Risk Assessment Program Progress Report
October 9, 2013
Risk assessment team

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Heather Summers-Biotic endpoints risk assessment

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Report Outline

Updates to the ecological risk assessment
Remediation options and risk reduction
Frequently asked questions---and answers
Updates to the ecological risk assessment

Summarized in the report available on the SRST data site.
This is the schematic of creating a Bayesian network relative risk model (BN-RRM)
Endpoints for the BN-RRM

**Biotic Endpoints-individual models:**
- Smallmouth Bass
- White Sucker
- Belted Kingfisher
- Carolina Wren

**Water Quality-Ecosystem Services:**
- Water quality standards
- Fishing
- Boating
- Recreation
Biotic Risk for each risk region

The highest risk is downstream in regions 4, 5, and 6.
Water Quality Risk for each risk region

More even distribution that the biotic risk

Source of Hg
Waynesboro

15.91
17.71
18.28
17.1
16.03
There are distributions: Risk Comparison for Carolina Wren and region 5 and region 2
Comparing risk to biotic and water quality endpoints
Updates to the ecological risk assessment- Temperature to bass and Hg fish exposure-response.
Temperature and Bass-exposure and response

Lower Lethal Temperatures for SMB Egg/Fry

Upper Lethal Temperatures for SMB Egg/Fry
## Temperature and risk categories

<table>
<thead>
<tr>
<th>Rank</th>
<th>Temperature Ranges</th>
<th>Frequency</th>
<th>R2</th>
<th>R5</th>
<th>R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero</td>
<td>22-26°C</td>
<td></td>
<td></td>
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<tr>
<td>Low</td>
<td>19-21.9 or 26.1-29°C</td>
<td>17.9</td>
<td>27.0</td>
<td>25.1</td>
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<tr>
<td>Medium</td>
<td>16-18.9 or 29.1-31.9°C</td>
<td>15.1</td>
<td>14.1</td>
<td>7.8</td>
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<tr>
<td>High</td>
<td>≤ 15.9 or ≥ 32°C</td>
<td>67.0</td>
<td>42.4</td>
<td>53.3</td>
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</tbody>
</table>

### Scenario 1

<table>
<thead>
<tr>
<th>Rank</th>
<th>Temperature Ranges</th>
<th>Frequency</th>
<th>R2</th>
<th>R5</th>
<th>R6</th>
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<tbody>
<tr>
<td>Zero</td>
<td>18-26°C</td>
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<td>Low</td>
<td>16-17.9 or 26.1-29°C</td>
<td>9.1</td>
<td>18.1</td>
<td>18.5</td>
<td></td>
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<tr>
<td>Medium</td>
<td>14-15.9 or 29.1-31.9°C</td>
<td>11.8</td>
<td>6.9</td>
<td>9.1</td>
<td></td>
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<tr>
<td>High</td>
<td>≤ 13.9 or ≥ 32°C</td>
<td>55.2</td>
<td>35.5</td>
<td>44.5</td>
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### Scenario 2

<table>
<thead>
<tr>
<th>Rank</th>
<th>Temperature Ranges</th>
<th>Frequency</th>
<th>R2</th>
<th>R5</th>
<th>R6</th>
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</thead>
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<td>20-26°C</td>
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<tr>
<td>Low</td>
<td>17-19.9 or 26.1-29°C</td>
<td>20.1</td>
<td>26.6</td>
<td>21.0</td>
<td></td>
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<tr>
<td>Medium</td>
<td>15-16.9 or 29.1-31.9°C</td>
<td>9.3</td>
<td>7.7</td>
<td>8.8</td>
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<tr>
<td>High</td>
<td>≤ 14.9 or ≥ 32°C</td>
<td>61.3</td>
<td>37.1</td>
<td>48.4</td>
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Concentrations and Toxicity

Hg Exposure Response Curve (Dillion et al)

