Overlays to Hydrology-Based Environmental Flow Regimes

Science Advisory Committee
March 4, 2009
Austin, Texas
Overlays - Definition

- Application of analysis to validate or refine flow estimates derived from hydrologic analysis
- Not limited to quantitative adjustments
- Expected ecological response -> research priorities and indicators
Overlays - Examples

- Literature Survey and Summary Report

- Subsistence
  - Water Quality Standards
  - Longitudinal Connectivity
  - Water Quality Models

- Base
  - Analysis of Fish Assemblage
  - Hydraulic-Habitat Models

- High Flow Pulse
  - Effective Discharge Estimate
  - Spawning/Migratory Cues
  - Riparian/Oxbow Connection Points
  - Sediment Transport Model

- Overbank
  - Bankfull Discharge Estimate
  - High Flow Rating Curves
  - HEC-RAS Water Surface Model
  - GIS Analysis of Inundated Areas
Subsistence

Ecological Response

- Maintain water quality criteria
- Providing life cycle cues
- Providing refugia habitat

Overlays

- Water Quality Standards
- Longitudinal Connectivity

- Water Quality Models
Identify water quality constituents of concern
- pH, mercury (in fish tissue), elevated bacteria, depressed dissolved oxygen concentration (DO) and nuisance vegetation

Relationship to Flow Regime Components
- *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

Potential water quality modeling tasks
- *Subsistence flows* – Daily and/or diurnal DO kinetic analysis
- *Base flows* - Evaluate summer (Jul-Aug) low flows against 8.4cfs 7Q2 for Big Cypress
Longitudinal Connectivity

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
**Base Flows**

**Ecological Response**
- Ensure adequate habitat conditions, including variability

**Overlays**
- Analysis of Fish Assemblage
- Hydraulic-Habitat Model
  - Stream Survey & Discharge Rating Curve
  - Habitat Suitability Criteria
Analysis of Fish Assemblage – Literature Review

Life history summaries of select species representing various flow dependencies (i.e. dependent on flowing channel habitats, backwater habitats)

“The ichthyofauna of the Cypress Bayou basin appears to have shifted from assemblages dominated by cyprinids, percids, and cyprinodontids in the 1950’s to assemblages dominated by centrachids, other cyprinids, clupeids, and atherinids in the 1980’s.”

Analysis of Fish Assemblage – Museum Study

- **Pelagophils**: Obligate riverine species, broadcast-spawn buoyant eggs within current

- **Lithophils**: Includes most Centrarchidae, spawn elliptical egg envelopes over rock or gravel nests

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<tr>
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<tbody>
<tr>
<td>Non guarders</td>
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<tr>
<td>Open Substratum</td>
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<td></td>
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<tr>
<td>Pelagophils</td>
<td>22.49</td>
<td>7.25</td>
<td>0.72</td>
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<tr>
<td>Guarders</td>
<td></td>
<td></td>
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<tr>
<td>Nest Spawners</td>
<td></td>
<td></td>
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<tr>
<td>Lithophils</td>
<td>7.38</td>
<td>42.58</td>
<td>56.15</td>
</tr>
</tbody>
</table>
Historical Analysis of Fish Assemblage – Studies and Resources

- Fishes of Texas - University of Texas at Austin, Texas Natural History Collections
- Analysis of Existing Biological Data – Texas State University, Texas Instream Flow Program
- Texas Freshwater Fishes - http://www.bio.txstate.edu/~tbonner/txfishes/index.htm
Hydraulic-Habitat Model

Hydraulic Model

Habitat Area

Flow vs. Habitat

Habitat Suitability
Existing Data
Cross Section Surveys & Rating Curves

Cross Section Survey

Rating Curve
Modeled Depth and Velocity

- **Water Surface Elevations**
  - Graph showing water surface elevations with observed values and modeled values for different depths.

- **Velocity Profiles**
  - Graph showing velocity profiles with mean and adjusted values for different velocities.
Habitat Suitability Criteria
Big Cypress at 1 Mile DS LOP
Q = 100 cfs
Species = SPOTTED SUCKER_ADULT
Ecological Response Curves
Flow vs. WUA

Weighted Usable Area versus Simulated Discharge

- SPOTTED SUCKER
- SPOTTED BASS
- PICKEREL
- BIUNTNOSE DARTER
- FLATHEAD CATFISH
- IRONCOLOR SHINER
- BLACKSIDE DARTER
- BLACKTAIL SHINER
Refinement/Validation of Initial Building Block Recommendations

- Does anything jump out as a concern
- Period of Record - pre vs. post impact
- Effect of other overlays
- Assemblage trends analysis
- Hydrologic conditions (Three?)
- All months or by seasons
- Spatial differences
High Flow Pulses

Ecological Responses
- Maintain important physical habitat features
- Longitudinal connectivity

Overlays
- Effective Discharge Estimate
- Spawning/Migratory Cues
- Riparian/Oxbow Connection Points
- Sediment Transport Models
Overbank

Ecological Responses
- Maintain riparian areas
- Provide lateral connectivity between the river channel and active floodplain

