LOUISIANA DEPARTMENT OF
CONSERVATION AND ENERGY

OPEN-LOOP VS. CLOSED-LOOP COOLING
FOR DATA CENTERS

Open-Loop Cooling (Cooling Towers)

- Warm water from servers is cooled by direct contact with air, causing evaporation.
- This method is widely used in large data centers because evaporation removes heat very efficiently. However, evaporation means continuous water consumption.

Closed-Loop Cooling (Sealed Liquid Circuits)

- Water or coolant circulates in sealed pipes or coils, never being exposed to air.
- Heat is removed at the server and then rejected through a secondary loop.

Open-Loop vs. Closed-Loop Cooling Comparison

Type of Cooling	Water Use	Energy Efficiency	Contamination & Reliability	Infrastructure Complexity
Open-Loop	High water consumption due to evaporation.	Energy-efficient because evaporation removes heat with low electrical input.	Water is exposed to air – requires filtration, chemical treatment, and monitoring for biological growth.	Requires cooling towers, water treatment systems, and large-scale plumbing.
Closed-Loop	Minimal water loss; water stays inside sealed circuits.	Less energy-efficient because heat must pass through a heat exchanger.	Sealed system – no airborne contamination, more stable water chemistry, and reduced maintenance.	Requires pumps, heat exchangers, and sometimes a secondary tower or dry cooler.

THREATS TO CADDO LAKE WETLANDS

CHANGES WILL OCCUR

Over the last 400 years, the wetlands at Caddo Lake have changed slowly at times and dramatically at other times. Some changes were natural and some man-made, and changes will continue. In the future, growing demands for water, invasive species, and pollution could be the most significant of the man-made changes threatening the health of the Caddo Lake wetlands. The good news is that there are ways to reduce these threats.

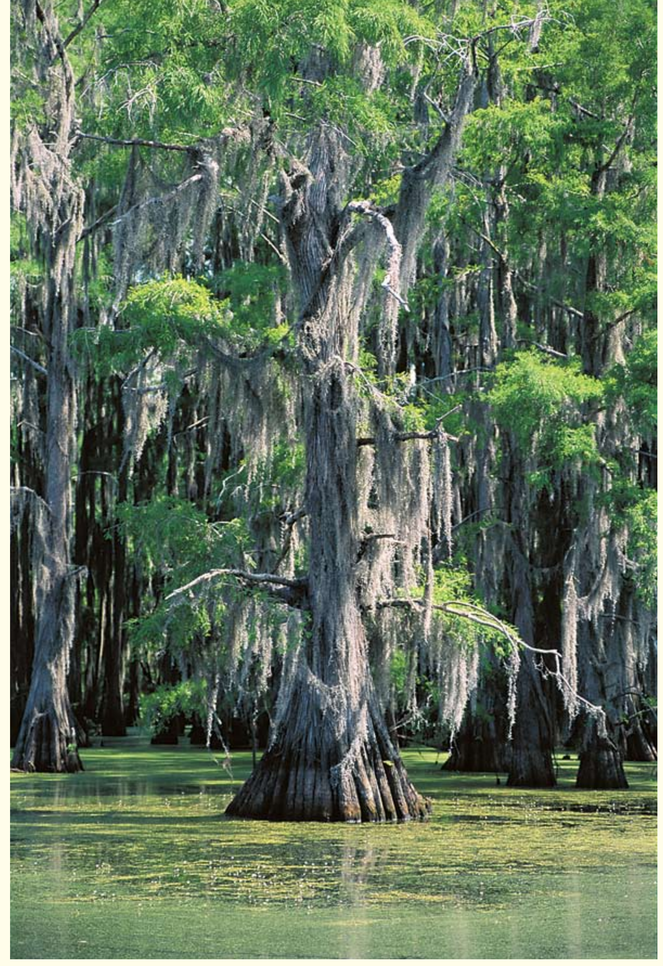
PAST CHANGES AND IMPACTS

A great log jam on the Red River apparently created the first large lake. In doing so it both flooded thousands of acres of existing wetlands and created thousands of acres of new wetlands. When the raft was removed in the 1800s, lake levels dropped, again changing the areas of wetlands dramatically. Then, when a dam was added in the early 1900s, many wetlands were again flooded and new wetlands were created.

