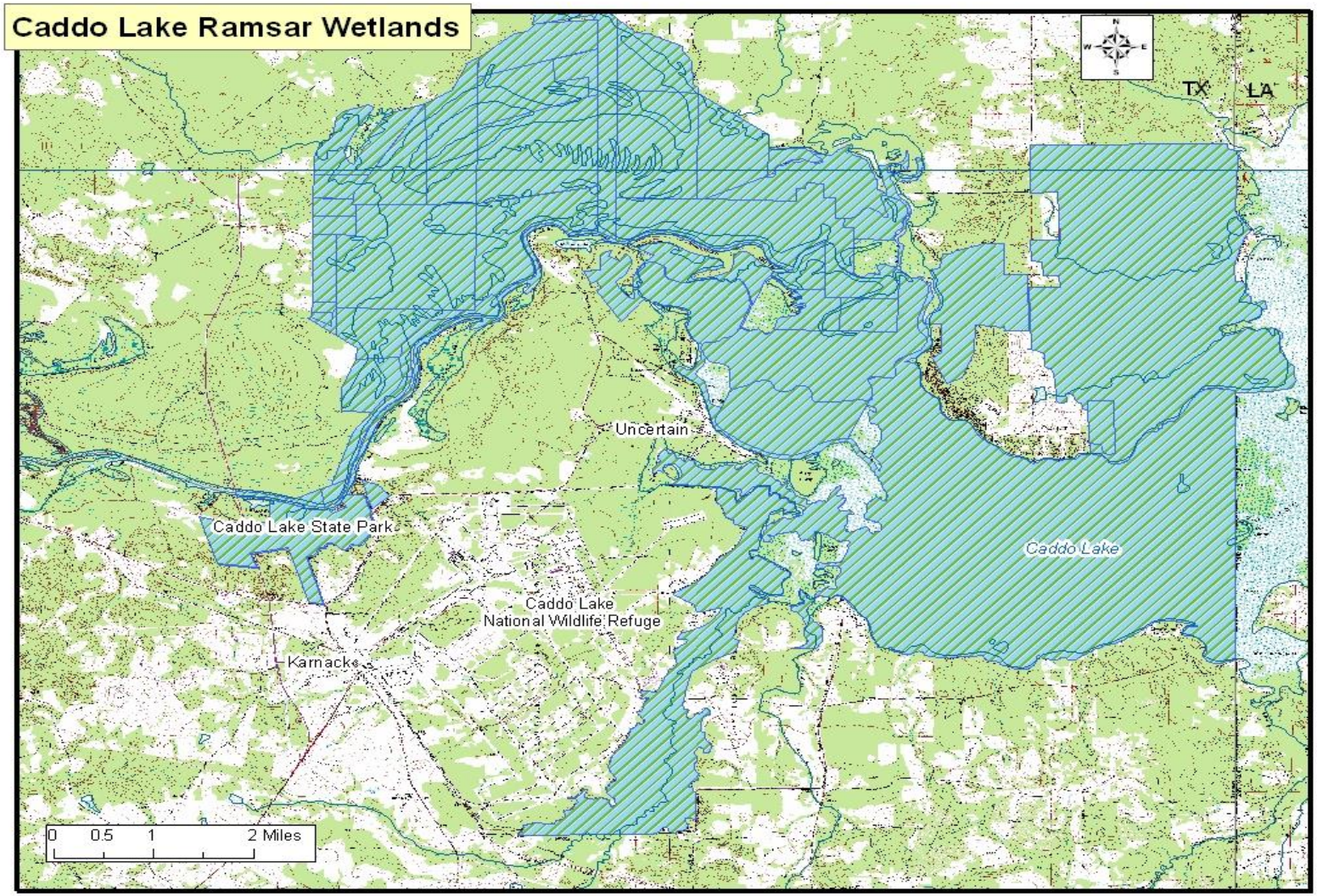
Attachment 1. Cypress Basin



Attachment 2. Caddo Lake Watershed



Attachment 3 Ramsar Designation for Caddo Lake



Attachment 4

Major Participating Organizations

There have been approximately 200 individual participants. The major organizations that have sent representatives to the multiday workshops are listed below.