Overlays
- Bankfull Discharge Estimate
- High Flow Rating Curves
- HEC-RAS Water Surface Model
- GIS Analysis of Inundated Areas
Bankfull discharge ($\bar{X} = 1687$ cfs) in upstream reach is much less than the 2 to 3-year recurrence discharge of 6,000 cfs that was prescribed.
# Comparison to NWS Flood Stage

<table>
<thead>
<tr>
<th>NWS Flood Stages</th>
<th>Stage</th>
<th>Discharge</th>
<th>Flows Project - Building Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27.3</td>
<td>20,000</td>
<td>Preliminary Large Flood estimate - approximate 10 year recurrence</td>
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<tr>
<td></td>
<td>24.1</td>
<td>10,000</td>
<td>Preliminary Small Flood estimate - approximate 3 year recurrence</td>
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<tr>
<td>Major Flood Stage:</td>
<td>22</td>
<td>6,046</td>
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<tr>
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<td>22.0</td>
<td>6,000</td>
<td>Preliminary bankfull estimate - approximate 2 year recurrence</td>
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<td>Moderate Flood Stage:</td>
<td>21</td>
<td>4,681</td>
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<tr>
<td>Flood Stage:</td>
<td>20</td>
<td>3,580</td>
<td></td>
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<tr>
<td>Action Stage:</td>
<td>20</td>
<td>3,580</td>
<td></td>
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<tr>
<td></td>
<td>19.4</td>
<td>3,000</td>
<td>Flow that connects to oxbows and other off-channel wetlands upstream of Jefferson</td>
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<tr>
<td></td>
<td>18.7</td>
<td>2,500</td>
<td>Approximate mean bankfull over study reach</td>
</tr>
<tr>
<td></td>
<td>17.4</td>
<td>1,687</td>
<td>Approximate mean bankfull in upper reach</td>
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</table>
Instream Flow Building Blocks
Big Cypress Creek – Hydrology based only

<table>
<thead>
<tr>
<th></th>
<th>Low Flows</th>
<th>Key</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
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<th>DEC</th>
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<tbody>
<tr>
<td><strong>Floods</strong></td>
<td></td>
<td></td>
<td>396</td>
<td>500</td>
<td>536</td>
<td>445</td>
<td>264</td>
<td>140</td>
<td>70</td>
<td>41</td>
<td>32</td>
<td>49</td>
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<td><strong>High Flow</strong></td>
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<td>268</td>
<td>347</td>
<td>390</td>
<td>330</td>
<td>150</td>
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<td><strong>Pulses</strong></td>
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<td>116</td>
<td>195</td>
<td>218</td>
<td>198</td>
<td>114</td>
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<td>6</td>
<td>6</td>
<td>6</td>
<td>26</td>
<td>61</td>
</tr>
</tbody>
</table>

**Key**
- Wet Year
- Avg Year
- Dry Year

20,000 cfs for 2-3 days
   Every 10 years
   PeakFQ(10) = 23,300

6,000-10,000 cfs for 2-3 days
   Every 3-5 years
   PeakFQ(2-3) = 6,485 - 9,956

6,000 cfs for 2-3 days
   Every 2 years
   PeakFQ(2) = 6,485

1,500 cfs for 11 days
   7X a year every year

20,000 cfs for 2-3 days
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### Instream Flow Building Blocks

**Big Cypress Creek**

#### Floods

<table>
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<tr>
<th>Flow Rate</th>
<th>Duration</th>
<th>Frequency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000 cfs</td>
<td>2-3 days</td>
<td>Every 10 years</td>
<td>For channel migration</td>
</tr>
<tr>
<td>3,000-10,000 cfs</td>
<td>2-3 days</td>
<td>Every 3-5 years</td>
<td>Maintain aquatic habitat in floodplain, Riparian seed dispersal, Inhibition of upland vegetation for both creek &amp; lake, Seed dispersal, Vegetation removal</td>
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3000 = flow that connects to oxbows and other off-channel wetlands upstream of Jefferson.

#### High Flow Pulses

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<tr>
<td>2,500 cfs</td>
<td>2-3 days</td>
<td>Every 2 years</td>
<td>For channel maintenance, Oxbow connectivity</td>
</tr>
<tr>
<td>1,500 cfs</td>
<td>2-3 days</td>
<td>3-5X a year every year</td>
<td>1 occurring in March for Paddlefish, Sediment transport, Waterfowl habitat flushing (Includes December)</td>
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2,500 = about mean bankfull over the reach studied.

2-3 days = peak period for high-flow and floods.

#### Low Flows

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<tr>
<td>396</td>
<td>Maintain biodiversity and connectivity (backwater &amp; oxbows)</td>
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<tr>
<td>500</td>
<td>Benthic drift &amp; dispersal, fish spawning</td>
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<tr>
<td>536</td>
<td>Fish habitat</td>
</tr>
<tr>
<td>445</td>
<td>Pre-dam median</td>
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<tr>
<td>264</td>
<td>79</td>
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<tr>
<td>140</td>
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