Environmental Flow Issues & Science

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Projected Upper Colorado River Flows vs. Population Growth in Major Lower Basin Metropolitan Areas

Opportunity Change

Source: McCabe and Wolock 2007
• Classic claims against E-flows
• Wyoming’s experience
• Definitions & concepts
• Scientific basis & methods
• So what?
Classic Claims Against E-Flows

• Costs too much to measure
• Water needs to be diverted
• Will cause streams to go dry
• A ploy to take back water rights
• Will impact interstate compacts
• Will stop economic development
• Need dams to get an instream flow
• That won’t work in *(fill in state name)*
History of E-Flow in Wyo
Upper Green River

- Application submitted in 1969
- Denied in 1972
  - No quantitative basis to support the request
  - No diversion or storage (abandon-ability)
  - A right of this nature would be of such value that it should be vested in the state
38 Years Later

- 17 failed laws from 1974 to 1985
- Successful legislation in 1986
- First filing submitted in 1986
- 100th instream flow filing in 2006
What Hasn’t Happened in Wyoming Since 1986?

• No one’s lost a water right
• Streams have not gone dry
• There’s been no call for regulation.
• 98% of streams are still unprotected
• No dams built to provide an instream flow
• Compacts and decrees have been unaffected
• No controversy over any ISF filing once issued
What’s Happened in Wyoming Since 1986?

• Helped build several dams (mitigated impacts)
• Protected habitat in >100 stream segments (with current day priority dates)
• Staved off petitions to list 4 native species as T&E
• Used state law to protect water for Wild & Scenic River (vs. federal reserved water right)
• Enhanced property values on private properties (upon request of landowners)
Definitions and Concepts
Environmental Flow Can Mean:

- Water in the creek but no regulatory mechanism
- Enforceable regulatory mechanism but no water
- Water in the creek that’s protected by an enforceable regulatory mechanism
A little water, some of the time?
All the water, all the time?
A seasonally adjusted flow regime?
River systems were built and are maintained by different magnitudes of discharge occurring over time and space. (Hill et al. 1991)
Protection vs. Restoration?
• Upside Down Instream Flow
• Limit amount taken out
• Public land issue
• Bottom up instream flow
• Put water back
• Private land issue
Scientific Basis & Methods
How much water can we take out of a river?
Each Situation is Unique

Rivers and the species that live there change in predictable ways over distance.
Methods Evolution

1970’s – Hydrologic statistics
1980’s – Quantitative biology models
1990’s – Ecosystem processes
2000’s – Holistic methods
Types of Methods

• Standard-setting methods
  – Estimate single level or threshold of flow

• Incremental methods
  – Evaluate habitat value vs. flow relationship

• Multiple component methods
  – Integrated analyses / multiple outcomes
Habitat Modeling Caveats

- Models manage risk – they don’t eliminate it
- There isn’t a straight-line relationship between flow and habitat.
- A flow that’s good for one species may be detrimental to others.
- A flow that maximizes habitat in one stream segment may not provide much in another.
- There isn’t a single “best” flow – think flow regimes.
Models can tell us about:

- **Hydrology**
  - Short and long-term water availability
- **Biology**
  - Short-term physical habitat availability
- **Geomorphology**
  - Long-term trends of channel conditions
- **Connectivity**
  - Multiple elements and concepts
- **Water quality**
  - Short and long-term
River systems were built and are maintained by different magnitudes of discharge occurring over time and space. (Hill et al. 1991)
The problem with minimum flows . . .
Hydrology Methods

• Indicators of Hydraulic Alteration (IHA)
• Range of Variability Approach (RVA)
• Flow duration curves
Hydrology Model Considerations

- Low to moderate effort
- Need long-term gage data
- Relationship with biology is assumed
- Good for describing hydrology (planning)
- Need other tools to assess needs for other flow elements
Biology
Biology also embraces other aquatic organisms . . . and riparian vegetation

When one tugs at a single thing in nature, he finds it attached to the rest of the world – John Muir
Biology Methods

- Single Transect Methods
- Tennant Method (and variations)
- Physical Habitat Simulation HABSIM
- MesoHABSitat SIMulator (MesoHABSIM)
- Two Dimensional Models (River 2-D)
Single Transect Methods
(Wetted Perimeter)

Graph showing the relationship between flow (cfs) and wetted perimeter (ft).
Physical Habitat Simulation (PHABSIM)

A. Site-specific microhabitat data

- V1, V2, V3, V4, V5: Velocity
- D1, D2, D3, D4, D5: Depth
- C1, C2, C3, C4, C5: Cover
- A1, A2, A3, A4, A5: Area

B. Habitat suitability criteria

- Velocity
- Depth
- Cover

C. Seasonal relationship between discharge and microhabitat for each life stage

- Weighted Usable Area
- Discharge (m³/s)

Courtesy Rick Anderson, CDOW
MesoHABSIM

COMMON SHINER

<table>
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<tr>
<th>Presence</th>
<th>Beta</th>
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<tbody>
<tr>
<td>BOULDER</td>
<td>1.71</td>
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<tr>
<td>RIPRAP</td>
<td>1.40</td>
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<tr>
<td>SHADING</td>
<td>-1.48</td>
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<tr>
<td>DEPTH 50-75 cm</td>
<td>-1.23</td>
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</table>

