Maryland Temperature TMDL Development

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WHY TEMPERATURE TMDLS?
Temperature and Aquatic Life

• Many aquatic species have a preferred temperature range and cannot sustain life outside of this range.

• Water temperature exerts a major influence on feeding, reproduction, and growth.

• Temperature is also important because of its influence on gas solubility, specifically decrease in dissolved oxygen.
Temperature and Trout

• The eastern brook trout are an important cold-water species of North America.

• Studies have found an optimal temperature for trout propagation (13-16°C), but few have investigated an upper threshold for growth.

• Literature value is 68°F/20°C, which is what we use as our criteria
Process Overview

1. Assessment
2. Integrated Report Listing
3. TMDL
DESIGNATED USE CRITERIA,
INTEGRATED REPORT LISTING METHODOLOGY,
TMDL DEVELOPMENT MONITORING DATA
MD Use Class Designations

- Use Class I: Protection of Aquatic Life Water Contact Recreation
- Use Class II: Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting
- Use Class III: Nontidal Cold Water
- Use Class IV: Recreational Trout Waters
• Maryland Biological Stream Survey (MBSS)
  https://dnr.maryland.gov/streams/Pages/mbss.aspx

• Probabilistic random sampling method performed by MD DNR, designed to assess the entire state. Samples 1\textsuperscript{st} through 4\textsuperscript{th} order wadeable streams

• Air and water temperature recorded at 20 minute intervals from June 1 to August 31, compiled to daily average value
Impairment Listing Methodology (I)

Step 1: Temperature Data Available – Meets all protocols?
  No
  Yes

Step 2: Assessment of Temperature: 90th percentile ≤20°C; Max<23.8°C
  No
  Yes

Step 3a: Are there young-of-year (YOY) and multiple year classes (MYC) of at least one trout species?
  Yes
  No

Step 3b: Is there more than one coldwater obligate found at a site (same or different genera)?
  Yes
  Cold water obligates absent or diminished
  No

Step 4: Assessment Decision

Stream placed in Category 2 (meeting temperature standards) of the IR for temperature.

Stream placed in Category 3 (insufficient data) of the IR for temperature. Prioritized for follow-up monitoring.

Stream placed in Category 5 (impaired) of the IR for temperature impairment.
Impairment Listing Methodology (II)

Step 1: Temperature Data Available – Meets all protocols?

- Yes
- No

Step 2: Assessment of Temperature - 90th percentile ≤20°C; Max<23.8°C

- Yes
- No

Step 3: Assessment Decision
- Stream placed in Category 2 (meeting temperature standards) of the IR for temperature.
- Stream placed in Category 3 (insufficient data) of the IR for temperature. Prioritized for follow-up monitoring.
- Stream placed in Category 5 (impaired) of the IR for temperature impairment.

Additional MDE Monitoring for TMDL Development
TMDL DEVELOPMENT
Other States TMDLs

- Mostly forested watersheds impacted by logging
- Did use concept of thermal energy loads
Water temperature is influenced by numerous natural variables, including:

- Solar radiation
- Air temperature
- Ground temperature
- Precipitation
- Surface water inflows
- Groundwater exchanges
TMDL Modeling Overview

- Hydrology
- Temperature
- Various modeling scenarios calculated
- Conversion of temperature to thermal energy
Physically based, continuous model developed to predict the impact of land management practices on water

https://swat.tamu.edu/
SWAT Hydrology Model

- Includes the following components:
  - Weather
  - Surface runoff
  - Return flow
  - Percolation
  - Evapotranspiration
  - Transmission losses
  - Pond and reservoir storage
  - Crop growth and irrigation
  - Groundwater flow
  - Reach routing
  - Nutrient and pesticide loading
  - Water transfer

- Automatic calibration
Hydrology Calibration

USGS 01589300 Gwynns Falls at Villa Nova, MD

Legend:
- Streamflow monitoring station
- Watershed boundary
- Use Class III - Nontidal cold water

Map showing streamflow data and watershed boundary with indicator points and arrows.
SWAT Temperature Model

• Reflects combined influence of meteorological (air temperature) and hydrological conditions (streamflow, snowmelt, groundwater, rainfall, surface runoff, and lateral soil flow) on water temperature within a watershed.

• The model calculates stream temperature in three steps:
  1. Temperature and amount of local hydrological contributions (snowmelt, surface runoff, and groundwater) within the subbasin
  2. Temperature and inflow volume from upstream subbasin(s)
  3. Heat transfer at the air-water interface during the streamflow travel time in the subbasin.
## TMDL Allocation Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>% retrofit</th>
<th>% riparian cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0</td>
<td>68</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>8</td>
<td>75</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>18</td>
<td>83</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>30</td>
<td>90</td>
</tr>
</tbody>
</table>

![Graph showing TMDL Allocation Scenarios](image)

**Graph Description**: The graphs illustrate the level of implementation for retrofit and riparian canopy scenarios across different scenarios. The vertical bars represent the level of implementation, while the line indicates the 90th percentile temperature.
Conversion to Thermal Energy

\[ H = TC_p V \rho = \text{GJ/d} \]

