Developing Tier 1 Environmental Flow Targets Using a Functional Flows Approach

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Tier 1 Environmental Flow Targets

- Single method statewide based on functional flows approach
- Science-based analysis focusing on:
  - Stream classification
  - Dimensionless Reference Hydrographs
  - Functional flow metrics and ecological endpoints
- Resulting e-flow targets: rapid, coarse, comprehensive across state
**Functional Flows Approach**

Focus on hydrograph flow components that:

- Support natural disturbances
- Promote physical dynamics
- Drive ecosystem functions
- Support high biodiversity

Consideration of geomorphic setting and channel-floodplain dynamics

(Yarnell et al. 2010)
Functional Flows Approach

• “Functional Flow” = hydrograph component that provides a distinct geomorphic, ecologic or biogeochemical function

• Reflective of natural patterns that occur in space & time

Yarnell et al. 2015
Wet Season Initiation Flow

First Flushing Flow

• prepares riverscape by:
  – clearing channel bed of organics, fine sediment
  – reconnecting channel-riparian-floodplain habitats
  – reactivating exchanges with hyporheic zone

• kick-starts ecological processes such as nutrient cycling

• provides key ecological cues for native species to migrate upstream
Peak Magnitude Flow

- Primary geomorphic disturbance
- Resets natural processes such as succession
- Redistributes large volumes of sediment
- Prevents vegetation encroachment
- Reduces extent of exotic species not adapted to disturbance regime
- Most effective when given SPACE – levee setbacks, levee breaches to floodplain, tributary junctions
Spring Recession Flow

High to Low Flow Transition

- Redistributes and sorts sediment mobilized by high flows
- Limits riparian vegetation encroachment
- Provides distinct annual cues for native species to reproduce and outmigrate
- Extended floodplain inundation

(Sacramento River, CA)

(Jeffres et al 2008)
Dry Season Low Flow

• Driver of seasonal river ecosystems
• Dictates extent and quality of physical instream habitat
• Creates ecological niche partitioning with native species utilizing refugia
• More effective when geomorphic diversity provides varied refugia
• Reduces extent of exotic species not adapted to limiting conditions

Santa Clara River, CA
Interannual Flow Variability

Magnitude, timing and duration of specific flow events vary: within their associated season depending on regional climatic conditions, and between years depending on global climate conditions.

Supports diversity in geomorphic habitat and subsequent diversity in native species over the long-term.
Functionality in Practice

- Develop a non-dimensional hydrograph for a hydrologic stream class
- Magnitude, duration set by statistical variability of unimpaired system
- Timing set by aquatic species needs
- Flow targets set based on water year type

Example hydrograph for a hydrologic stream class with key functional flows required for a particular group of aquatic species.
Natural Flow Classes

- **(SM)** Snowmelt
- **(HSR)** High-volume snowmelt and rain
- **(LSR)** Low-volume snowmelt and rain
- **(RGW)** Rain and seasonal groundwater
- **(WS)** Winter storms
- **(GW)** Groundwater
- **(PGR)** Perennial groundwater and rain
- **(FER)** Flashy, ephemeral rain
- **(HLP)** High elevation, low precipitation
Hydrologic Classification

Seasonal variability and relative magnitude of flow

Hydrologic attributes

Reach-scale map

Predictive model

Lane et al. 2016; Stein et al 2016
Dimensionless Reference Hydrographs
## Functional Flow Metrics

Focus on quantitative metrics related to an ecological function

<table>
<thead>
<tr>
<th>Season</th>
<th>Function</th>
<th>Timing</th>
<th>Flow Metrics</th>
<th>Frequency (duration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Cue fish migration</td>
<td>Sept 1 - Nov 30</td>
<td>peak magnitude, percent over baseflow</td>
<td>Annually (2 weeks)</td>
</tr>
<tr>
<td>Winter</td>
<td>Clean spawning gravels</td>
<td>Dec 1 – Apr 1</td>
<td>Peak magnitude, recurrence interval</td>
<td>Once every 5 years (2-4 weeks)</td>
</tr>
<tr>
<td>Spring</td>
<td>Cue and support spawning</td>
<td>March 1 – May 30</td>
<td>Recession rate, duration</td>
<td>Annually (6-8 weeks)</td>
</tr>
<tr>
<td>Summer</td>
<td>Oversummering habitat</td>
<td>Apr 1-Sept 30</td>
<td>Magnitude, recurrence interval</td>
<td>Annually</td>
</tr>
</tbody>
</table>
Functional Flow Calculator
## Functional Flow Calculator

### Season: Winter
- **Function**: Clean spawning gravels; clear riparian
- **Timing**: Nov 1 – Apr 24
- **Flow Metrics**: Peak magnitude (720-2785 cfs)
- **Frequency (duration)**: Once every 5-8 years (10-29 days)

### Winter High Flows

<table>
<thead>
<tr>
<th></th>
<th>Flow (CFS) 0.1</th>
<th>Flow (CFS) 0.5</th>
<th>Flow (CFS) 0.9</th>
<th>Date (First Cross Date) 0.1</th>
<th>Date (First Cross Date) 0.5</th>
<th>Date (First Cross Date) 0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-yr high flow (magnitude &amp; duration)</td>
<td>167</td>
<td>333</td>
<td>719</td>
<td>13</td>
<td>173</td>
<td>333</td>
</tr>
<tr>
<td>10-yr high flow (magnitude &amp; duration)</td>
<td>721</td>
<td>1690</td>
<td>2785</td>
<td>20</td>
<td>114</td>
<td>305</td>
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<tr>
<td>20-yr high flow (magnitude &amp; duration)</td>
<td>877</td>
<td>2162</td>
<td>3401</td>
<td>74</td>
<td>122</td>
<td>146</td>
</tr>
<tr>
<td>100-yr high flow (magnitude &amp; duration)</td>
<td>1264</td>
<td>3133</td>
<td>7275</td>
<td>136</td>
<td>320</td>
<td>349</td>
</tr>
<tr>
<td>Average Annual Flow</td>
<td>757.25</td>
<td>1829.5</td>
<td>3545</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Max Continuous Duration (Days)

<table>
<thead>
<tr>
<th></th>
<th>Flow (CFS) 0.1</th>
<th>Flow (CFS) 0.5</th>
<th>Flow (CFS) 0.9</th>
<th>Frequency # of times above percent 0.1</th>
<th>Frequency # of times above percent 0.5</th>
<th>Frequency # of times above percent 0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-yr high flow (magnitude &amp; duration)</td>
<td>107</td>
<td>140</td>
<td>177</td>
<td>3</td>
<td>6</td>
<td>9</td>
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<tr>
<td>10-yr high flow (magnitude &amp; duration)</td>
<td>10</td>
<td>16</td>
<td>29</td>
<td>4</td>
<td>7</td>
<td>9</td>
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<tr>
<td>20-yr high flow (magnitude &amp; duration)</td>
<td>5</td>
<td>8</td>
<td>14</td>
<td>2</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>100-yr high flow (magnitude &amp; duration)</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
Choose ecological endpoints for each stream class based on scientific literature.

Ecological endpoints and flow metrics vary by stream class.

Relationships based on scientific hypotheses, not detailed analyses.
Tier 1 Environmental Flows

- Functional Flows approach focuses on quantifying and restoring flow components with greatest link to processes.
- Use of reference hydrographs from each hydrologic stream class to quantify functional flow metrics can **rapidly** provide a range of environmental flow targets from which to choose.
- Tier 1 flows serve as the ‘first cut’; Tier 2 flows can be developed if site specific refinement is needed.
- More information coming!