- Reproductive Threshold: 0.04
- Biochemical Threshold: 0.06
- Behavioral Threshold: 0.50
- Growth Threshold: 1.44
- Lethal Threshold: 2.80

Percent Injury (Adult and Juvenile fish) vs. Hg Tissue Residue (mg/kg wet wt)
Comparison to thresholds of Depew et al (2012)

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Percent Injury (Adult and Juvenile fish)

Hg Tissue Residue (mg/kg wet wt)
Goal to refine the risk assessment model-Hg concentration and response
Variation in risk scores for smallmouth bass

<table>
<thead>
<tr>
<th></th>
<th>RR 2</th>
<th>RR 3</th>
<th>RR 4</th>
<th>RR 5</th>
<th>RR 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original scenario risk score</td>
<td>2.5</td>
<td>2.84</td>
<td>4.51</td>
<td>5.57</td>
<td>3.63</td>
</tr>
<tr>
<td>Maximum difference scenario (Temp+Hg) risk score</td>
<td>2.48</td>
<td>2.9</td>
<td>4.54</td>
<td>5.51</td>
<td>3.53</td>
</tr>
<tr>
<td>Cold Temp+ Lower CI Hg risk score</td>
<td>1.83</td>
<td>2.62</td>
<td>4.13</td>
<td>5.07</td>
<td>2.64</td>
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Overall patterns do not change
<table>
<thead>
<tr>
<th>Variables</th>
<th>Input Parameter</th>
<th>State</th>
<th>Value</th>
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<tbody>
<tr>
<td>Anthropogenic Inputs</td>
<td>Phosphorus</td>
<td>Zero</td>
<td>&lt;0.1 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>0.1-0.3 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>0.3 to 0.5 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 0.5 mg/L</td>
</tr>
<tr>
<td></td>
<td>E. coli Levels</td>
<td>Zero</td>
<td>&lt; 200 cfu/100mL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
<td>200-1000 cfu/100mL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 1000 CFU/100mL</td>
</tr>
<tr>
<td>Dissolved Oxygen (DO)</td>
<td>Fall/Winter DO Levels</td>
<td>Normal</td>
<td>&gt; 9 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>5-9 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>&lt; 5 mg/L</td>
</tr>
<tr>
<td></td>
<td>Spring/Summer DO Levels</td>
<td>Normal</td>
<td>&gt; 9 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>5-9 mg/L</td>
</tr>
<tr>
<td>Mercury</td>
<td>Fish Mercury Body Burden</td>
<td>Zero</td>
<td>&gt; 0.3 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>0.3 to 1.0 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>1.1 to 3 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 3 mg/kg</td>
</tr>
<tr>
<td>Deviation in Daily Stream Temperature from 30-year Averages</td>
<td>Fall/Winter Temperature</td>
<td>Zero</td>
<td>± 0-2 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
<td>± 2-4 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 4 °C</td>
</tr>
<tr>
<td></td>
<td>Spring/Summer Temperature</td>
<td>Zero</td>
<td>± 0-2 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
<td>± 2-4 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 4 °C</td>
</tr>
<tr>
<td>Deviation in Daily Stream Discharge from 30-year Averages</td>
<td>Fall/Winter Discharge</td>
<td>No Change</td>
<td>76-125% of 30-yr average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase</td>
<td>126-175% of 30-yr average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decrease</td>
<td>25-75% of 30-yr average</td>
</tr>
<tr>
<td></td>
<td>Spring/Summer Discharge</td>
<td>No Change</td>
<td>76-125% of 30-yr average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase</td>
<td>126-175% of 30-yr average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decrease</td>
<td>25-75% of 30-yr average</td>
</tr>
<tr>
<td>Input of Fish</td>
<td>Fish Stocking</td>
<td>Yes</td>
<td>Fish stocking in risk region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>No fish stocking in risk region</td>
</tr>
</tbody>
</table>
Remediation options and risk reduction

Primary Goal: **NO REGRETS** remediation.