These changes affected the vegetation and wildlife. For example, there are few young cypress trees at Caddo Lake. There are 400 year old cypress trees which likely started their life before the great raft.

There are also 100 year old cypress trees, which germinated after the raft was pulled but before the dam was added. There are plenty of cypress seeds, but cypress trees cannot sprout and survive in water. They need dry conditions for months to survive in their early stages. They do not get such conditions in a relatively constant level lake.

More recently, invasive species have limited cypress regeneration. Nutria will eat young trees and Chinese tallow trees will shade them out, even in wetland areas that do dry periodically.

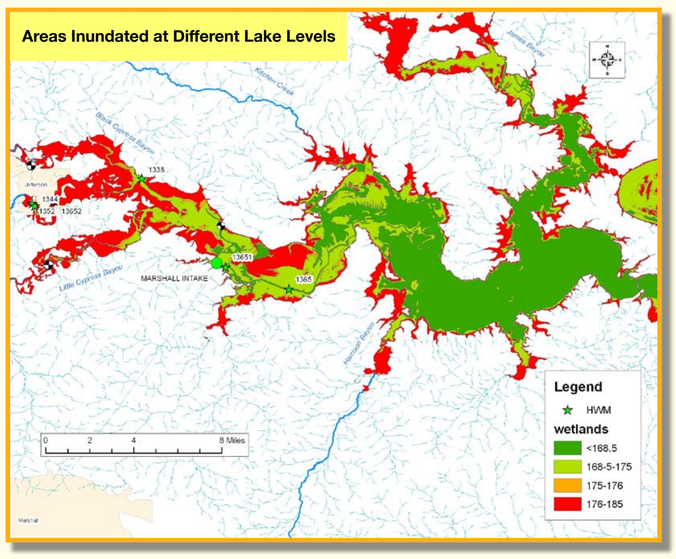


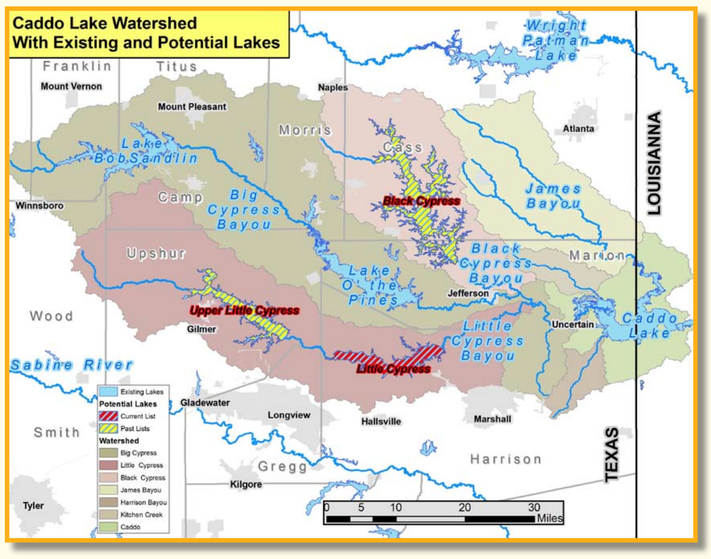
REDUCTIONS IN FLOOD AND LAKE LEVELS

Many of the wetlands that currently surround Caddo Lake are above normal lake levels. They need periodic inundation to survive. Upstream dams or large diversions of water from Caddo can reduce the water levels needed for such flooding.

While some of the wetlands at Caddo have been affected by the existing dams, most remain healthy today because Little Cypress, Black Cypress and James Bayous do not have significant dams. They can provide natural flood flows that refresh the wetlands.