Federal Agencies

- U.S. Army Corps of Engineers
  - Fort Worth District
  - Vicksburg District
- U.S. Fish and Wildlife Service
  - Wildlife Without Borders Program
  - Fisheries & Aquatic Resource Center
- U.S. Geological Survey
  - Texas Water Science Center
  - National Wetlands Research Center

State Agencies

- La Depart. of Environmental Quality
- La Depart. Of Natural Resources
- La Depart. of Wildlife & Fisheries
- Tx Comm. on Environmental Quality
- Tx Parks & Wildlife Depart.
- Tx State Soil & Water Cons. Board
- Tx Water Development Board

Regional and Local Governments

- City of Longview
- City of Marshall
- City of Uncertain
- Cypress Valley Navigation District
- Harrison County
- North East Texas Municipal Water District

Universities

- East Texas Baptist University
- Louisiana State University – Shreveport
- Stephen F. Austin State University
- Texas A&M University
- Texas A&M Water Resources Institute
- Texas Christian University
- Texas State University
- Texas Tech University
- University of Texas – Tyler

Other Organizations

- American Ecology, Inc.
- American Electric Power
- Caddo Lake Institute
- Collins Academy
- Ducks Unlimited
- Environmental Defense Fund
- Espey Consultants
- Greater Caddo Lake Assn. of Texas
- HDR Engineering, Inc.
- National Wildlife Federation
- Nature Conservancy of Louisiana
- Nature Conservancy of Texas
- Red River Valley Association
- Texas Conservation Alliance
- TXU/Luminant

Attachment 5

Time Table for Major Activities

December 2004: Orientation Meeting. (~60 Scientists and Stakeholders)

April 2005: Texas A&M Summary Report on Past Scientific Studies.

May 2005: First Project Workshop. (~90 Scientists and Stakeholders)

Fall 2005 – Fall 2008: Research & Filling Data Gaps: Field Work and Other Research.

April & May 2006: Science Planning Meetings – At Caddo and Austin to Guide Research.

September 2006: Hydrology Update. Expansion & Update of Texas A&M Summary Report.

October 2006: Historic Trends in Fish Community, Cypress Basin**.** Texas State University.

October 2006: Second Project Workshop. (~80 Scientists and Stakeholders) Also Served as the First Hydrology Workgroup Meeting for the Parallel State Sponsored Caddo Lake Watershed Protection Planning Process.

May & June 2007: Science Planning Meetings – Two (at Caddo and Austin) to Guide Research.

July 2008: Science Planning Meeting – In Austin to Guide Research.

December 2008: Third Project Workshop. (~ 75 Scientist and Stakeholders) Also Served as the Second Hydrology Workgroup Meeting for the Parallel State Sponsored Caddo Lake Watershed Protection Planning Process.

January 2009: Science Planning Meeting – In Austin to Guide Research for Fourth Project Workshop and Adaptive Management.

January & May 2010: Science Planning Meetings – In Austin to Guide Research on Indicators of Success and for Fourth Project Workshop and Adaptive Management.

Fall 2011: Fourth Project Workshop. (~ 60 Scientist and Stakeholders).

Fall 2012: Fourth Project Workshop. – In Jefferson to Guide Work on Monitoring Plans and Lake O' The Pines Operations.

