OSSIPEE WATERSHED: TEN YEARS OF WATER MONITORING

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GROWING POPULATIONS: POTENTIAL THREAT TO WATER RESOURCES

- NH is the fastest growing state in New England
  - Twice as fast as any other New England state
- Potential inputs
  - Nitrogen
    - Septic systems, animal waste
    - Fertilizer
    - Atmospheric deposition
  - Phosphorus
    - Septic systems
    - Fertilizers and detergents
    - Erosion/sediment
  - Sodium and Chloride
    - Road salt
OVERVIEW OF WATERSHED

• Subwatershed of the Saco River Basin
• Drains into the Saco River, through Maine and into the Atlantic Ocean
• Located in 14 towns
SITE CATEGORIES ACCORDING TO SAMPLING REGIME

- **Summer**
  - 10 sites, 1-4 years
  - 8 sites, 5-9 years

- **Apr-Oct**
  - 8 sites, 1-4 years
  - 5 sites, 7-8 years
  - 5 sites, 10 years

- **Year round**
  - 7 sites, 8-10 years, year round since 2004 (April-Oct prior to 2004)
  - 2 sites, 7 years, year round since 2009 (summer only prior to 2009)
SUMMER 5-9 YEARS

- OL-1u: West Branch River, Freedom
- OL-10: Hutchins Pond Outflow
  - Interest in understanding potential impacts from the wetland, horse farm, campground, and ski area
- OL-13: Leavitt Brook, Effingham
- OL-2: Bearcamp River
- OL-4u: Lovell River, Ossipee
- OL-5ua: Weetamoe Brook, Ossipee
- OL-7: Red Brook
  - Crosses RT 25
- OL-9u: Cold Brook, Freedom
APR-OCT 7-8 YEARS

- GF-2: Cold River, Freedom
  - Located in downtown Freedom where the river flows under the Maple Street Bridge; road runoff
- GM-2: Pequawket Brook, Madison
  - Downstream of a large gravel operation
- GM-3: Forrest Brook, Madison
  - Located in the center of Madison near two drinking water protection zones
- GO-4: Bearcamp River, West Ossipee
  - UNH property
- GT-5: Swift River, Tamworth
  - In the center of the Tamworth Village, downstream from new development
• **GE-1**: Pine River, Effingham
  • Downstream of two gravel pits and a designated drinking water zone
• **GE-2**: South River, Parsonfield, ME
  • Located downstream of the town’s transfer station and capped landfill; potential road run-off as well
• **GF-1**: Danforth Brook, Freedom
  • Determine impact of road runoff as the brook flows under Ossipee Lake Road.
• **GO-1**: Beech River, Ossipee
  • Upstream of a mill, dump, and old tannery
• **GT-1**: Bearcamp River, Tamworth
  • Located downstream of the town’s drinking water supply zone
LONG-TERM SITES 8-10 YEARS YEAR ROUND SINCE 2004

- GE-3: Ossipee River, Effingham Falls
  - Chosen to determine quality of water leaving Ossipee Lake
- GF-3: Cold River, Freedom
  - Concern over potential malfunctioning septic systems in Freedom Village
- GO-5: Bearcamp River, West Ossipee
  - Flows under the Whittier Covered Bridge
- GT-4: Chocorua River, Tamworth
  - Serves to monitor impacts along a 7 mile stretch of the busiest, most diversely utilized highway in the area. Drains RT 16
- GM-1: Banfield Brook, Madison
  - Determine the impact of road run-off, erosion, and timber cutting
- GO-2: Frenchman Brook, Ossipee
  - Downstream of the site where the brook passes under RT 16, potential for road runoff impact. History of dumping upstream
- GS-1: Cold River, Sandwich
  - Gravel pit located upstream of site. Site is located upstream of Tamworth’s drinking wellhead zone
7 YEARS, YEAR ROUND SINCE 2009

- OL-12u: Phillips Brook, Effingham
  - Influenced by episodic flooding and draining due to upstream and downstream beaver activity. Concern for road salt as well

- OL-14u: Square Brook, Freedom
  - Site located close to Ossipee Lake Road; influence of road salt
PARAMETERS