There are also no significant diversions of water from Caddo Lake. In the past, dams were proposed for Little Cypress and Black Cypress Bayous and large diversions of water from Caddo were considered. Luckily, none of these proposals seem likely in the near future.





WHAT YOU CAN DO

Water conservation is one key to reducing the need for more dams and diversions. You can also join with others working in public meetings to protect the natural "instream flows" to the wetlands of Caddo Lake for the long-term.

INVASIVE SPECIES

The wetlands at Caddo Lake, like most around the world, are at risk from invasive plants and animals.

Some invasive species, such as Chinese tallow, were brought here on purpose. Others are here because they were carried unintentionally to the U.S. from their native countries. With few predators or natural controls here, many invasive species have spread and now threaten the wetlands at Caddo Lake.

Giant Salvinia was first found in Caddo Lake in 2006. It now creates problems for fishing and boating in many parts of the Lake. You will see signs warning of this problem at boat ramps.

WHAT YOU CAN DO Learn to identify invasive species and the problems they create. Avoid buying, planting or using invasive plants. Clean your boat and trailer of all plants before leaving a boat ramp.

POLLUTION

One of the most important services wetlands provide is maintaining water quality by filtering out pollutants. While there are a number of pollutants that are a threat to the Caddo wetlands, mercury is getting most of the attention. It is found naturally in some soils, and, in small amounts, is not a problem for wetlands systems. In larger amounts, however, it can be toxic.

The levels of mercury in certain fish at Caddo not only threaten the health of those fish but also the health of people who eat those fish, especially children. Thus, the state of Texas has posted fish consumption warning signs around Caddo Lake.

Many man-made sources of mercury can contribute to the high levels in fish at Caddo, including coal-fired power plants, improperly managed meters at natural gas wells, switches from older cars, and household mercury thermometers.

WHAT YOU CAN DO Proper disposal of old pesticides, unused paints, motor oil, batteries and other wastes will reduce mercury and other pollutants. Report improper dumping of wastes or other polluting activities. In Texas call (800) 832-8224 or (512) 239-2507. In Louisiana call (888) 763-5424 or (225) 219-3640.

"Context and Introduction to Hydrology Modelling to Address In-Basin Needs and Potential Out-of-Basin Transfers of Water in the Cypress Basin,"
- Caddo Lake Institute, October 2025

Caddo Lake Institute and partners have appreciated our 20-year partnership with Northeast Texas Municipal Water District to manage water resources in the Cypress Basin for the benefit of people and ecosystems. While the region is facing new challenges and opportunities, we hope to continue this partnership for many years to come. This document provides a synopsis of the background of the flows work and its benefits and lays out the context for and conclusions of our modeling analysis (attached) examining the potential for both ongoing flows implementation and potential lease of water from the Cypress basin.

OVERVIEW: The Caddo Lake Institute's (CLI) mission is to maintain and restore a functioning hydrology, river corridor, and wetland system that can support diversity consistent with the natural habitat of the region; this natural resource will then support the cultural and economic integrity of the region. To protect the Caddo Lake watershed, many partners and projects have been undertaken over the past 30 years. The keystone project that maintains and restores multiple types of habitats and improves multiple issues across a large area is the "Flows Project." "Flows" are releases of water, at the right time and in the right amount to support natural processes downstream of Lake O' the Pines (LOTP.) Nationally, the project was begun by (and continues to operate under) The Nature Conservancy and the United States Corps of Engineers as part of the National Sustainable Rivers Program.