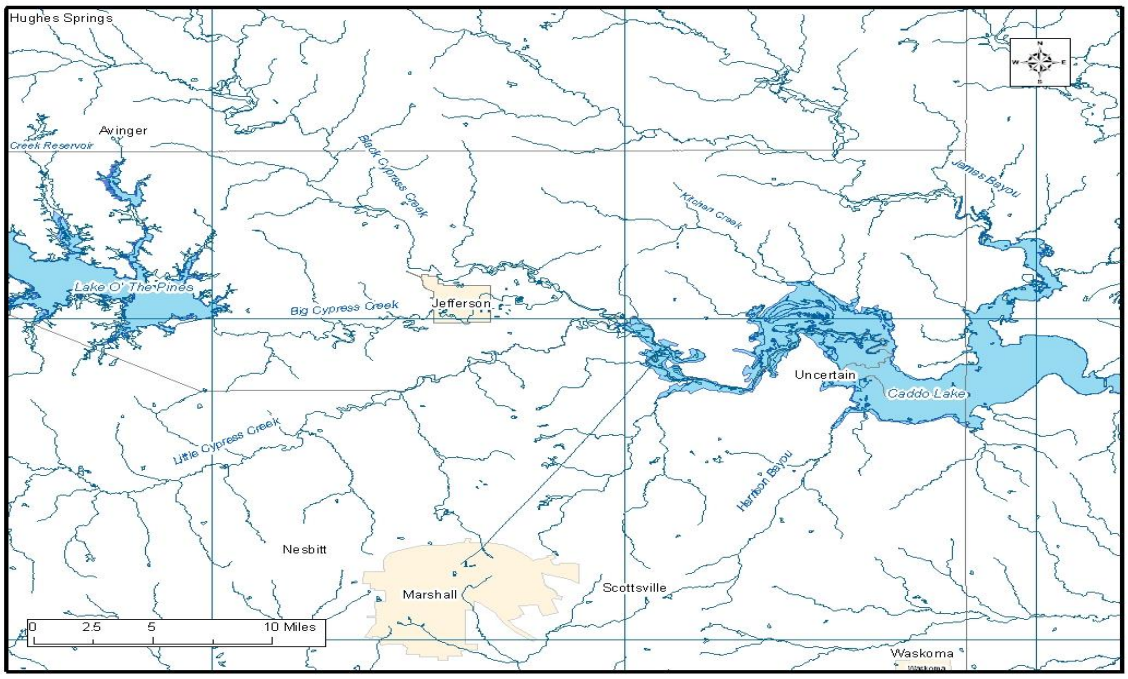
Summer 2013: Installation of Monitoring Areas with Soil Moisture Monitors, Water Wells and Surveys of Vegetation on Three Properties Along Big Cypress Bayou.

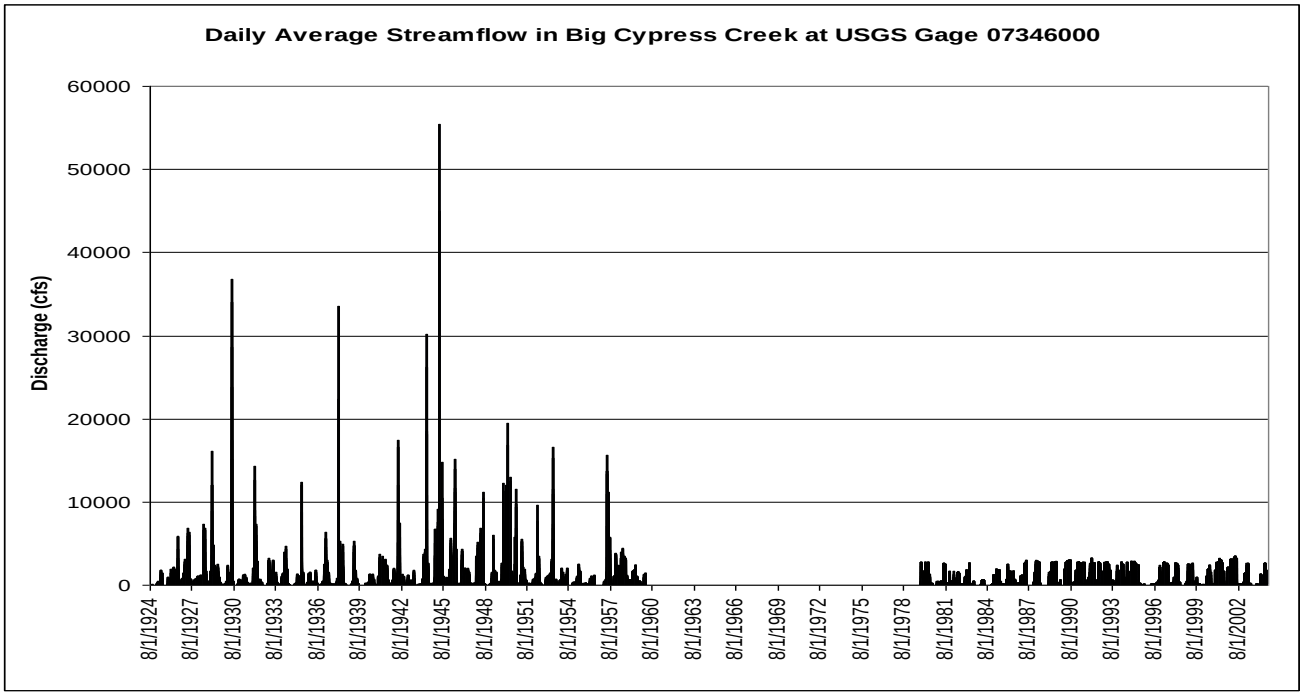
March 2014: Experimental Reintroduction of Paddlefish to Big Cypress Bayou and Caddo Lake.