Where:

- \( H = \text{heat, J s}^{-1} \)
- \( T = \text{water temperature, } ^\circ\text{C [from SWAT model]} \)
- \( C_p = \text{specific heat, 4,184 J (kg } ^\circ\text{C})^{-1} \)
- \( V = \text{streamflow volume, m}^3/\text{s [from SWAT model]} \)
- \( \rho = \text{water density, 1,000 kg/m}^3 \)
TMDL Implementation

• Two main mechanisms:
  – Urban retrofit
  – Riparian canopy – 50 m buffer

• MS4 permits

• WLA implementation plans
Contact

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Development of Jurisdictional Guidance in Order to Implement for Temperature TMDLs

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Integrated Water Planning Program, Water Science Administration

August 11, 2020
Integrated Water Planning Program (IWPP)

- IWPP is part of the Water and Science Administration (WSA)
  1. TMDL Development
  2. Watershed Restoration Division
  3. Water and Sewer Plan Review
Outline

- Mission: Develop a TMDL and WIPs that inform conservation of in-stream conditions that support sustainable wild trout
- TMDLs and DUs (to set the stage)
- Implementation Guidance
- Resource based water quality management
- Spatially oriented prioritization
Use Class-III (-P) Designated Uses

- Use Class I: Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life
- **Use Class I-P: Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply**
- Use Class II: Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting
- **Use Class II-P: Tidal Fresh Water Estuary – includes applicable Use II and Public Water Supply**
- **Use Class III: Nontidal Cold Water**
- **Use Class III-P: Nontidal Cold Water and Public Water Supply**
- Use Class IV: Recreational Trout Waters
- **Use Class IV-P: Recreational Trout Waters and Public Water Supply**
Use Class III Waters of Maryland are in Green
TMDL = \( \sum \text{WLA} + \sum \text{LA} + \text{MOS} \)

Clean Water Act mandates development of TMDLs for all the waters identified on their Section 303(d) list of impaired waters.

- \( \sum \text{WLA} = \) sum of wasteload allocations (point sources)
  - NPDES Stormwater Wasteload Allocation (SW-WLA)
- \( \sum \text{LA} = \) the sum of load allocations (nonpoint sources and background)
- MOS = margin of safety
Achieving Reductions

• Ideal approach for achieving actual reductions/progress is a combination of modeling tools and BMPs with spatially oriented processes/methods and data collection
Fundamentals

- Processes (i.e. methodologies) get reductions
  - Develop a robust and curated reference
  - Information hubs
  - Temperature database to aggregate information across jurisdictions.

  Washington State “Freshwater Information Network”
Local TMDL Implementation

• Most implementation driven by:
  – NPDES Surface Water discharge permits
  – NPDES MS4 permits

• Phase I stormwater permits in Maryland require the development of TMDL stormwater wasteload allocation (SW-WLA) implementation plans for all applicable pollutants.
What is in these SW-WLA (watershed) implementation plans?

MS4 permit requirements for SW-WLA WIPs include five basic elements:
1. Schedule of projects and programs with end date
2. Accounting of cost estimates
3. Detailed monitoring and modeling plan
4. Specific adaptive management process
5. Set up a system of accountability; technologically relevant forms of public engagement
• Maryland DOT State Highway Administration
• Anne Arundel
• Baltimore City
• Baltimore County
• Carroll County
• Charles County
• Frederick County
• Harford County
• Howard County
• Montgomery County
• Prince George’s County
Prioritize the resource-base and/or the designated use to drive planning

- Resources defined by designated use:
  - Use Class -P/Reservoirs/Irrigation/Appropriations
  - Beaches/Public Bathing
  - Wild Fisheries
  - Aquaculture
  - Agricultural Water Supply (FDA Regulations)
- Existing planning structures:
  - 319 non-point source plans (for working landscapes)
  - Scenic and Wild Rivers Program (for tourism)
• **Requires a process, not just a framework**
  • Partnerships with other agencies driven by Chesapeake Bay WIP development
    – DNR
      • Fisheries
      • Forest Service
    – Maryland Department of Planning
    – Maryland Department of Health
    – Maryland Department of Agriculture
• IWPP initiating resource-based processes with the
  – Baltimore City Reservoir Technical Group (RTG)
  – Patuxent Reservoirs Technical Advisory Committee (TAC)
  – Potomac River Basin Drinking Water Source Protection Partnership (DWSPP)
Measuring progress outside of a modeling environment

- Not all actions can be explicitly represented in the available models
- Maintain jurisdictional authority with a purpose by helping jurisdictions document the importance of localized natural resource economics
- The CWA and SDWA are conveyor belts of data in state-based water programs
- Evaluating through risk and resource connection
Resources and Risks

• The resource goal—*in Clean Water Act language terms, the Trout Growth and Propagation Designated Use*—is achieved after all of the life history requirements of wild trout have been satisfied.
  – Coldwater obligate species
  – Spawning and nursery habitat
  – Ensuring adequate food organisms
  – Maintaining sufficient fish passage