The key local partners are Northeast Texas Municipal Water District (NETMWD), Texas Parks and Wildlife Department (TPWD), the United States Army Corps of Engineers (USACE), The Nature Conservancy in Texas, and many others. The project was necessary because when water rights were granted to Northeast Texas Municipal Water District after the damming up of Big Cypress Bayou above Caddo Lake to create LOTP, no water was required to be set aside for downstream flows, as would be required now. And the project has been possible because not all of the water in the basin is being sold. As pressures on

water supplies in Texas are growing and the DFW area/North Texas Municipal Water District expressed interest in purchasing unsold water out of LOTP, CLI needed to determine the potential impacts of this on the Flows Project and the functional health of Caddo Lake and the communities it supports. To determine impacts of the sale of the amount of water DFW sought on the flows project, Hazen and Sawyer (formerly Aquastrategies) hydrologists were contracted to examine the issue. The Water Availability Model Memo from Hazen and Sawyer attached ("HS Hydrology Memo") has been reviewed by other key contractors for CLI and presented in part at the most recent Flows Conference in March 2025.

The simplest way to describe the Flows Project is releasing the right amount of water at the right time to improve and maintain downstream habitat. The Flows Project uses scientifically validated releases within the ability of the dam to mimic mother nature, with pulses in the Spring that scour sediment, signal fish to spawn, and bring water to the bottomland hardwoods to keep them viable.

The Flows Project has always been collaborative and CLI hopes it will continue to be. CLI seeks to identify an agreed-upon path forward that can meet the needs of NETMWD and local communities, and the integrity of Big Cypress Bayou and Caddo Lake for the long-term. This balanced approach has been at the heart of the Flows Project for decades. **We hope these efforts will help form the basis of a collaborative effort with NETMWD for jointly moving forward to refine this modeling *before* key decisions are made, including by developing additional scenarios to be modeled, and to identify an agreed-upon, formal approach for protecting water in and downstream flows for Big Cypress Bayou, LOTP, and Caddo Lake. We believe this type of collaborative approach would, in addition to being cost-effective, be in the best interests of the whole basin.**

NEED FOR THE FLOWS PROJECT AND RELEASES OF WATER FOR DOWNSTREAM:

Participants in the Flows Project (who first met two decades ago) were aware of the downstream impacts on the Big Cypress Creek and Caddo Lake system that occurred when the dam was built to create LOTP. Because the Big Cypress Bayou and Caddo Lake were not thriving, key partners recognized the need for and importance of water flows through the basin and initiated the Flows Project.

Below are examples from Flow Project partners that independently describe the consequences of inadequate water flows through the system:

From the USACE:

> USACE/ Cypress Valley Watershed Texas, April 2017 – "Problems and Opportunities: The problems in the watershed include both the loss of structure

and function of riparian, aquatic, lacustrine, and floodplain habitats caused by the creation of two upstream reservoirs, Bob Sandlin Lake and Lake O' the Pines (a Corps of Engineers reservoir.) Construction of these lakes drastically altered the natural hydrology, including reducing the magnitude, frequency, and duration of flows below the dams, specifically in Big Cypress Bayou and Caddo Lake. In response to the flow changes, the dynamics of the ecosystem changed both directly and indirectly. Direct changes include the reduction of bottomland hardwood dominated forests and frequently flooded backwater areas, and limited regeneration of bald cypress, which has caused adverse impacts on both the riparian and aquatic flora and fauna throughout the watershed. Indirect changes that occurred include: an overall decrease of the biodiversity, nutrient loading, localized flooding, increased erosion, increased channel degradation, and an influx of aquatic invasive species resulting in reduction of quality and quantity of riparian and aquatic habitat. Construction of the reservoirs also significantly impacted migration of various fish species throughout the watershed.

