Environmental Flows

John Staelin, Board of Supervisors
Purpose

- Why are we concerned about instream flows
- What are we doing about it
Why Important - Valuable Fishery

“Serious smallmouth anglers know the Shenandoah River is one of the top smallmouth bass rivers in the eastern United States”  
(VA Dept. Game & Inland Fisheries)
Why Important - Tourism

- Big money maker in Valley
- Economic health dependent on minimum flows
Shenandoah Valley located near major metropolitan areas
Why Important:

Aquatic Ecosystems

- Fish depend on certain minimum flows, others depend on fish.
Why Important - Industry
Why Important - Residential
Why Concerned:
10 Year Population Projection

- Shenandoah Valley 9% average increase
- 4 of top 10 Agricultural Producers in Virginia
- Water demand high
Supply and Demand in the North Fork

Maximum Daily Demand (mgd)

Year
2000 2025 2050 2075

Maximum Daily Demand
Low Daily Mean Flow of Record

Graph showing the increase in maximum daily demand from 2000 to 2075.
What are we doing:

Water Supply Planning

- Commonwealth regulates water usage issues withdraw permits
- Major Drought 2002 triggered water supply plan requirements
- 30 year plans compiled to determine projected water consumption
What are we doing:
Water Supply Planning

- Will there be enough water for all in 2040?
  - Business/Industry/Human consumption needs can be calculated/projected
  - Aquatic system needs protection
  - Angler/boaters/tourism harder to define water needs

- What minimum flow level sustains healthy river?
  - Economic/Social Impact
  - Human consumption limits based on scientific data
South Fork Shenandoah River Habitat-Flow Modeling to Determine Ecological and Recreational Characteristics during Low-Flow Periods

Jennifer L. Krstolic & R. Clay Ramey
March 7, 2013

Northern Shenandoah Valley Regional Commission
Central Shenandoah Planning District Commission

In Cooperation with the US Geological Survey
Geographic Setting of the Shenandoah River
USGS Long-Term Monitoring Provides Historic Flow Statistics

<table>
<thead>
<tr>
<th></th>
<th>Front Royal 01631000</th>
<th>Luray 01629500</th>
<th>Lynnwood 01628500</th>
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<tbody>
<tr>
<td><strong>%</strong></td>
<td><strong>Discharge in Mgal/d</strong></td>
<td></td>
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<tr>
<td><strong>Annual</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>95</td>
<td>3,005</td>
<td>2,702</td>
<td>2,023</td>
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<tr>
<td>90</td>
<td>2,042</td>
<td>1,790</td>
<td>1,357</td>
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<td>75</td>
<td>1,138</td>
<td>976</td>
<td>724</td>
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<td>50</td>
<td>613</td>
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<td>390</td>
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<td>304</td>
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<td>228</td>
<td>152</td>
</tr>
<tr>
<td>5</td>
<td>212</td>
<td>198</td>
<td>128</td>
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<tr>
<td><strong>7Q10</strong></td>
<td><strong>160.0</strong></td>
<td><strong>145.0</strong></td>
<td><strong>97.0</strong></td>
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<td><strong>July-August-September</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>95</td>
<td>1,525</td>
<td>1,480</td>
<td>1,034</td>
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<tr>
<td>90</td>
<td>963</td>
<td>737</td>
<td>633</td>
</tr>
<tr>
<td>75</td>
<td>537</td>
<td>497</td>
<td>352</td>
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<td>50</td>
<td>360</td>
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<td>25</td>
<td>271</td>
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<td>171</td>
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<tr>
<td>10</td>
<td>213</td>
<td>200</td>
<td>131</td>
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<tr>
<td>5</td>
<td>187</td>
<td>169</td>
<td>115</td>
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http://waterdata.usgs.gov/va/nwis/current/?type=flow&group_key=basin_cd
What are the Habitat Needs of Fish in the Shenandoah River Watershed?

Non-game Fish

River chub (www.fishbase.org)

Cyprinella spp. (www.fishbase.org)

Game Fish

smallmouth bass (sub-adult and adult)
(Exploration Underwater Photo 2009)
What are the Suitable Flow Ranges for Recreation in the Shenandoah River Watershed?
Benefits and Outcomes

- Field data collection coupled with habitat modeling to provide relevant recreation and ecological flow information for the Shenandoah River Watershed.

- Select drought thresholds from science-based understanding of fish habitat needs.

- Update drought plans to include potential impacts on the aquatic community.

