ENVIRONMENTAL FLOWS IN THE CYPRESS RIVER BASIN

Trinity and San Jacinto Rivers and Galveston Bay
Bay Basin Expert Science Team
November 13, 2008
Galveston, Texas
From “Rivers for Life: Managing Water for People and Nature” by Sandra Postel and Brian Richter (Island Press 2003)
Developing Environmental Flows

Challenges Include:

- identifying what components of flow are ecologically most critical in river and bay systems
- quantifying those flow components to help guide development of flow standards
- achieving these tasks for all rivers within resource constraints while satisfying all stakeholder requirements
- short time line
- incorporating new knowledge and understanding into water management over time
Environmental Flow Recommendations: A Collaborative and Adaptive Approach

- **Adaptive**
  - Initial recommendations based on best available science
  - Refinement following flow experiments

- **Flexible**
  - Inter-disciplinary
  - Accommodates any inputs
  - Time constraints

Utility for SB3 Environmental Flow Allocation Process

- Its foundation is a synthesis of existing science and analysis tools by an interdisciplinary team of scientists, experts, and stakeholders.
- Incorporates and integrates of all types of information (e.g., field studies, hydraulic model outputs), not just IHA.
- Generates robust initial recommendations even with limited inputs.
- Initial phases are not particularly costly.
- Not necessarily just for dams.
- One issue: has been utilized primarily in site-specific applications – are other tools for regional or basin-wide scales (e.g., Ecological Limits of Hydrologic Alteration).
Goals

1. **An Environmental Flow Regime:** Now, a SB 3 Set Aside.

   But more than the SB 3 process

2. **New Operating Plan for Releases from Lake O' the Pines.**

3. **An Long-term Adaptive Management Process:** For continuation of the work.
Answer a Few Questions

**Funding**
Flows work supported primarily by federal & private funding. WPP work supported Primarily by EPA, TCEQ and NETMWD

**Key Cost**
Literature review and report (TX A&M) $70,000

**Participation by Scientists**
Due to their past work, e.g., proposed reservoirs, barge canal, etc

**Stakeholder Engagement**
Involved in discussions on reservoirs, barge canal, etc
Examples of 175+ Participants in the Work to Date

- **Local & Regional Governments** – NETMWD, CVND, some local counties and cities.
- **Tx & La State Agencies** – TPWD, TWDB, TCEQ, TSSWCB, LDEQ
- **Federal Agencies** – Corps of Engineers, USGS, USF&WS, National Wetlands Research Center
- **Universities** – East Texas Baptist University, Texas A&M, Texas Tech, LSU Shreveport, TCU, Texas State.
- **Reps from Business and industries** – AEP, Nestle Waters NA, Caddo Lake Chamber of Commerce
Orientation Meeting

December 2004

Explanation of the Process
Assessment of Available Resources (personnel and data)
Field Reconnaissance
Riverine Components - Hydrology, Physical Processes, Water Quality, Biology (Aquatic and Terrestrial), Lake and Wetland Issues

Appendices include land use maps, output from IHA and species lists.

Annotated Bibliography
Ecosystem Flow Workshop
May 2005

- 2 days, 87 scientists, water managers and local community
- Overview of process and expected results and Presentations of the Summary Report
- Two break-out sessions with two groups each session defined ecological flow recommendations for:
  1. Big Cypress Creek and Caddo Lake
  2. Low Flows and High Flow Pulses/Floods
- Building Blocks for River and Lake
- Prioritized Research Needs
- Operational Constraints, Stakeholder Concerns and Monitoring
Developing Environmental Flows
* A Multi-Level Approach

The Common Denominator

- **Low Flows** – Determine the amount of habitat available.
- **High Flow Pulses** – Open up additional habitat area, bring additional food material from upstream areas, moderate temperatures and oxygen levels, clean spawning gravels, and provide cues for migration to spawning areas.
- **Floods** – Create the physical template of the river ecosystem, including formation of oxbows (backwaters) and secondary channels, floodplains, and spawning bars, and keep introduced species populations in check.
Instream Flow Building Blocks
Big Cypress Creek/ Caddo Lake