Fall 2014: Cypress Bayou Basin BioBlitz – Collection of Fish and Other Aquatic Species in the Basin.

Fall 2016: Schedule for Fifth Project Workshop.

Attachment 6: Lake O' the Pines and the Changes in Flows with Construction of the Dam





The range of flows changed significantly with the construction of the dam. Before the dam was built in 1959, flow in Big Cypress Creek above Caddo Lake ranged as high as 57,000 cfs. The maximum release now from the dam to Big Cypress is 3000 cfs. Thus, the variation of flows and the inundation of wetlands along Big Cypress and in Caddo Lake are limited by the construction of the dam. Current law requires only a 5 cfs release from the dam, although NETMWD has generally provided greater releases. There was no gaged information for 1960 to 1980.

Attachment 7 **KEY PROVISIONS OF SB 3**

Definitions

(15) **Environmental flow analysis** means the application of a scientifically derived process for predicting the response of an ecosystem to changes in instream flows or freshwater inflows.

(16) **Environmental flow regime** means a schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies.

(17) **Environmental flow standards** must consist of a schedule of flow quantities, reflecting seasonal and yearly fluctuations that may vary geographically by specific location….

Goals: The [TCEQ] by rule shall:

1) adopt appropriate environmental flow standards … that are adequate to support a sound ecological environment, to the maximum extent reasonable considering other public interests and other relevant factors;

(2) establish an amount of unappropriated water, if available, to be **set aside** to satisfy the environmental flow standards to the maximum extent reasonable when considering human water needs….

Methodology:

Each … expert science team shall develop environmental flow analyses and a recommended environmental flow regime for the river basin … through a collaborative process designed to achieve a consensus. In developing the analyses and recommendations, the science team must consider all reasonably available science, without regard to the need for the water for other uses…

Each … stakeholders committee shall review the environmental flow analyses and environmental flow regime recommendations submitted by the … expert science team and shall consider them in conjunction with other factors, including the present and future needs for water for other uses …

The … stakeholders committee and the advisory group may not change the environmental flow analyses or environmental flow regime recommendations of the … expert science team.

The … stakeholders committee shall develop recommendations regarding environmental flow standards and strategies to meet the environmental flow standards and submit those recommendations to [TCEQ.]

For River Basins Not Scheduled for the Environmental Flow Process

...in a river basin and bay system for which the [state environmental flows] advisory group has not yet established a schedule for the development of environmental flow regime recommendations and the adoption of environmental flow standards, an effort to develop information on environmental flow needs and ways in which those needs can be met by a voluntary consensus-building process (as this Project is doing for the Cypress watershed).

Attachment 8

DAM AND IMPOUNDMENT STATISTICS FOR CADDO LAKE*

– LOCATION –

On Cypress Bayou in Caddo Parish, Louisiana 19 Miles Northwest of Shreveport, Louisiana. The Lake Extends into Harrison and Marion Counties, Texas.

– DRAINAGE AREA –

2,700 Square Miles (Includes Drainage Area of Lake O' The Pines).

– DAM –

Type ..... Earthfill and Concrete Spillway

Maximum Height ..... 36 Ft.

Top Width ..... 30 Ft.

– SPILLWAY –

Type..... Floodwall (Broad-Crested Wier)

Control ..... None.

– AUTHORIZATION –

Federal ..... Flood Control Act of October 27, 1965

– RESERVOIR DATA –

(Data From U. S. Army Corps of Engineers, New Orleans District)

Feature	Feet Above M.S.L.	Acre Feet	Acres
Top of Dam	**176.0**	**391,400**	**43,000**
Spillway High Section	**170.5**	**186,600**	**31,000**
Spillway Low Section	**168.5**	**129,000**	**26,800**
Dead Storage	**168.0**	**69,200**	**20,700**
Usable Storage	**–**	**59,800**	**–**