From Texas A&M University:

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:
https://www.conservationgateway.org/Documents/Caddo_Summary_Rpt.pdf

The major disruption of natural flows into Caddo Lake is caused by the presence of Lake O' the Pines on Big Cypress Creek, upstream from Caddo Lake. The Lake O' the Pines reservoir was completed in late 1959 and has dramatically altered the flow regime of Big Cypress Creek. …

Many water quality parameters, such as dissolved oxygen and pH, become problematic during periods of low flow. Rampant growth of macrophytes [aquatic plants] in the upper reaches of Caddo Lake are problematic in that decay of this accumulated biomass also leads to conditions of low dissolved oxygen and may fuel summer phytoplankton [algae] blooms. …

Lower inflows will not flush nutrients from Caddo Lake as quickly as higher inflows. For the same reasons mentioned above, intermediate and low flows will be more effective at flushing nutrients from the system during the summer months. Low inflows would likely have very little impact on alleviating potential problems associated with low dissolved oxygen and pH. In other words, during conditions of low inflow Caddo Lake will likely be plagued by periodic conditions of poor water quality. …

> Perhaps the most notable current fishery problem in the basin is the occurrence of periodic fish kills in the upper reaches of Caddo Lake during the late summer and early fall period when warm water temperatures and decomposition of aquatic macrophytes causes aquatic hypoxia. …
>
> Although it provides about a third of the total inflow to Caddo Lake, flow regulation in Big Cypress Bayou probably has major effects on the lake ecosystem. …
>
> Since many wetland plants (including some of the bottomland hardwood tree species in Table 170 are poor competitors in upland environments, these species will eventually be eliminated as flood pulses are diminished. …

FROM TEXAS PARKS AND WILDLIFE DEPARTMENT'S Texas Wildlife Action Plan, Summary Report, February 2006,[1] the Texas Parks and Wildlife Department explained the impacts of LOTP on page 58 as:

> "Lake O' the Pines has dramatically altered flow regimes downstream in Big Cypress Creek. Resulting physical effects on riverine and floodplain habitat have altered fish spawning and foraging habitat and potentially eliminated spawning cues for fishes."

FROM ESPEY ENGINEERING:

> In a presentation to the Caddo Lake Institute, two experts on environmental impacts of water management explained that the available studies at the time showed some of the impacts of the LOTP –
>
> "1998 drought conditions illustrate that even at 25 cfs releases from Lake O' The Pines, Caddo Lake inflows are negative.[2]"

THE PROCESS OF DEVELOPING CONCENSUS ON NEEDED FLOWS:

Based on a consensus among scientists and stakeholders at the orientation meeting in 2004, the Flows Project process was based on the methodology developed by the National Academy of Sciences for the State of Texas. The Project has been part of a national framework through The Nature Conservancy (TNC) – USACE's Sustainable Rivers Program, and the process has been informed by experience gained across the country. The work of the Flows Project has been adjusted with the assistance of the state agencies to be

[1] The report is available at https://tpwd.texas.gov/documents/507/TWAP-2006-pwd_rp_w7000_1187.pdf

[2] Presentation by David Harkins, Ph.D., P.E., Espey Consultants, Inc. and Brad Cross, Senior Hydrogeologist LBG-Guyton Associates, August 2001.

consistent with the goals and intent of both Senate Bills 2 and 3 and these flows are acknowledged in the Region D Water Plan and the USACE's Operations Manual.

NETMWD has participated in the Project since the initial meeting (December 2-3, 2004) along with the USACE, US Geological Survey, US Fish and Wildlife Service, Louisiana Department of Environmental Quality, the Louisiana Department of Wildlife and Fisheries, the Texas Water Development Board, the Texas Parks and Wildlife Department, TNC, the National Wildlife Federation, the Caddo Lake Institute, several electric utilities, universities, local civic groups, landowners, and many other stakeholders in and out of the basin. NETMWD participated in the five additional multiday Project workshops and five science planning meetings from 2005 to date, with the exception of the Flows Project workshop in 2025.

Through that process, recognizing that the construction and operation of LOTP dramatically affected water flows in Big Cypress Creek and into Caddo Lake, NETMWD has voluntarily made environmental flow releases through the dam to help maintain ecological health. The USACE also has helped in those efforts by using its authority to manage water in the LOTP flood pool, to pursue the same environmental flow and ecological health goals. Because water demands in the local area currently are lower than the amount permitted from LOTP, that voluntary—hand-shake level—approach by NETMWD has been nationally successful over the last 11 years. However, in the absence of a clearly defined approach for addressing drought periods, just as the project was starting, releases were delayed from 2011-2013 as water levels began to dip close to the elevation of key customer water intake pipes in LOTP. Significant tree die-offs occurred during this drought period, though as flowed returned, the forest was able to generate new growth. Water quality and appropriate fish species are also trending in a positive direction since flow releases began.

