

Water Quality and Flow Building Blocks *for* Caddo Lake and Cypress Basin Flow-Ecology Workshop

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Tim Osting
Espey Consultants, Inc.
3809 S. 2nd Street, B-300
Austin, TX 78704
(512) 326-5659

1.0 Introduction

The process of developing environmental flow guidelines is on-going, and to date flow building blocks have been developed for four water bodies within the Cypress basin (Table 1).

In developing the current environmental flow building blocks, water quality has thus far been addressed qualitatively. Previous water quality studies are available which may be useful in evaluating issues, in particular identifying flow dependencies. Currently, the Watershed Protection Plan (WPP) process has begun to identify potential water quality problems and sources (EC 2008). The proposed modeling and analysis associated with the WPP effort can be used beneficially to augment and refine instream flow building blocks by enhancing the understanding of flow-dependent water quality issues.

Table 1 – Cypress Basin water bodies with environmental flow guidelines

Streams

Big Cypress Creek (TCEQ Segment 0402)
Little Cypress Creek (TCEQ Segment 0409)
Black Cypress Creek (TCEQ Segment 0406)

Lake

Caddo Lake (TCEQ Segment 0401)

2.0 Current water quality issues

Water quality issues should be considered when making environmental flows recommendations. While not providing specific guidance on how to consider water quality issues for Overbanking, Pulse and Base flow recommendations, the Texas Instream Flow Program (TIFP) does provide the following guidance for Subsistence flows: (1) identify water quality constituents of concern, (2) conduct water quality modeling studies and (3) assess the relationship of low flow to water quality. To date, water quality issues have been identified in Caddo Lake and tributaries (1); however, limited modeling work (2) has been completed to assess relationships with flow (3).

A number of studies within the Cypress basin have identified water quality constituents (or, parameters) of concern including **pH, mercury (in fish tissue), elevated bacteria, depressed dissolved oxygen concentration (DO) and nuisance vegetation**. The studies have been completed by government, private and non-profit entities, and include the WPP project (EC 2008).

The Texas Commission on Environmental Quality (TCEQ) has listed several Cypress Basin water bodies on the draft 2008 303d list for pH, mercury in fish tissue, elevated bacteria and depressed DO. All listings for water bodies in Table 1 are category 5b (in need of standards review) or 5c (in need of more data), so determination of Total Maximum Daily Loads (TMDLs) are not currently in progress. A 1996 study is available addressing Aquatic Life Use and DO in the Cypress basin during low-flow summer conditions (Crowe and Hambleton 1998) and a 2005 least-impacted watershed study is available for Black Cypress Creek (Crowe and Bayer 2005); further investigation of these study's data or results may be beneficial. Of these identified water quality issues, DO has the greatest potential for impact through prescriptive flow building blocks because increased velocity provides reaeration and mixing to increase DO concentration.

As part of the initial Flow-Ecology workshop in May 2005, a team of six researchers from Texas A&M University (TAMU) compiled a "Summary report supporting development of flow recommendations..." (Winemiller et al. 2005). The report addresses Hydrology, Geomorphology, Water Quality and Biology, and includes discussion on water quality issues including DO, nutrients, aquatic macrophytes and eutrophication. A major finding is that high flows during the summer are beneficial for flushing nutrients and for decreasing potential for low DO and low pH conditions, particularly in Caddo Lake (Winemiller et al. 2005).

Nuisance aquatic vegetation is a current issue. Vegetation growth is aided by high nutrient levels so understanding nutrient loading and dynamics may help control nuisance species (e.g., water hyacinth and giant salvinia); however, reductions in nutrient loading may not solve the problem by itself. Additionally, vegetation is less affected by flow regime than by other factors, so intentional fluctuations of the lake level may have desirable effect to control some species while having little or no effect on other species.

Nutrient work, including a field data collection effort leading to a water and nutrient budget for Caddo Lake (HDR 2007) and the WPP project (EC 2008), identifies an increasing trend in total phosphorus levels. The results of the nutrient budget indicate phosphorus loading to Caddo Lake from ungauged watersheds is high in comparison to loading from gauged tributaries like Little Cypress, Big Cypress and Black Cypress Creeks (HDR 2007). This indicates control of nutrient loading to the lake may be best addressed by the watershed practices, rather than through a flow building block.

Elevated levels of mercury have been identified in fish tissue from Caddo Lake. Fish consumption advisories have been issued and TCEQ has investigated the need for a TMDL. Given the complexity of tracing mercury from its source through a conversion process to methyl-mercury then up the food chain into fish, it is not clear at this time how to consider mercury in the context of a flow building block. Some factors including pH, low DO and high sulfates may be linked to production of methyl mercury; therefore, consideration of pH, DO and sulfates, in particular DO in wetland areas, is the best apparent approach at this time.