**Floods**
- 6,000-10,000 cfs for 2-3 days
  - Every 3-5 years
  - *Maintain aquatic habitat in floodplain*
  - *Riparian seed dispersal*
  - *Inhibition of upland vegetation for both creek & lake*
  - *Seed dispersal*
  - *Vegetation removal*
  - 20,000 cfs for 2-3 days
  - Every 10 years
  - *For channel migration*

**High Flow Pulses**
- 6,000 cfs for 2-3 days
  - Every 2 years
  - *For channel maintenance*

- 1,500 cfs for 2-3 days
  - 3-5X a year every year
  - *1 occurring in March for Paddlefish*
  - *Sediment transport, oxbow connectivity*
  - Waterfowl habitat flushing
  - (Includes December)

**Low Flows**
- 40 – 536 cfs
  - Maintain biodiversity and connectivity (backwater & oxbows)

**Key**
- 266-347 cfs
  - Pre-dam median
- 390 - 79 cfs
  - Ebbtide drift & dispersal, fish spawning
- 35 - 40 cfs
  - Fish habitat
- 40 - 117 cfs
  - Pre-dam median
- 90 cfs
  - Fish habitat
- 218 - 49 cfs
  - Spawning habitat
- 13 - 6 cfs
  - Maintain aquatic diversity
- 40 - 90 cfs
  - Fish habitat

**Months**
- JAN
- FEB
- MAR
- APR
- MAY
- JUN
- JUL
- AUG
- SEP
- OCT
- NOV
- DEC
Low Flow Targets

- Magnitude, Duration, Frequency, Timing, Rate of Change
- Range of Variation Analysis
- Wet, Normal, Dry
- Flow Regime – Environmental Flow Components
Indicators of Hydrologic Alteration – Environmental Flow Component (EFC)

- Divides the hydrograph into high flow (>75th percentile) and low flow (<50th percentile)
- High flows are further divided into Large Floods (10 year recurrence), Small Floods (2 year recurrence) and High Flow Pulses (rise faster than 25% and fall faster than 10%)
- Low flows also include Extreme Low Flows (<10th percentile)
- Percentile statistics of the low flows for each month are also generated
Environmental Flow Component (EFC) analysis computes statistics for five different flow components: extreme low flows, low flows, high flow pulses, small floods, and large floods. If you wish, this analysis may be performed for two separate seasons (see Analysis Days tab).

The parameters used to define EFCs can be set below.

**High Flow Pulses:**
- All flows that exceed 75\% percent of flows for the period will be classified as high flow pulses.
- No flows that are below 50\% percent of flows for the period will be classified as high flow pulses.
- Between these two flow levels, a high flow pulse will begin when flow increases by more than 25\% percent per day, and will end when flow decreases by less than 10\% percent per day.

**Flood Definition:**
- A small flood event is defined as a high flow pulse with a recurrence time of at least 2.00 years.
- A large flood event is defined as a high flow pulse with a recurrence time of at least 10.00 years.

**Extreme Lowflow Definition:**
- An extreme low flow is defined as a flow in the lowest 10\% percent of all low flows in the period.
Relationship between Flow and Life History needs

Pre-impact period: 1924-1956 (33 years)

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<tr>
<th>Month</th>
<th>10%</th>
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<th>50%</th>
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<td>86.88</td>
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<td>117.00</td>
<td>274.75</td>
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EFC Monthly Low Flows

- Pre-spawn adults migrate to shallows
- Spawning
- Post-spawn adults disperse and feed in backwaters
- Eggs, larvae drift in channel
- Larvae feed in channel pools
- Juveniles disperse and feed in backwaters
**IHA-EFC Statistics for Big Cypress 1924-1956 (33 years)**

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<th>EFC Low Percentiles</th>
<th>Low Flow Building Blocks</th>
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<td>Dec</td>
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Instream Flow Building Blocks
Big Cypress Creek/Caddo Lake

Floods

6,000-10,000 cfs for 2-3 days
Every 3-5 years
* Maintain aquatic habitat in floodplain
* Riparian seed dispersal
* Inhibition of upland vegetation for both creek & lake
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* Vegetation removal
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3-5X a year every year
* 1 occurring in March for Paddlefish
* Sediment transport, oxbow connectivity
  * Waterfowl habitat flushing
  (Includes December)