POTENTIAL SALES OF WATER:

In 2008, after initial environmental flow recommendations were developed, NETMWD released its "Notice of Available Water and Opportunity to Express Interest." The City of Longview expressed an interest in leasing 20,000 acre-feet/year and at least one other municipal water supplier advised NETMWD of an interest in obtaining an amount larger than Longview, possibly 30,000 acre-feet/year.

No other information on any potential sales or leases of significant amounts of water from LOTP or other locations in the Cypress Basin were made public or shared with the Flows Project until 2024, when the interest in water by the North Texas Municipal Water District (DFW area) became public. As it became clear that a serious effort was underway by NETMWD, and others, to potentially move large amounts of water from LOTP, and other

sources in Cypress Creek Basin, to the greater Dallas/Fort Worth metroplex, CLI, along with other partners recognized that a more formal protection approach for environmental flows is needed. If large amounts of water are diverted from LOTP, and other water bodies in the Big Cypress Basin, the ability to meet local needs including the need for flows to keep Big Cypress Bayou and Caddo Lake healthy and productive through ongoing voluntary approaches would be greatly affected, as would water levels in LOTP.

TECHNICAL REVIEW OF POTENTIAL SALES AND LOCAL NEEDS - The Hydrology Memo:

After discussions with NETMWD, CLI launched a major scientific and technical effort designed to help all parties understand what impacts of a water sale might be and what approaches for downstream flow and lake-level protection might be used to strike a reasonable balance if large volumes of water were diverted.

The linchpin of those efforts by CLI has been a significant investment in a science-based modeling exercise, using versions of models the State of Texas has developed for managing state-owned surface waters. Inputs to the model include: the (draft) WAM model created for TCEQ (in 2023 by consultants for NTMWD and NETMWD); 109,484 acre feet per year from LOTP and Lone Star Steel/Ellison creek to be transferred/sold out of LOTP to the DFW area; the regional water supply demands and the flows for downstream as stated in the 2026 Region D water plan. As explained in the accompanying technical memo from Hazen & Sawyer (HS Hydrology Memo, formerly Aqua Strategies), a well-respected consulting firm located in Austin, TX, with extensive expertise in running Texas water availability models, various scenarios were modeled using different assumptions about future water use and about levels of environmental flow protection. The results from those initial scenarios allow us to begin to understand what the impacts are likely to be for flows of water in Big Cypress Bayou below LOTP and for water levels in LOTP and in Caddo Lake from various combinations of water withdrawals and flow protection.

Collaboratively working with the attached to further refine the approach and answer key gaps in knowledge would not only save time, money and resources, it would be a continuation of an historically successful partnership approach to this entire project.

As set out in the Hazen & Sawyer HS Hydrology Memo, the model was used to predict lake levels and downstream environmental flow levels expected if different amounts of water use and releases for flow protection were to occur over a future period of time with a repeat of historical rainfall, drought, evaporation, and runoff. Although weather patterns are not expected to match precisely what they have been in the past, this approach is consistent with the standard modeling approach across Texas. Because the precise details of potential water sale transactions are unknown, at least to us, various

assumptions based on input from NETMWD leadership to the extent that input was available, were required to undertake that modeling. For example, one of many major variables is how much water might be made available for transfer every year (firm water) versus how much might be made available to be transferred only during periods of relatively high lake levels (non-firm water). Our modeling runs assess various options of both.