3.0 Water quality and instream flow studies

Some water quality issues are evident across the spectrum of flows, but other issues may be evident only within particular ranges of flow or during certain seasons. Issues having identifiable relationships with flow can be evaluated within context of instream flow building blocks. For example, the greatest potential for low DO exists for extended low flow conditions (low velocity prevents mixing and re-aeration of a water body) and during hot summer periods (natural DO content is low at high water temperatures). A second example relates to low DO following a rainfall event, where organic matter and/or nutrients sourced from the watershed have been added to the water body; this increase in available food may lead to an increase in respiration of oxygen-demanding organisms and subsequent depletion of DO. The first example illustrates that DO may be affected by simple changes in flow (e.g., by water use, diversions or return flows) so may be beneficially addressed through prescription of a flow building block. The second example is less easily addressed by a flow building block since DO may be more strongly related to nutrient loading from the watershed than to flow.

Ultimately, there are a number of factors influencing water quality so development of a flow building block based on water quality should answer this question: What water quality impacts can be affected by flows and flows alone? Table 2 is a summary of typical parameters that may be impacted at each building block flow level.

Table 2 –Water quality and flow building blocks

Streams

Subsistence - Diurnal variation of DO

Low Flow during Summer - Change in temperature

Pulses - Flushing and refresh of pools or backwater areas

Pulses - Overbanking, interaction with maintenance flows; post-event influx of vegetation and organic matter

Lake

Base – May need to consider diurnal variation of DO, particularly in backwater or swamp areas

Pulses – Flushing and refresh of pools or backwater areas

4.0 WPP Phase 1: What has been done so far?

Espey Consultants, Inc., (EC) is currently working on the Caddo Lake WPP project for Northeast Texas Municipal Water District (NETMWD) and TCEQ. To help link the WPP work to this Flow-Ecology project, Caddo Lake Institute asked EC to prepare this paper and participate in discussions of relevant water quality issues.

The Phase 1 WPP work focuses on data accumulation and analysis (EC2008). Analysis includes evaluation of standards excursions; spatial and temporal trends; and potential watershed pollutant sources. Where data is available, trends with precipitation and flow are analyzed. Specifically, trends of DO with flow indicate little evidence of a trend; however, many segments exhibit occasional or persistent low DO. Additional analysis is possible on a station-by-station basis.

5.0 WPP Phase 2: What modeling questions may be answered?

The WPP work will be a whole-basin model with focus on load reductions leading to achievement of long-term water quality goals. Water quality issues may be characterized across large areas, on a reach-by-reach basis or across a sub-basin. Characterization of specific local impacts will be considered to the extent possible, but may not be considered to a level of spatial or temporal detail that is beneficial for instream flow analysis.

Given data available to execute and evaluate the model (monthly or quarterly sampling intervals), long time-steps (weekly, monthly, yearly) will likely be used. Instream flow analysis benefits from understanding of short-term response, e.g., daily cycles of dissolved oxygen concentration, so the WPP modeling effort may be limited in linkage to flows building blocks.

Development of a water balance is necessary for the WPP model and this flow balance may be useful in developing flow building blocks. The water balance will detail the

location, amount and timing of sources and sinks of water including tributaries, dams, diversions, return flows and effluent discharges. This will allow additional areas or reaches, particularly those between flow gauges, to be analyzed for potential hydrological differences or water quality impacts.

6.0 Linkage: How can the WPP work be augmented to benefit the flows building blocks?

The WPP project focuses on non-point source water quality issues; therefore, the tools used to analyze Best Management Practices and pollutant load reductions are not tailored to analysis of instream flows. WPP work tasks can be augmented to improve understanding of flows building blocks, or water quality relationships to flow. Additional tasks related to data analysis are presented in Table 3, and tasks related to modeling are discussed below and in Table 4.

Table 3 – Potential water quality Data Analysis tasks

Diurnal DO analysis by location (station), where data is available
Evaluation of water quality (DO) response to flow pulses
Temperature may be investigated if important to aquatic species
Seasonality of DO records may be evaluated for particular locations

Daily or diurnal conditions are typically of interest in development of flow building blocks. However, for both the river and the lake, modeling in the WPP project may be more representative of basin-wide conditions averaged over relatively long periods (weeks, months, seasons, years); therefore, scoping of additional modeling or additional flow scenarios to characterize conditions not considered by the WPP project may be beneficial to the Flows-Ecology project. Potential scenarios include (1) modified flow regime resulting from modified outlet works, (2) a particular set of unlikely but possible diversion/discharge combinations, or (3) diurnal variations at select locations. Evaluation of model output at additional specific check-point locations may also be beneficial. Potential model-based analyses may be categorized according to flow level (Table 4).

Table 4 – Potential water quality Modeling tasks

Streams

Subsistence flows – Daily and/or diurnal DO kinetic analysis

Base flows - Evaluate summer (Jul-Aug) low flows against 8.4cfs 7Q2 for Big Cypress

Lake

Pulses - Evaluation and comparison of the prescribed pulse regime against the historical regime may be beneficial. Specifically, the current recommendation that fewer pulses are necessary for river health may adversely impact the lake with reduced flushing.

Drawdown - An appropriate set of drawdown characteristics that achieve beneficial nutrient and nuisance vegetation effects can be investigated.

7.0 References

Crowe, Art and Faith Hambleton. 1998. Cypress Creek Basin. Aquatic Life Use and Dissolved Oxygen concentrations during low-flow, high-stress summer conditions 1995-1996. Texas Natural Resources Conservation Commission (TNRCC) (now the TCEQ), February 1998. (<http://www.caddolakedata.us/>, accessed November 15, 2008).

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