High abundance (69%)

<table>
<thead>
<tr>
<th>Presence</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOULDER</td>
<td>1.68</td>
</tr>
<tr>
<td>SHADING</td>
<td>-1.01</td>
</tr>
</tbody>
</table>
2-Dimensional models

GPS & ADP/Sonar Survey

Courtesy Rick Anderson, CDOW
2D Modeling simulates river hydraulics for a flow range

600 cfs

Courtesy Rick Anderson, CDOW
1. Delineate meso habitat and determine surface area
2. Determine hydraulic variables (depth and velocity)
3. Rate the habitats’ suitability based on species abundance
Overall Habitat Suitability

Predicted Bluhead Biomass (Kg/m²)

- 0: Unusable
- 22: Unsuitable
- 83: Marginal
- 174: Optimal

Courtesy Rick Anderson, CDOW
Biology Model Considerations

- Emphasis has been on fish
- Focus on short-term survival or habitat suitability
- Flow / habitat relationship differs in different streams or stream segments
- Need other tools to assess needs for other flow elements
Geomorphology
Geomorphologic condition is a function of:

- Sediment addition or removal
- Flow addition or removal
- Channel alteration
Geomorphology Models

- Channel maintenance methods
- Flushing flow methods
  - field-based
  - office-based
- Geomorphic classifications (Rosgen)
- HEC-6 and HEC-RAS
Geomorphology Model Considerations

- Usually have broad confidence intervals
- Address long-term physical habitat (not tied to species)
- Need to specify timing, duration, ramping
- Need other tools to assess needs for other flow elements
Water temperature

. . . any time of day or year
Ice formation processes are a function of flow in some streams.
Water Quality Considerations

- Addressed long before water quantity
- Focus on minimum flows and thresholds
- Don’t identify ecological trade-offs
- Need other tools to assess needs for other flow elements
Connectivity

The Four Dimensional View of Rivers

(Longitudinal, Lateral, Vertical, Time)

(Adapted from Ward 1989)
Connectivity isn’t just about fish

• Nutrients & minerals
• Woody material
• Bedload
Connectivity

• Specify which of 4 dimensions you’re using (lateral, vertical, longitudinal, time)
• Identify which elements are of interest (organisms, chemistry, bedload, energy)
• Specify time and duration when needed
• Need other tools to assess needs for other flow elements
Holistic Methods

- Downstream Response to Imposed Flow Transformation (DRIFT)
- Decision Flow Assessment (DFA)
- Bayesian Probability Models
- Ecological Limits of Hydrologic Alteration (ELOHA)
Bayesian Probability Models

IF

Action A

THEN

Outcome B

70%

Outcome C

30%
Ecological Limits of Hydrologic Alteration (ELOHA)

**Scientific Process**
- **Step 1. Hydrologic Foundation**
  - Baseline Hydrographs
  - Hydrologic Model and Stream Gauges
  - Developed Hydrographs
- **Step 2. Stream Classification**
  - Stream Hydrologic Classification
  - Geomorphic Stratification
- **Step 3. Flow Alteration**
  - Degree of Hydrologic Alteration
  - Hydrologic Alteration by River Type
- **Step 4. Flow-Ecology Relationships**
  - Flow - Ecology Hypotheses
  - Ecological Data and Indices

**Social Process**
- Implementation
- Environmental Flow Standards
- Acceptable Ecological Conditions
- Societal Values and Management Needs
- Adaptive Adjustments
- Flow Alteration-Ecological Response Relationships by River Type
Holistic Models

- Still address limited range of elements
- Biological outcome is the weakest link
- Refinement is needed
- Research is focused here
Challenges and Opportunities

IFC’s Instream Flow Program Initiative (IFPI)
Top needed resources:

• More supportive state laws and policies
• More institutional capacity & support (agency staff, budgets, & training)
• More knowledgeable and active public

• *Not more or better scientific methods*
Western States E-Flow Status
*(institutional capacity, legal authority, public involvement, protected streams)*

- Alaska
- Colorado
- Washington
- Oregon
- Montana
- Wyoming
- California
- Hawaii
- Idaho
- Utah
- Arizona
- New Mexico
So What?

- Keep discussions real and credible.
- Be specific. Are you talking about water in the creek? Water rights? Water management?
- Talk flow regimes – not minimum flows (even if you can only get a single base flow).
- Define the goal – protection or restoration?
Strategies Depend on Desired Outcomes
(use the right tool for specific questions)

Long-term persistence of organisms comes from long-term persistence of habitat
E-Flow Management is an Important State Tool

- Affirm state rights & control over water
  - Manage water for ESA, TMDL, Hydro, and Wild and Scenic Rivers with state law versus federal law
- Add flexibility & value to private water rights
  - Allow temporary change of use / encourage conservation
- Maximize beneficial uses for public benefit
  - Essential for mitigating impacts of new dams
  - Opportunities should & can be additive / ensure no injury
Maximum public value of water is achieved by developing an integrated system of water management that recognizes public benefits and values from extractive uses as well as environmental flows

(Richter 2009)