- Out in the field
  - Temperature
  - Dissolved Oxygen
  - pH
  - Specific Conductivity
  - Turbidity

- In the lab
  - Dissolved Organic Carbon (DOC)
  - Dissolved Inorganic Nitrogen (DIN)
    - Nitrate (NO$_3$)
    - Ammonium (NH$_4$)
  - Dissolved Organic Nitrogen (DON)
  - Total Dissolved Nitrogen (TDN)
  - Total Phosphorus
  - Soluble Reactive Phosphorus (PO$_4$)
  - Chloride (Cl)
  - Sulfate (SO$_4$)
  - Sodium (Na)
  - Potassium (K)
  - Magnesium (Mg)
  - Calcium (Ca)
  - Silica (Silicon Dioxide SiO$_2$)
IMPORTANCE OF TEMPERATURE AND DISSOLVED OXYGEN

• Temperature
  • Changes can negatively impact aquatic organisms
  • Directly affects amount of DO water can hold
  • Increases caused by industrial discharge, impervious surface runoff, cutting of riparian vegetation, dams, and soil erosion

• Dissolved Oxygen
  • Sources include inputs from the atmosphere, photosynthesis, and swift-moving water
  • Essential to metabolic processes
  • Decomposition of organic matter consumes oxygen.
  • Readings below 5 mg/L are considered critical
IMPORTANCE OF NUTRIENTS

• Nutrients
  • Essential for growth, but toxic in large amounts
    • Overproduction, eutrophication, toxic algal blooms, fish kills
  • Phosphorus—often a limiting nutrient, present in low concentrations
    • No numeric standard, but anything above 50 µg/L indicates disturbance
  • Nitrogen—also a limiting nutrient
    • Elevated levels of nitrate (NO₃) can lead to death of aquatic organisms
    • EPA Maximum Contaminant Level (MCL) is 10 mg N/L in public water supplies
      • Blue baby syndrome
    • Associated with stomach cancer at concentrations of 4 mg N/L
EUTROPHICATION

1. Nutrient load up: excessive nutrients from fertilisers are flushed from the land into rivers or lakes by rainwater.

2. Plants flourish: these pollutants cause aquatic plant growth of algae, duckweed and other plants.

3. Algae blooms, oxygen is depleted: algae blooms, preventing sunlight reaching other plants. The plants die and oxygen in the water is depleted.

4. Decomposition further depletes oxygen: dead plants are broken down by bacteria decomposers, using up even more oxygen in the water.

5. Death of the ecosystem: oxygen levels reach a point where no life is possible. Fish and other organisms die.

http://www.bbc.co.uk/schools/gcsebite size/science/edexcel/problems_in_environment/pollutionrev4.shtml
IMPORTANCE OF DOC, SILICA, AND CHLORIDE

• Dissolved Organic Carbon (DOC)
  • Concentration indicates impact of terrestrial inputs on aquatic environment
  • Wetlands tend to increase amount present

• Silica (SiO$_2$)
  • Common in most rock-forming minerals
  • Presence in water result of weathering
  • Ground water has higher concentrations than surface water
  • Essential to diatom growth

• Chloride
  • Affected by geology
    • Marine clays and sediments
  • Human activities
    • Road salt, crop irrigation
    • Drinking water limit is 250 mg/L. Typical NH levels are less than 30 mg/L
  • Excessive amounts could negatively impact vegetation and be toxic to aquatic species
    • Acute: 860 mg Cl/L
    • Chronic: 230 mg Cl/L
FIELD PARAMETERS
TEMP VARIABILITY
LONG-TERM: TEMPERATURE
DO VARIABILITY

Critical level at 5 mg/L
LONG-TERM: DO
Upward trends suggest that DO levels for OL-7 could be increasing over time. Recently, sampling occurring in cooler months (Apr and Oct) and early/late summer.
PH VARIABILITY

Class B waters
6.5-8.0
SPECIFIC CONDUCTANCE VARIABILITY
TURBIDITY VARIABILITY

Turbidity above 10 NTU max value: 200.5

Site Group
- 10 yrs April-Oct
- 5-9 yrs Summer
- 7-8 yrs April-Oct
- 7 yrs, year round 2009
- 8-10 yrs, year round 2004