Low Flows

40 - 536 cfs
Maintain biodiversity and connectivity (backwater & oxbows)

Key

- Wet Year
- Avg Year
- Dry Year

268-347 cfs
Pre-dam median

390 - 79 cfs
Benthic drift & dispersal, fish spawning

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Fish habitat

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Spawning habitat

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Maintain aquatic diversity

40 - 90 cfs
Fish habitat

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
High Flow
Ecosystem Benefits

- Channel Maintenance - Flushing accumulated fine sediments from gravel, scouring pools, building riffles, removing vegetation from active channel inundating bars and maintaining channel capacity.
- Flood Plain connectivity, Cypress Regeneration and spawning cues
- Channel Forming – large scale fluvial geomorphic adjustments
High Flow Concepts and Approaches

- Bankfull Discharge – Connectivity
- Effective, Dominate or Channel Forming Discharge – Sediment Transport

- Measure water surface elevation at bankfull
- Model sediment transport capacity
- 2 year return flow

Effective discharge calculation: a practical guide / by David S. Biedenharn ... [et al.]; prepared for U.S. Army Corps of Engineers. 2000
Big Cypress High Flow Recurrence

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<th>PeakFQ</th>
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<td>10.0</td>
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- Channel Maintenance flow – High Flow Pulse 1,500 cfs from IHA
- Bankfull Flow – 2 year recurrence
- Channel Forming Flow – 10 year recurrence

Durations of occurrence adjusted based on professional judgment. Magnitude of bankfull identified as a top research priority.
Second Ecosystem Flow Workshop

October 2006 (80 participants)

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<th>Little Cypress Creek</th>
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Second Ecosystem Flow Workshop

October 2006 (80 participants)
Implementation of Flow Prescription & Data Collection and Research Program

- Installation of new stream gage on Big Cypress at Karnack
- Museum study of historical fish data
- Characterize segment and reach-scale channel geomorphologic features
- Baseline collections of the fish assemblage
- Establish instrumented cross-sections at non-gauged locations.
- Habitat requirements of target organisms
- Modeling to develop Flow-Habitat response Curves & habitat time Series
- Measurements to quantify overbank discharge
- Cross section surveys on Big Cypress to support HEC-RAS development
- Flow-Inundation mapping
- Watershed Protection Plan
Refinements to the Preliminary Recommendations

- Assembled and analyzed additional data
- Redeveloped existing habitat models
- Collected new field data
A resilient, functioning ecosystem characterized by intact, natural processes and a balanced, integrated, and adaptive community of organisms comparable to that of the natural habitat of a region.
Biological Condition Gradient

1. Native or natural condition
2. Minimal loss of species; some density changes may occur
3. Some replacement of sensitive-rare species; functions fully maintained
4. Some sensitive species maintained but notable replacement by more-tolerant taxa; altered distributions; functions largely maintained
5. Tolerant species show increasing dominance; sensitive species are rare; functions altered
6. Severe alteration of structure and function
Historical Trends in Fish Assemblage

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<td>Pelagophils†</td>
<td>22.49</td>
<td>7.25</td>
<td>0.72</td>
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<td>Nest Spawners</td>
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<tr>
<td>Lithophils∞</td>
<td>7.38</td>
<td>42.58</td>
<td>56.15</td>
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- **Pelagophils†**: Obligate riverine species, broadcast-pawn buoyant eggs within current
- **Lithophils∞**: Includes most Centrarchidae, spawn elliptical egg envelopes over rock or gravel nests
“The primary objective of base flow recommendations will be to ensure adequate habitat conditions, including variability, to support the natural biological community of the specific river sub-basin.”