- Test state-mandated “Water Supply Planning Initiative” water-use scenarios for impacts to aquatic habitat.
Field work at each study site:
- GPS and surveying techniques
  - Elevation control for cross sections
  - Habitat mapping via canoe or boat
  - Survey water-surface slope
- Discharge and stage measured for a wide range of summer conditions
  - Acoustic Doppler Current meters used for velocity and discharge.
- Fish Community sampling and habitat
Field: Study Site Design

Study Site and Model Grid
GPS Habitat Mapping by Boat

Riffle: 11.7%
Run: 52.6%
Pool: 35.7%

HTTP://water.usgs.gov/GIS/metadata/usgswrd/XML/ds_539_Shenandoah_Habitat.xml
Fish Habitat-Suitability Curve Field Methods

- Snorkeling
- Electro-shocking
- Habitat Suitability Curves
  - Depth
  - Velocity
  - Substrate
### Fish Habitat Suitability Criteria: Depth

#### Depth Suitability Criteria for fish in the South Fork Shenandoah River

<table>
<thead>
<tr>
<th>Taxa/Life Stage</th>
<th>n</th>
<th>Lower</th>
<th>Optimal</th>
<th>Upper</th>
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<tbody>
<tr>
<td>Sub-adult Smallmouth Bass</td>
<td>61</td>
<td>1.3</td>
<td>1.7</td>
<td>2.9</td>
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<tr>
<td>Smallmouth Bass</td>
<td>45</td>
<td>2.1</td>
<td>2.8</td>
<td>5.5</td>
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<tr>
<td>Juvenile Redbreast Sunfish</td>
<td>31</td>
<td>0.8</td>
<td>1.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Sub-adult Redbreast Sunfish</td>
<td>31</td>
<td>1.3</td>
<td>1.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Redbreast Sunfish</td>
<td>30</td>
<td>0.9</td>
<td>1.6</td>
<td>3.5</td>
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<tr>
<td>Cyprinella spp.</td>
<td>61</td>
<td>0.9</td>
<td>1.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Margined Madtom</td>
<td>30</td>
<td>0.7</td>
<td>0.9</td>
<td>1.6</td>
</tr>
<tr>
<td>River Chub</td>
<td>54</td>
<td>0.1</td>
<td>1.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Young of Year</td>
<td>37</td>
<td>0.9</td>
<td>1.1</td>
<td>2</td>
</tr>
</tbody>
</table>

**HSC:** Depth Velocity Substrate
Model Development to Identify Ecological Flows

River-wide habitat Classification

Fish Community Assessment

Calibration data: Discharge, Depth, Velocity

Historic Streamflow data

RHABSIM Habitat Simulation Model

Discharge

Habitat Area

Manning’s Equation:
\[
V = 1.486 R^{2/3} S_e^{1/2} \frac{1}{n}
\]
Model output for Fish Habitat & Canoeing
Middle Section near Luray

Discharge in cubic feet per second (ft³/s) or million gallons per day (Mgal/d)

EXPLANATION
July–August–September flow percentiles
- >75%
- 25%–75%
- 10%–<25%
- 5%–<10%
- <5%

Ecological (fish) habitat
- Game fish habitat
  - Sub-adult smallmouth bass
- Nongame fish habitat
  - River chub

Recreational (canoe) habitat
- Canoeing
Game Fish Habitat Availability during the Drought of 2002

Sub-adult smallmouth bass Habitat 2002

EXPLANATION

Game fish habitat
- Sub-adult smallmouth bass
- Discharge

Normal range of habitat for July–August–September
- 75% habitat percentile
- 50% habitat percentile
- 25% habitat percentile

Usable habitat area

x 10^6

June July August September October 2002
Conservation Scenarios:

- 10%
- 20%
- 50%

reduction in withdrawals
Water-Withdrawal Reduction Scenarios for the Middle Section

EXPLANATION

- Habitat, no reductions
- 10% reduced withdrawals
- 20% reduced withdrawals
- 50% reduced withdrawals

Normal range of habitat for July–August–September:
- 75% habitat percentile
- 50% habitat percentile
- 25% habitat percentile

Discharge
Increased Water-Use Scenarios:

- 5%
- 20%
- 50%
2002 Increased Water-Use Scenarios for the Middle Section

Game fish: black line = Sub-adult Smallmouth Bass habitat

Usable habitat area

EXPLANATION

- Habitat, no increases
- 5% increased withdrawals
- 20% increased withdrawals
- 50% increased withdrawals
- Normal range of habitat for July-August-September
  - 75% habitat percentile
  - 50% habitat percentile
  - 25% habitat percentile
- Discharge
Findings

- Suitable recreation conditions occur when streamflows are greater than 50 percentile for summer.

