Developing a Microbial TMDL* for Northeast Creek

Environmental Management and Policy Practicum

Fall 2005

*TMDL = Total Maximum Daily Load
Total Maximum Daily Load (TMDL) Program

- Section 303(d) of the Clean Water Act requires
  - States to identify waters not meeting ambient water quality standards
  - Define the pollutants and sources responsible for impairment
  - Establish a TMDL (for each pollutant) necessary to meet standards
  - Allocate responsibility to sources for reducing pollutant output
- USEPA made little progress on this for many years
- In the early 1990s USEPA was sued by environmental groups for its failure to enforce the Clean Water Act
- Court directs USEPA and the states to develop TMDLs for all impaired water bodies in the United States
- USEPA and the states must complete an estimated 4,000 TMDLs per year over the next 10 years to comply with court ruling
- Elevated concentrations of fecal indicator organisms (e.g., fecal coliforms) are a leading cause of biological impairment
Northeast Creek

- A 303(d)-listed, 8.4 mile long stream segment located upstream of Jordan Lake
- Identified as "high priority" for TMDL development due to high fecal coliform counts arising from stormwater/urban runoff
- Biological impairment the most frequently cited reason for 303(d) listing of North Carolina water bodies
- Objective of this project is to characterize the problem
  - Identify the sources and of the microbial contaminants
  - Characterize the partitioning behavior of the microbes
  - Compare the sources and behavior of indicators and pathogens
- Developing a Total Maximum Daily Load limit for this watershed will require answering a number of other questions
Indicator Concentrations Increase During Storms*

Data from Morgan Creek, 303(d)-listed stream in Chapel Hill, NC

Bacterial source tracking techniques can also assist in identifying the original source (i.e. human, animal) of some indicator organisms

Issues to be Resolved by Field Work and Experimentation

1. While concentrations of indicator organisms in the water column increase during a storm, their direct sources are often unclear
   - overland flow from nonpoint sources often assumed responsible
2. Indicator organisms in runoff and receiving waters are generally assumed to exist in the "free" unattached phase
   - Recent research suggests many are attached to solids, an important factor in modeling microbial transport and BMP effectiveness
3. Do indicator organisms survive and/or multiply in sewers and receiving water sediments, and are they resuspended during storms?
4. Are indicator organisms accurate surrogates for pathogens?
   - Do both have common origins (e.g., upland sources vs. sediments)
   - Do both exhibit similar attachment behavior

Results will have broad application in the development of restoration plans for other biologically-impaired waters throughout the country
Microbial Partitioning in the Water Column

"Free" unattached microbe

microbe attached to less dense particles (e.g., algae, leafy matter)

density = 1 to 1.3 g/cm³

microbe attached to more dense particles (e.g., clays, sand)

density ~ 2.5 g/cm³

Settle slowly (if at all)

"Settleable"
Practical Implications
Stormwater Management

Applications

• Assessing detention basin effectiveness
• Design of other BMPs relying on sedimentation

To receiving water
Practical Implications
Surface Water Modeling

Upstream

Downstream

Applications
• Modeling microbial fate and transport

Sediments
Indicators Exhibit Significant Levels of Attachment (pathogens?)

Data from Morgan Creek, 303(d)-listed stream in Chapel Hill, NC

- Attachment behavior evaluated using a calibrated centrifugation technique*

*Kromelis, Characklis, Simmons, Dilts, Likirdopulos and Sobsey. "Intrastrom Variability in Stormwater Quality and its Effects on Microbial-Particle Interaction (in prep)
EMP Practicum

- Field and experimental work will aid in characterizing the nature and origin of the microbial contaminants.
- But many questions need to be answered before a policy (i.e. TMDL limit) can be recommended:
  - What impacts will new technologies or practices have on reducing microbial loading to the system?
  - What impacts will new technologies or practices have on limiting human exposure to these agents?
  - What are the benefits of reducing human exposure?
  - What type of regulatory actions could be implemented to bring about a reduction in microbial inputs and the resulting reduction in human exposure?
  - What are the costs of modifying technologies, regulations and/or behavior to reduce human exposure?
  - What is the best way to communicate recommended actions to policymakers, regulators and stakeholders?
Estimate point source microbial inputs (primarily RTP WWTP) and potential reductions through improved technologies (Healy-DiGiano)

Estimate nonpoint source microbial inputs and BMP effectiveness (Hunn-Band)

BMPs

Model instream microbial transport & fate (Russo-Characklis)

Evaluate the range of possible regulatory and institutional scenarios (Bolte-Andrews)

Evaluate human exposure (e.g., ingestion, contact) and health risk (Burns-Rusyn/Sama-Crawford-Brown)

Estimate microbial inactivation in water treatment and reduction in consumer exposure through improved technologies (Kelly-Singer)

Estimate the Costs and Benefits associated with a range of proposed TMDL levels (all students-Whittington)

Northeast Creek

Jordan Lake

Development of a TMDL for Northeast Creek

Simple Schematic
Discussion

• Facilities
  - Rosenau Room 12
  - Miller Hall Project space

• Required Courses
  - Environmental Management and Policy Colloquium (ENVR 200.007)
  - Environmental Management and Policy Practicum (ENVR 200A/B)

• Final products
  - Individual - thesis satisfying the MS, MSEE or MSPH requirement
  - Group - comprehensive report recommending a TMDL level for Northeast Creek with a detailed implementation plan and full justification for the selected regulatory limit and the changes in technology and practice necessary to achieve it