• Thermal impairments are caused by:
  – altered hydrologic regimes
    • impervious surfaces
    • dams
    • groundwater withdrawals
    • drain tile/ditching
    • deforestation
1. MDE Data
   a. Water Supply (i.e. appropriations)
   b. Sediment Stormwater and Dam Safety
   c. Environmental Assessment and Standards
      i. Tier II Program
   d. NPDES
      i. All discharges, including CAFOs

2. DNR Data
   a. Fisheries
   b. Hatcheries (critical for constituent engagement)
   c. Forest Service

3. Jurisdictional Data
   a. Stormwater Geodatabase

4. Non-governmental
   a. The Nature Conservancy
   b. Trout Unlimited
1. Watershed Characterization
2. Water Resource Development
3. Linkages Among the Watershed, Populations
4. Land Use Practices
5. Goals of Stream Habitat Restoration
6. Cautions for Habitat Enhancement and Restoration
7. Stream Habitat Factors
8. Habitat protection: Preventing and Remedying Adverse Habitat Modifications
9. Habitat Restoration
10. Habitat Enhancement
11. Habitat Degradation
12. Presence of non-native Species
13. Quality of Spawning Habitat
14. Interannual Variability of Recruitment
15. Streamflow Management
16. Life History and Behavioral Patterns of Salmonids
17. Factors Influencing Salmonid Abundance
18. Coldwater Stream Management
   a. Regulation of the Fishery
   b. Characteristics of Coldwater Streams and Economic Value of Cold water Stream Fisheries
   c. Local Sportfishing Opportunities
   d. Role of hatcheries in fisheries management
Linking Planning Needs and Reporting Requirements

- Jurisdictions need to outline short-term, mid-term and long-term planning metrics for technical adaptive management for:
  - BMP Effectiveness
  - Watershed-scale progress
  - Fisheries
- Maryland Biological Stressor Identification Methodology
  - Example: submetrics for in-stream habitat
    - Channelization present
    - Concrete/gabion present
    - Beaver pond present
    - Instream habitat structure
    - Pool/glide/eddy quality
    - Riffle/run quality
    - Velocity/depth diversity
Rudimentary planning horizons (temperatures borrowed from Hilderbrand 2009):

- Jurisdictions will report based on short-term, mid-term, and long-term planning horizons
- Short-term management goals
  - Short-term: limit the maximum daily temperature changes to less than 9 degrees celsius
  - Short-term: limit the average daily fluctuation to 3 degrees celsius
  - temperature intervals
  - specific sub-watersheds
  - specific life-cycle periods
  - habitat connectivity
- Mid-range planning metrics
  - Mid-term: maximum daily temperatures should not exceed 22 degrees celsius
  - degree of within-stream variability in temperatures
  - maximum fluctuation in a stream that still supported trout was 9°C (Hilderbrand 2009)
  - acute thermal shock from mixing zones
- Long-term planning horizons
  - Long-term: maximum daily temperature should not exceed 20 degrees celsius
  - meeting in-stream temperature criteria
  - presence of a self-sustaining trout population
Reporting progress is not just for compliance

• Post implementation monitoring depends on planning horizons
• What data and programmatic information from internal and jurisdictional reporting exist?
  – Identify data gaps spatially and temporally
  – Perceive future pressures
• Electronic data submission of temperature and spatial data
• Maps of “mitigation potential”
• Identify operational constraints
• Interjurisdictional stream temperature database
• Translating stream temperatures to thermal habitats
  – NorWeST project methodology
Implementation and BMPs

• Prioritize practices that promote wild trout
• BMPs that promote thermal remediation categorized in two ways:
  – Stormwater management facilities
  – Land use change practices (e.g. riparian reforestation, stream shading, reduction of impervious surfaces)
• BMPs that mimic natural stream hydrology
• Focus restoration efforts in headwaters and where trout exist
• Design BMPs
  – deeper
  – shaded
  – fish passage
  – minimize groundwater withdrawals
  – protect riparian zones
Adaptive Management is NOT a Catch Phrase

- Technical process using management triggers
- View the TMDL endpoint in the context of the resource base
  - Projects that provide a benefit to the fishery could be prioritized
- Uncertainty requires tracking implementation in alternative ways
  - Monitoring the amount of water (appropriations) in trust
  - Irrigation improvements
  - Road improvements
- Stakeholders need to use joint fact finding
  - Spatial data compilation
  - Creates a common purpose for the workgroup experience
  - WQSs cannot be achieved?
    • “Use Attainability Analysis”?
      - No internal consensus on the adaptive management framework?
        » Then a coordinated workgroup cannot be established…
    • and WQSs cannot realistically be addressed.
Wrap-up

• Mission: Develop a TMDL and WIPs that inform conservation of in-stream conditions that support sustainable wild trout

• TMDLs and DUs (to set the stage)

• Implementation Guidance

• Resource based water quality management

• Spatially oriented prioritization

• ICPRB Upper Potomac River Temperature Studies presented at a drinking water meeting
American Fisheries Society

- Developing a symposium at the Annual Meeting of the American Fisheries Society next summer in Baltimore

- 2021 Baltimore, MD: August 8-12, 2021

- Please be in touch to collaborate!

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