An overview of key modeling results, and a summary of key underlying assumptions, are provided in the attached HS Hydrology Memo. Because rainfall varies significantly and because local customers *use the most water when rainfall and natural flows are lowest*, it is not simple to provide one single, static amount of water to meet environmental flow needs, in part because the amount needed to maintain ecological health varies greatly from year to year. Static releases were part of the problem with the dam, because mother nature varies season to season and year to year for a reason. Just ensuring the ability to meet a minimum flow amount needed each year, although critically important, is not sufficient to support a healthy river/lake/forest system. This could be compared to "life support or intensive care" for the basin, and every once in a while it can go into such a condition, but this isn't sustainable for long. Accordingly, our modeling efforts use an iterative process that looks at the impacts of different combinations of protection scenarios and transaction sizes, including flow protections that vary based on drought severity. In other words, we are trying to find ways to adjust the releases of downstream water based on real life factors such as rainfall and stream flows, without pushing the system to a "life support" condition that will not sustain the health of the basin or communities.

When meeting increased demands from a large interbasin transfer, such as the DFW area water sale, water levels in LOTP will lessen dramatically from historical conditions and flow levels in Big Cypress Bayou and in Caddo Lake will be adversely impacted. An established management approach for making releases to maintain environmental flows can greatly limit adverse downstream impacts if a careful balance is struck between the frequency and amount of such out of area transfers and of those downstream releases. We acknowledge that striking the right balance is a challenging undertaking and our modeling efforts are intended to help inform that critical task.

CONCLUSIONS:

While the attached Hazen & Sawyer Hydrology Memo is best reviewed by professionals, some topline generalizations are:

* This region uses the most water during a drought. In 2011, the region used 50,000-acre feet of water. The amount of water discussed in this potential sale would be 231% more usage than the historic all-time high.

* The amount of water desired by North Texas Municipal Water District/DFW, would be over half (53.7%) of NETMWD's total authorized amount.

* The historic low water level in Caddo Lake would have been another foot lower had the proposed DFW water sale been in place,
*Meeting the building blocks all parties had agreed were needed for the health of forests, fish, and water quantity were in danger.
* We simulated that diverting only 65,000 acre feet a year (not even the total 100,000 acre feet DFW proposed) during drought, would only provide needed flows 20% of the time.

A key conclusion of the report is:

> "None of the modeled scenarios were capable of providing the full non-firm out-of-basin target demand of 44,384 AFY, modeled as a constant diversion target amount across the year. Potential future scenarios could evaluate whether this non-firm use could occur at higher rates during normally wetter periods of the year (e.g., spring, fall); which could reveal if it is possible to divert the full requested non-firm amount more reliably while protecting firm use and environmental flow achievement. "

CLI seeks to work with key partners to identify an agreed-upon path forward that meets the needs of NETMWD and local communities, including financial considerations, and the need to protect environmental flows for Big Cypress Bayou and Caddo Lake for the long-term.

Sincerely,

Laura-Ashley Overdyke, Executive Director, Caddo Lake Institute

CLI needs to be clear that the focus of these decades of work on flows (and the attached memo) are focused on downstream of Lake O' the Pines itself, and therefore, while we know that quantity of water and flows of water directly relate to water quality, water quality, both in Lake O' the Pines itself and below it, was not a focus of the attached modeling.

ADDITIONAL RESOURCES AND REFERENCES

- *Video explainer of the local project:* *https://www.youtube.com/watch?v=b_hcv9Lu66M*

- *More detail on the history of this project can be found at:* *Summary of Development of Building Blocks and Other Work on the Cypress River Basin as of 2012 with a 2015 Update, Lowerre, Richard, 2015*

- *More information on the Sustainable Rivers Program can be found at: https://www.nature.org/en-us/what-we-do/our-priorities/protect-water-and-land/land-and-water-stories/sustainable-rivers-project/*

- *A published article about the positive impacts of the flow releases can be found at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://caddolakeinstitute.org/wp-content/uploads/2025/10/American-Fisheries-Chapter-Flows-Results.pdf*