- Habitat availability for fish is generally at a maximum when streamflows are between the 25th and 75th percentile.

- A ‘tipping point’ below which habitat loss occurs in the lower part of the watershed was the 5% flow. For the upper portion of the watershed the tipping point was often 10% flow.

- Traditional flow statistics for drought planning (7Q10) are not protective of fish habitat.

- Timing of water withdrawals (or conservation) and preceding flow/habitat condition effects the magnitude of impact they have on habitat availability.

- During normal years, increased water use is not likely to correspond with habitat loss, but during drought years increased water use may cause extensive habitat loss.
Benefits and Outcomes

- Field data collection coupled with habitat modeling to provide relevant recreation and ecological flow information for the Shenandoah River Watershed.

- Select drought thresholds from science-based understanding of fish habitat needs.

- Update drought plans to include potential impacts on the aquatic community.

- Test state-mandated “Water Supply Planning Initiative” water-use scenarios for impacts to aquatic habitat.
Environmental Flows

Alison Teetor
Natural Resource Planner
What are we doing:
Uses of Minimum Instream Flow Data

- Local - Drought Response (current)
- State - Water withdrawal permitting (future)
- Regional - Offsite storage needs (future)
What are we doing: Drought Response Plan

- **Drought Indicators**
  - Precipitation
  - Stream flow
  - Groundwater levels
  - Palmer Drought Severity Index (PDSI)
What are we doing:
Drought Response

- Incorporate low flow data in Drought Response
What are we doing: Drought Response Plan

Stage levels

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cootes Store</th>
<th>Mt. Jackson</th>
<th>Strasburg</th>
</tr>
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<tbody>
<tr>
<td>Normal</td>
<td>62% (&gt;100 cfs)</td>
<td>37% (&gt;120 cfs)</td>
<td>22% (&gt;150 cfs)</td>
</tr>
<tr>
<td>Watch</td>
<td>62% (&lt; 100 cfs)</td>
<td>37% (&gt;120 cfs)</td>
<td>22% (&gt;150 cfs)</td>
</tr>
<tr>
<td>Warning</td>
<td>50% (&lt;60 cfs)</td>
<td>25% (&lt;75 cfs)</td>
<td>5% (&lt;90 cfs)</td>
</tr>
<tr>
<td>Emergency</td>
<td>33% (&lt;25 cfs)</td>
<td>4% (&lt;30 cfs)</td>
<td>1% (&lt;65 cfs)</td>
</tr>
</tbody>
</table>

South Fork Shenandoah Front Royal

<table>
<thead>
<tr>
<th>Stage</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&gt; 25%</td>
</tr>
<tr>
<td>Watch</td>
<td>25%</td>
</tr>
<tr>
<td>Warning</td>
<td>10%</td>
</tr>
<tr>
<td>Emergency</td>
<td>5%</td>
</tr>
</tbody>
</table>
What are we doing:
Drought Response Plan

**Watch**
- Precipitation at or below normal for time period
- Stream Flow 10-25%
- Groundwater 10-25%

**Warning**
- Precipitation at or below normal for time period
- Stream Flow below 10%
- Groundwater below 10%

**Emergency**
- Precipitation at or below normal for time period
- Stream Flow at or below 5%
- Groundwater at or below 5%
Web Site Development Drought Awareness

Drought Indicators Updated on 2008-05-28

<table>
<thead>
<tr>
<th>Drought Intensity</th>
<th>D4 Exceptional</th>
<th>D3 Extreme</th>
<th>D2 Severe</th>
<th>D1 Moderate</th>
<th>D0 Abnormally Dry</th>
<th>Normal</th>
<th>Wet</th>
</tr>
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</tbody>
</table>
What are we doing:
Regional Investment

- Long term regional approach
- 2 Planning Districts, 7 Counties, 4 Cities, numerous towns have all worked together
- 20 years and still going strong USGS partnership
- Long term monitoring data essential
- Stream gage data vitally important
State Water Withdrawal Permitting

MGD by Withdrawal Location
- < 1
- 1 - 5
- 5 - 10
- 10 - 50
- > 50

[Map of Virginia showing water withdrawal locations by MGD.]
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http://va.water.usgs.gov/

Publications:
http://pubs.usgs.gov/sir/2012/5081/
http://pubs.usgs.gov/sir/2006/5025/
http://pubs.er.usgs.gov/publication/wri984157