Study Plan

to

Augment Data for the Development of Large River Nutrient Enrichment Indicators

Division of Surface Water
Ecological Assessment Section
June 1, 2016
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Background

Nutrient enrichment indicators for large rivers have yet to be established. To date, collection of data to support the development of large river enrichment indicators has been on an add-on basis, and has resulted in ~ 49 sites with a mostly complete set of observations (none of the large river sites has a complete set of observations). That said, lines of evidence supporting potential indicators can be drawn from existing data analyzed in light of the state of the science. For example, Minnesota found a strong relationship between sestonic chlorophyll, BOD5 and biological quality. Within our own data, a strong relationship exists between chlorophyll and BOD5, and BOD5 and biological quality, as evidenced in Figure 1. The plots in Figure 1 are drawn from 49 sites where chlorophyll, BOD5 and EPT were all sampled, and show a clear pathway from chlorophyll to BOD5 to EPT. From the larger, historic database, where matched data are lacking, a strong relationship between TSS and chlorophyll is evident, as would be expected, and between TSS and EPT richness (Figure 2). For all BOD5 data (i.e., either matched or unmatched to chlorophyll), biological indicators show strong negative correlations with BOD5 (Figure 3).

The upshot of all this is that the suite of enrichment indicators are obvious, and benchmarks that indicate over-enrichment are clearly suggested: e.g., sestonic chlorophyll > 50 ug/l, BOD5>3 mg/l, TSS>40 mg/l. However, the sample size for fully matched data is rather small, so any resulting conclusions drawn with respect to the biological indicators is necessarily open to question. Augmenting the data set with 21 sites where a complete complement of parameters are sampled would add credibility to the results at hand and should prove sufficient to support development of a water quality standard.

A list of sites and sampling parameters is included in Table 1. Note that with the exception of stations H11W20 (Great Miami River at RM ~15) and H11S26 (Whitewater River), all access points are public.

Because drainage areas of sampling locations range from 700 to 7000 mi², and follow a normal distribution, benthic chlorophyll should be sampled at all locations where site-specific conditions allow collection. This will help determine the upper practical limit for the SNAP method.

Figure 1. Relationships between a) chlorophyll and BOD5, and b) EPT richness adjusted for drainage area and BOD5. Note that these figures are drawn from matched data.
Figure 2. Relationships between TSS and chlorophyll, and TSS and EPT richness. If EPT richness is corrected for drainage area for the matched data (where the sample size is smaller), the relationship between EPT and TSS shows a negative trend.

Figure 3. Scatter plots of IBI and EPT richness by BOD5, stratified by stream size (2-wadeable, 3- small rivers, 4-large rivers).
Table 1. List of proposed sampling locations to support development of large river nutrient standards. Gray-shaded sites are ambient water quality stations. The gray-shaded rows indicate monthly ambient monitoring stations. Samples: B-bugs, F-Fish, D-sondes, SC-sestonic chl, BC-benthic chl, WC-water/field chem.