Remediation with no change or perhaps even enhancement of other endpoints.

Inform the decision-making process including the MCDA tool.
Three Remediation Options

Agricultural Best Management Practice to reduce nutrient and other contaminant inputs to the South River.

Stabilized Banks to reduce Hg inputs to the South River.

Biochar to bind Hg and make it inaccessible to biota.
Ag-BMP Analysis

Well understood process that has been demonstrated to reduce nutrient inputs into aquatic systems.

Application of treatment nodes to the risk assessment derived from Hines and Landis.
Ag-BMP Analysis—The model

Smallmouth bass
Region 5
Ag-BMP Analysis—The model

Belted Kingfisher Risk Region 5
Ag-BMP Analysis—The model

Water Quality Risk Region 5
## Agricultural BMPs-Change in risk

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Original risk score</th>
<th>Risk score with Ag BMP</th>
<th>Risk score with “high” level of Ag Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smallmouth Bass</td>
<td>5.53</td>
<td>5.53</td>
<td>5.52</td>
</tr>
<tr>
<td>White sucker</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Belted Kingfisher</td>
<td>2.15</td>
<td>2.14</td>
<td>2.13</td>
</tr>
<tr>
<td>Carolina Wren</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Water Quality-Water Quality Standards</td>
<td>4.9</td>
<td>4.89</td>
<td>4.88</td>
</tr>
<tr>
<td>Water Quality-Fishing Use</td>
<td>3.22</td>
<td>3.22</td>
<td>3.22</td>
</tr>
<tr>
<td>Water Quality-Swimming Use</td>
<td>4.86</td>
<td>4.84</td>
<td>4.81</td>
</tr>
<tr>
<td>Water Quality-Boating Use</td>
<td>4.77</td>
<td>4.75</td>
<td>4.73</td>
</tr>
</tbody>
</table>
Agricultural BMPs-change in risk

Relatively low amounts of each risk region is in agriculture so the ability to reduce inputs is limited.

<table>
<thead>
<tr>
<th>Risk Region</th>
<th>Percent Agricultural Land (Pasture+Crops)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>

Ag-BMP Methods may be applicable to other landuses within the watershed.
Bank Stabilization

Information is available on the change in Hg inputs to an aquatic system.

Information is not as available on the changes in habitat and nutrient inputs into the receiving water.

BN was constructed based upon the remediation plan.
Currently not enough information to build appropriate conditional probability tables to inform the calculation.
Bank Stabilization-Nodes other than Hg affected

*Smallmouth bass*
- Turbidity

*White sucker*
- Stream cover and submerged aquatic vegetation

*Belted Kingfisher*
- Habitat changes, especially for nesting
- Submerged aquatic vegetation
- Turbidity

*Carolina Wren*
- Habitat alteration along the bank

*Water Quality*
- Discharge regime
- Dissolved $O_2$ levels
Biochar

Information can be found on the use of biochar in terrestrial environment as an amendment that increase nutrient availability to plants.

Pilot studies have been conducted in a pond and in a stream microcosm system.

Efficacy of Hg binding and the effects on nutrient dynamics and changes to sediment habitat are not well known.
Biochar BN-RRM Nodes that are affected

Not yet, there are a number of nodes that could be affected and there is not enough information to generate a conditional probability table or to provide input distributions
Biochar BN-RRM model Nodes

Smallmouth bass
- Mercury
- PAHs
- Pesticides

Water Quality
- Mercury
- Total Phosphorus

White sucker
- Mercury
- PAHs
- Stream cover (submerged aquatic vegetation-SAV)
- Pesticides

Belted Kingfisher
- Mercury
- PAHs
- Submerged aquatic vegetation (SAV)

Carolina Wren
- Mercury
- PAHs
- Pesticides
Frequently asked questions---and answers

1. How exactly does the RRM flange with the ACOE adaptive management model?

2. What exactly will come from the RRM and how will those outputs flow in and through the ACOE model?

3. Will the RRM be set up for people to run themselves? How will the SRST be able to use the RRM when we begin our monitoring after the remedies are implemented?