– GENERAL –

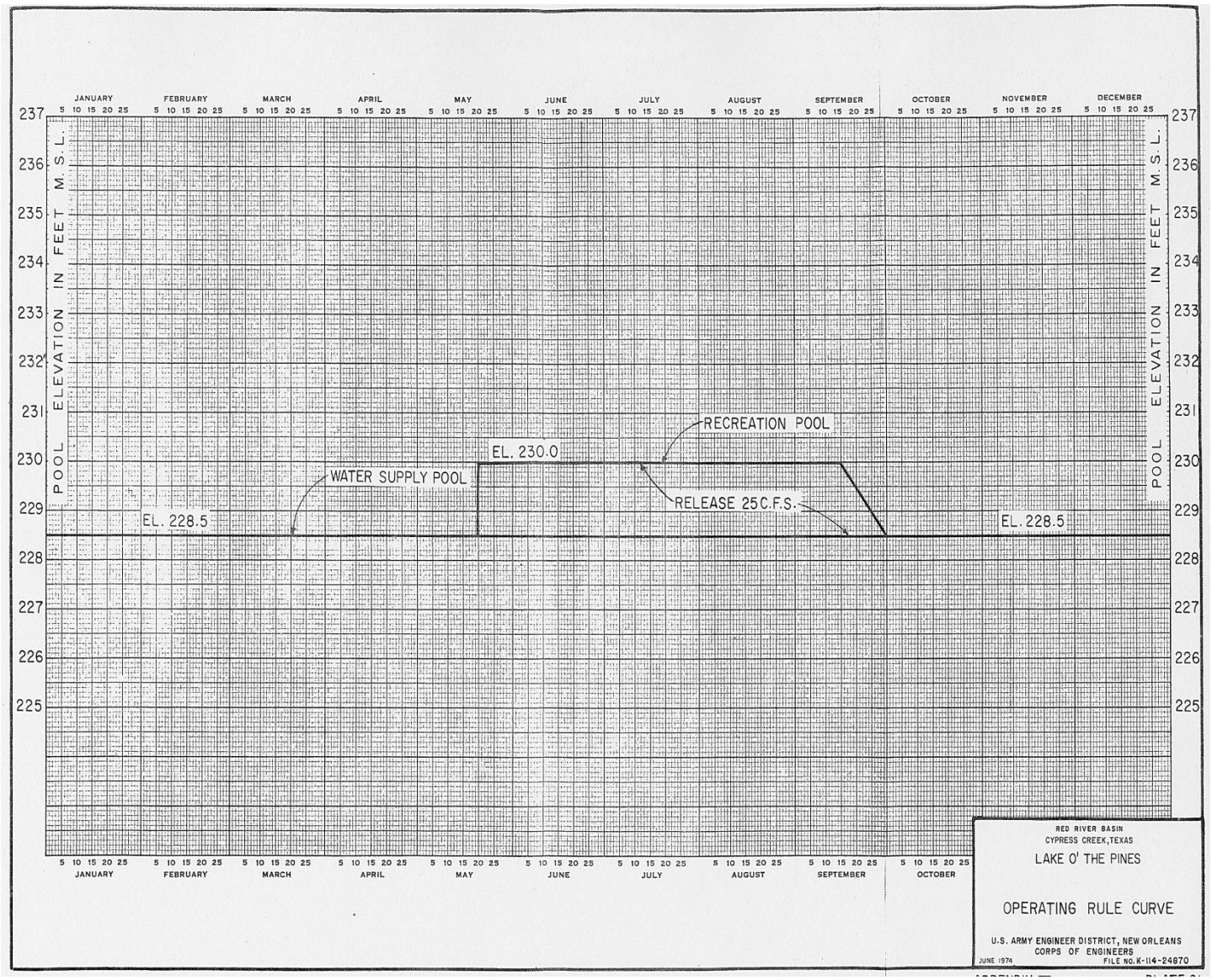
Construction Started ..... August 7, 1968

Dam Completed ..... June 18, 1971

Impoundment of Water Began 1914

*Source: Caddo Lake Contoured Depth Topo Map, A.I.D., Associates, Inc./Publishers, 1993

Attachment 9



ACKNOWLEGEMENTS

The Sponsors of the Project, including the Caddo Lake Institute, the Nature Conservancy and the U.S. Army Corps of Engineers wish to acknowledge and thank all those who have participated in the Project.

Over 200 scientists and stakeholders have participated in multi-day workshops and other meetings of the Project starting in 2004. A list of some of the major participants is provided in Attachment 4. A complete list of participants for each meeting can be found with information on the workshops and other meetings on CLI's website at www.caddolakeinstitute.us/flows.html.

The work of this project has been supported by the volunteer time of many of the participants and funding from a wide range of sources, including foundations, federal and state agencies and individuals.

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