<table>
<thead>
<tr>
<th>Station Name</th>
<th>rivercode</th>
<th>rm</th>
<th>da</th>
<th>lat</th>
<th>long</th>
<th>Samples/Collectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scioto River @ US 22 Circleville</td>
<td>02-001-000</td>
<td>99.82</td>
<td>3217</td>
<td>39.6015</td>
<td>-82.9551</td>
<td>SM RM SB SB RM RM, SB</td>
</tr>
<tr>
<td>Scioto R. On North End Of Chillicothe @ U.S. Rt. 35</td>
<td>02-001-000</td>
<td>71.8</td>
<td>3846</td>
<td>39.3469</td>
<td>-82.9836</td>
<td>SM RM SB SB RM RM, SB</td>
</tr>
<tr>
<td>Scioto R. At Portsmouth @ U.S. Rt. 52</td>
<td>02-001-000</td>
<td>0.93</td>
<td>6512</td>
<td>38.7394</td>
<td>-83.0025</td>
<td>SM RM SB SB RM RM, SB</td>
</tr>
<tr>
<td>Maumee R W Of Defiance, @ Bend Rd.</td>
<td>04-001-000</td>
<td>76.15</td>
<td>2292</td>
<td>41.2753</td>
<td>-84.5150</td>
<td>SM RM PG PG RM RM, PG</td>
</tr>
<tr>
<td>Maumee R. @ Farmersville</td>
<td>04-001-000</td>
<td>54.87</td>
<td>5562</td>
<td>41.3206</td>
<td>-84.2000</td>
<td>SM RM PG PG RM RM, PG</td>
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<tr>
<td>Maumee R. At Waterville @ St. Rt. 64</td>
<td>04-001-000</td>
<td>20.68</td>
<td>6330</td>
<td>41.5003</td>
<td>-83.7141</td>
<td>SM RM PG PG RM RM, PG</td>
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<tr>
<td>Auglaize R. At Cloverdale @ St. Rt. 114</td>
<td>04-100-000</td>
<td>28.5</td>
<td>719</td>
<td>41.0208</td>
<td>-84.2889</td>
<td>SM RM PG PG RM RM, PG</td>
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<tr>
<td>Muskingum R. Dist. Coshocton @ St. Rt. 83</td>
<td>17-001-000</td>
<td>108.28</td>
<td>4861</td>
<td>40.2361</td>
<td>-81.8717</td>
<td>SM RM SB SB RM RM, SB</td>
</tr>
<tr>
<td>Tuscarawas R. Near Orange @ St. Rt. 751</td>
<td>17-500-000</td>
<td>15.25</td>
<td>2480</td>
<td>40.2856</td>
<td>-81.6844</td>
<td>SM RM SB SB RM RM, SB</td>
</tr>
<tr>
<td>Walhonding R. At Coshocton @ U.S. Rt. 36 notice lat and long for public access</td>
<td>17-600-000</td>
<td>0.76</td>
<td>2255</td>
<td>40.2867</td>
<td>-81.8738</td>
<td>SM RM SB SB RM RM, SB</td>
</tr>
<tr>
<td>L. Miami R. At Milford, 0.98 Mi Upst. Wooster Pike</td>
<td>11-001-000</td>
<td>14.05</td>
<td>1200</td>
<td>39.1821</td>
<td>-84.2886</td>
<td>CM RM PG PG RM JJ, LM, MW</td>
</tr>
<tr>
<td>Great Miami R. At Dayton, 0.7 Mi. Upst. Railroad</td>
<td>14-001-000</td>
<td>85.2</td>
<td>1171</td>
<td>39.7989</td>
<td>-84.1625</td>
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<tr>
<td>Great Miami R. @ Farmersville-West Carrollton Rd.</td>
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<td>69.87</td>
<td>2647</td>
<td>39.6744</td>
<td>-84.2617</td>
<td>CM RM PG PG RM JJ, LM, MW</td>
</tr>
<tr>
<td>Great Miami R. At Miamiisburg @ Linden Ave.</td>
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<td>66.9</td>
<td>2711</td>
<td>39.6406</td>
<td>-84.2922</td>
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<tr>
<td>Great Miami R. At Franklin @ Old St. Rt. 123</td>
<td>14-001-000</td>
<td>60.58</td>
<td>2728</td>
<td>39.5631</td>
<td>-84.305</td>
<td>CM RM PG PG RM JJ, LM, MW</td>
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<tr>
<td>Great Miami R. Near Middletown @ St. Rt. 73</td>
<td>14-001-000</td>
<td>49.27</td>
<td>3189</td>
<td>39.4814</td>
<td>-84.4428</td>
<td>CM RM PG PG RM JJ, LM, MW</td>
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<tr>
<td>Great Miami R. @ Liberty-Fairfield Rd.</td>
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<td>43.23</td>
<td>3280</td>
<td>39.4293</td>
<td>-84.4764</td>
<td>CM RM PG PG RM JJ, LM, MW</td>
</tr>
<tr>
<td>Great Miami R. At Miamitown @ Harrison Rd.</td>
<td>14-001-000</td>
<td>15.49</td>
<td>3838</td>
<td>39.2161</td>
<td>-84.7035</td>
<td>CM RM PG PG RM JJ, LM, MW</td>
</tr>
<tr>
<td>Whitewater R. W Of Hooven @ Suspension Bridge Rd.</td>
<td>14-300-000</td>
<td>1.5</td>
<td>1469</td>
<td>39.1831</td>
<td>-84.7928</td>
<td>SM RM PG PG RM JJ, LM, MW</td>
</tr>
</tbody>
</table>

1Collect where feasible
2Sampling by committee in sites located outside SWDO
3AD to help as needed
Table 2. Sample counts.

<table>
<thead>
<tr>
<th>Media/Category</th>
<th>Samples</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>Fish</td>
<td>42 boat samples</td>
</tr>
<tr>
<td></td>
<td>Macroinvertebrates</td>
<td>21 HD; 21 quals</td>
</tr>
<tr>
<td>Chlorophyll a</td>
<td>Sestonic</td>
<td>21 sites x 4 events = 84 (+8 splits &amp; 8 blanks)</td>
</tr>
<tr>
<td></td>
<td>Benthic</td>
<td>collect where conditions permit</td>
</tr>
<tr>
<td>Sonde</td>
<td></td>
<td>42 deployments</td>
</tr>
</tbody>
</table>

Water Chemistry – Follow the Large River Template with cBOD5, cBOD20 and Ortho-P added

**Demand**

- BOD5, cBOD5, cBOD20
- TSS, TDS, TOC
  - 4 runs$^3$ x 21 sites = 84
  - 4 runs x 21 sites = 84

**Nutrients**

- Acidity, Alk, NH3, Chloride, COD, NO2, NOx, Ortho-P, TP, SO4, TKN
  - 4 runs x 21 sites = 84

**Metals**

- ICP 1
  - 4 runs x 21 sites = 84

**Field Parameters**

- Temperature, D.O., Sp.Cond., pH
  - 4 runs x 21 sites = 84

$^3$To coincide with sestonic chlorophyll

Contacts for field access:

Harrison Avenue (H11W20), Ron Schmidt, 1-513-478-5154

Whitewater (H11S26) via Green Acres Canoe, Sharon Lutz, 1-513-353-4770

Miami Township Park (H11K14) upstream US 50, Ron Miller, 1-513-305-5787 (call needed only for boat access)
QUALITY ASSURANCE/SAMPLING METHODS

Ohio EPA Manuals
All biological, chemical, data processing, and data analysis methods and procedures adhere to those specified in the Surface Water Field Sampling Manual for water column chemistry, bacteria and flows (Ohio EPA 2015a), Biological Criteria for the Protection of Aquatic Life, Volumes II - III (Ohio EPA 1987, 1989a, 2015b), 2015 Updates to the Biological Criteria for the Protection of Aquatic Life, Volume II (Ohio EPA 2015c), The Qualitative Habitat Evaluation Index (QHEI) - Rationale, Methods, and Application (Ohio EPA 1989b, 2006) for habitat assessment, Surface Water Field Sampling Manual – Appendix III for sediment sampling (Ohio EPA 2015a), and Ohio EPA Fish Tissue Collection Guidance Manual (Ohio EPA 2012) for fish tissue sampling.

Use Attainment
The attainment status of aquatic life uses will be determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. Numerical biological criteria are based on multi-metric biological indices including the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), indices measuring the response of the fish community; and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes et al. 1986, Omernik 1987). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is full if all three indices (or those available) meet the applicable criteria; partial if at least one of the indices did not attain, and performance did not fall below the fair category; and non if all indices either fail to attain or any index indicates poor or very poor performance. The results will be compared to WWH biocriteria for the Western Allegheny Plateau (WAP) ecoregion.

Recreational use attainment will be determined using E. coli bacteria, which are indicator organisms for the potential presence of pathogens in surface water. E. coli can originate from untreated human or animal wastes, and they are the basis for recreational use water quality criteria in Rule 3745-1-07 of the (OAC).

Stream Habitat Evaluation
Physical habitat is evaluated using the (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Ohio EPA 1989b). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable and diverse aquatic faunas. Evaluations of the type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to evaluate the characteristics of a stream segment. Individual sites may have much poorer physical habitat due to a localized disturbance, yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values higher than 60 were generally conducive to the establishment of warmwater faunas while those which scored in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

Biological Community Assessment
Quantitative macroinvertebrate sample will be collected from artificial substrates, and qualitative samples from natural stream habitats. Artificial substrate collections will be collected at all sites with greater than
20 mi² drainage areas, or at reference site locations. This sample provides quantitative data and consists of a composite sample of five modified Hester-Dendy multiple-plate artificial substrate samplers which are allowed to colonize for six weeks. Qualitative sampling will be conducted at all sampling locations. This sampling effort consists of an inventory of all observed macroinvertebrate taxa from the natural stream habitats at each site with no attempt to quantify populations, other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, and margin). Detailed macroinvertebrate assemblage sampling protocols are documented in Ohio EPA (2015b).

Fish will be sampled at each sampling location using pulsed DC headwater, wading, or boat electrofishing methods depending on watershed size at each sampling location. Sites with drainage areas greater than 20 mi², and at reference site locations, will be sampled twice during the sampling index period. Fish are processed in the field, which includes identifying each individual to species, counting individuals at all sites, weighing individuals at wading and boat sites, and recording any external abnormalities. Detailed fish assemblage sampling protocols are documented in Ohio EPA (2015b).

**Chlorophyll**
Benthic and sestonic chlorophyll-a samples will be collected and preserved using appropriate methods, as outlined in Ohio EPA (2015a Volume II), and delivered to the Ohio EPA DES lab for analysis. Alkalinity must be requested as a routine water quality parameter at all study sites along with the routine field parameters, especially temperature and pH.

**Surface Water**
Surface water grab samples will be collected and preserved using appropriate methods, as outlined in Ohio EPA (2015a), and delivered to the Ohio EPA Division of Environmental Services lab for analyses. Field measurements of dissolved oxygen, pH, temperature, and conductivity will be made using field meters. Automated data loggers will record hourly measurements of dissolved oxygen, pH, temperature, and conductivity. Water quality parameters to be collected at every site are noted in Table 2.

**Field Quality Control Samples**
Ten percent of the sediment, water, and bacteria samples will be submitted to the lab as field duplicates and field blanks; approximately 5% will be duplicates and 5% will be blanks. One sonde recorder site will have two instruments placed in the river as field duplicates. Field blanks will occur at a minimum of 5 percent of the water samples. Field instruments will be calibrated daily, using manufacturer guidelines and requirements noted in Ohio EPA (2015a). Matrix spike duplicates will be collected for organic water samples at a minimum of 5 percent of the samples.
REFERENCES


Ohio EPA. 1989b. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Division of Water Quality Planning and Assessment, Columbus, Ohio. http://www.epa.state.oh.us/dsw/bioassess/BioCriteriaProtAqLife.html