- Building Blocks derived from IHA with slight modifications
- Texas Instream Flow Program – Habitat Modeling
SB2 Subsistence and Base Flows

**Subsistence Flows**
- Spatial scale: River Reach
- Temporal scale: Hourly Flow, Varies from Month to Month
- Primary discipline:
  - Hydrology/Hydraulics
  - Biology
  - Geomorphology
  - Water Quality

- Identify Biological Considerations
- Identify Water Quality Constituents of Concern
- Conduct Water Quality Modeling Studies
- Assess Low Flow-Water Quality Relationships
- Calculate Low Flow Statistics
- Other Biological Considerations
- Subsistence Flows

**Base Flows**
- Spatial scale: River Reach
- Temporal scale: Daily Flow Range, Varies from Month to Month
- Primary discipline:
  - Hydrology/Hydraulics
  - Biology
  - Geomorphology
  - Water Quality

- Identify Biological Issues and Key Species
- Calculate Base Flow Statistics
- Model Hydraulic Characteristics in Relation to Flow
- Assess Habitat Flow Relationships, Including Diversity
- Describe Wet, Normal, and Dry Years
- Consider Biological and Riparian Issues
- Consider Water Quality Issues
- Base Flows
Existing PHABSIM data
Cross Section Surveys & Rating Curves
Modeled Depth and Velocity
Habitat Suitability Criteria
Big Cypress at 1 Mile DS LOP

Q = 100 cfs
Species = SPOTTED SUCKER_ADULT

Depth HSI

Velocity HSI

Cover HSI
Ecological Response Curves
Flow vs. WUA
## Application of Building Blocks

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<th>Swift Water</th>
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<td>Spotted bass</td>
<td>Rakerel</td>
<td>Bluntnose darter</td>
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<th>Bluntnose darter</th>
<th>Flathead catfish</th>
<th>Ironside shiner</th>
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</table>
Refinement/Validation of Initial Building Block Recommendations

- Does anything jump out as a concern?
- Does the change in habitat based on pre vs. post LOP conditions suggest a refinement?
- Re-evaluate adjustments from IHA outputs?
- Refinements for declining guilds?
- Do we need all three levels (wet/average/dry)?
- Are the base flows upstream and downstream of Jefferson the same?
SB2 High Flow Pulses and Overbank Flows

**Flow Pulses**
- **Spatial scale:** River Segment
- **Temporal scale:** Multiple High Flow Pulses Throughout the Year
- **Primary discipline:**
  - Hydrology/Hydraulics
  - Biology
  - Geomorphology
  - Water Quality

**Overbank Flows**
- **Spatial scale:** River Segment
- **Temporal scale:** Extreme Flow Events, Occur Less Than Once per Year
- **Primary discipline:**
  - Hydrology/Hydraulics
  - Biology
  - Geomorphology
  - Water Quality

Flow Pulses:
- Calculate High Flow Statistics
- Consider Significant Habitat Conditions
- Assess Active Channel Processes
- Develop Sediment Budgets
- Assess Channel Adjusting Flow Behavior
- Describe Significant Habitat Conditions
- Consider Biological Issues
- Consider Water Quality Issues
- High Flow Pulses

Overbank Flows:
- Calculate Flood Frequency Statistics
- Model Extent of Flood Events
- Assess Overbank Flow Behavior
- Conduct Riparian Studies
- Estimate Riparian Requirements
- Overbank Flows
Field Data Collection

- Base of transducer sensor surveyed in to benchmark of known datum.
- Continuous (hourly beginning in March 06 to August 07) recording of stage and water temperature.
- Transducer data downloaded and units calibrated every 3-4 weeks.

Pressure transducer installed at each site for continuous monitoring of stage and water temperature.

Surveyed channel features including bankfull height, structural components and into connects to floodplain wetlands.
Controlled Release

January 2006

1800 cfs in Jefferson

3000 cfs reaching sloughs
**Bankfull discharge** \((\bar{X} = 1687 \text{ cfs})\) in upstream reach is much less than the 2 to 3-year recurrence discharge of 6,000 cfs that was prescribed.
Good agreement between surveyed channel features and the flow prescriptions chosen to maintain longitudinal **connectivity** from dry (6 - 90 cfs) through wet year (40 – 536 cfs).

Cypress knees are important structure for aquatic biota.

Big Cypress Creek at Thomas Camp (BC03)
Maintain Biodiversity and Connectivity During a Wet Year
Should Flow Prescriptions be Adjusted for Variability in the Channel?

Upper Reach

Lower Reach

Location of U.S. Hwy 59

Upstream of U.S. Hwy 59

Downstream of U.S. Hwy 59

1500 cfs

6 cfs

Upper Reach

Lower Reach

Cypress Knees

Woody Snags

Thalweg

Bankfull

Cypress Knees

Woody Snags

Thalweg

Bankfull