4. What are the major data gaps that remain for inputs to the RRM and which contribute the most uncertainty?
1. How exactly does the RRM flange with the ACOE adaptive management model?
2. What exactly will come from the RRM and how will those outputs flow in and through the ACOE model?

As of October 2013 we have not seen a specific Army Corp of Engineers adaptive management model (MCDA) for the South River System.

Hard to build a flange without the specifications—however we are familiar with MCDA and the goals of the program.
1. How exactly does the RRM flange with the ACOE adaptive management model?
2. What exactly will come from the RRM and how will those outputs flow in and through the ACOE model?

First, we can calculate what the conditions in the South River should be in order to reduce risk in a particular region.

Second, if there is going to be one or more remediation processes used we can calculate risk and specifically target unintended consequences.
1. How exactly does the RRM flange with the ACOE adaptive management model?
2. What exactly will come from the RRM and how will those outputs flow in and through the ACOE model?

Third, the BN-RRM is now able to look at how remediation options such as BMPs for agriculture and bank stabilization alter risk to the South River. Already we can point to important data needs as far as how bank stabilization will alter nutrient inputs and habitat.
3. Will the RRM be set up for people to run themselves? How will the SRST be able to use the RRM when we begin our monitoring after the remedies are implemented?

The answer is yes and no.

Yes

We have CDs with the Region 2 Bayesian network models for all of our endpoints. The BNs are written using Netica (https://www.norsys.com/) and our models can be read by using the free version. Our goal is to put the models on the SRST server for everyone on the team.
3. Will the RRM be set up for people to run themselves? How will the SRST be able to use the RRM when we begin our monitoring after the remedies are implemented?

No

We do not plan on making a plug and play version so that anyone can put in numbers and get output without an understanding of Bayesian networks.

However, there are a number of laboratories and consultants that have a knowledge of the use of Bayesian networks in general and the BN-RRM in particular.
3. Will the RRM be set up for people to run themselves? How will the SRST be able to use the RRM when we begin our monitoring after the remedies are implemented?

As far as using the model as part of the monitoring program we are already working with the monitoring committee of the SRST. Monitoring would likely result in changes to the parent nodes in the various models.

We have already presented our models as they would be applied to evaluating the efficacy and unintended consequences of remediation activities.
4. What are the major data gaps that remain for inputs to the RRM and which contribute the most uncertainty?

**Current Risk Assessment**

We have no data on the upper reach (region 1) of the South River although nutrients and other materials come down that part of the watershed. So we are declining to calculate risk for that region. Not knowing those inputs are also a source of uncertainty for calculating risk in region 2.

There are no data on fish community composition along the river. Our experience has been that fish and macroinvertebrate community structure can be very informative in detecting patterns in freshwater systems.
4. What are the major data gaps that remain for inputs to the RRM and which contribute the most uncertainty? (See Table 1 of report)

**Remediation options**

Ag-BMPs are the best characterized and we have completed our first cut models.

Bank stabilization has been used and it does reduce Hg concentrations. It is not clear what the impacts are to nutrient inputs and aquatic habitat.

Biochar has only been used in pilot studies. There is little information on the effects of biochar on Hg and the nutrients in a river environment.
4. What are the major data gaps that remain for inputs to the RRM and which contribute the most uncertainty? (See Table 1 of report)

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Bank stabilization has been used and it does reduce Hg concentrations. It is not clear what the impacts are to nutrient inputs and aquatic habitat.

Biochar has only been used in pilot studies. There is little information on the effects of biochar on Hg and the nutrients in a river environment.
So where do things stand?

1. We have finalized the current assessment with updates for water temperature, Hg fish toxicity, and water quality.

2. Models that incorporate two of the three remediation methods have been constructed.

3. A variety of data gaps exist and uncertainty needs to be reduced.