Site Name

Turbidity (FTU)
LAB PARAMETERS
DOC VARIABILITY
LONG-TERM: DOC

![Diagram showing dissolved organic carbon (mg DOC/mL) over collection date from Jan 02 to Jan 12, with site names GE-3, GF-3, GM-1, GO-2, GO-5, GS-1, and GT-4]
Concentration of DOC is decreasing, indicating that wetland contribution could be decreasing and causing an increase in DO levels.

OL-7: DOC DECREASING
NITRATE VARIABILITY

Site Group
- 10 yrs April-Oct
- 5-9 yrs Summer
- 7-8 yrs April-Oct
- 7 yrs, year round 2009
- 8-10 yrs, year round 2004

Nitrate (mg NO₃-N/L)

Site Name
LONG-TERM: NITRATE
GM-2: NITRATE INCREASING

Site Name: GM-2

Site Name

GM-2

R² Linear = 0.243

Collection Date

Nitrate (mg NO3-N/L)

Jan 03 Jan 04 Jan 05 Jan 06 Jan 07 Jan 08 Jan 09 Jan 10 Jan 11 Jan 12
TOTAL PHOSPHORUS VARIABILITY

Disturbance level at 50 ug/L
LONG-TERM: TOTAL PHOSPHORUS

Site Group: 8-10 yrs, year round 2004

50 ug P/L indicates disturbance

Collection Date

Site Name
- GE-3
- GF-3
- GM-1
- GO-2
- GO-5
- GS-1
- GT-4
CHLORIDE VARIABILITY
LONG-TERM: CHLORIDE
OL-12U (7YRS, YEAR ROUND SINCE 2009): CHLORIDE DECREASING
GF-3: CHLORIDE DECREASING
SILICA VARIABILITY

Site Group
- 10 yrs April-Oct
- 5-9 yrs Summer
- 7-8 yrs April-Oct
- 7 yrs, year round 2009
- 8-10 yrs, year round 2004

Silicon Dioxide (mg SiO2/L)
LONG-TERM: SILICA
GROUNDWATER MONITORING 2009
NITRATE IN GROUNDWATER

Max in ground water = 11.8 mg/L

Max in surface water = 1.0 mg/L
CHLORIDE IN GROUNDWATER

Max in ground water = 219 mg/L

Max in surface water = 139 mg/L
STRATIFIED DRIFT AQUIFER

- Made up of layers of sand and gravel deposited by glaciers
- More vulnerable to contamination
- Recharge with rainwater quickly
  - Allow pollution to flow more rapidly into it
- Groundwater easily passes through it
- Supplies majority of residents and businesses located in the watershed with drinking water
CONCLUSIONS AND ADVICE

• Overall surface water quality parameters are in healthy ranges.
  • Ground water has much higher levels of Cl and NO₃ than surface water.

• Develop watershed management plan to maintain water quality

• 10 years serves as a good baseline; still a relatively short time frame.

• Climatic events and influence of flow to further explain changes over time.

• Conduct sub-watershed level land use analysis to explain variation among sites and assess sampling program
  • Population density
  • Land use NLCD 2006 (includes % impervious)

• Consider adding to long-term year round sampling
  • OL-7 for critical DO concentrations (maybe more samples from upstream site GE-4 as well) – but if naturally occurring long-term monitoring may not be necessary
  • GM-2 for Nitrate
LANDSCAPE MODEL FOR SOUTHEAST NH WATERSHEDS

DIN Output (mg/L)

Human Population Density (people/km^2)

Lamprey and Oyster

Septic
Sewered

0.01
0.1
1

0.01
0.1
1

100
10
1

0.01
0.1
1

100
10
1

Septic
Sewered
ANNUAL NITRATE AND HUMAN POPULATION DENSITY IN THE LAMPREY

- Mean Annual NO₃-N (mg L⁻¹)
  - 0.00
  - 0.05
  - 0.10
  - 0.15
  - 0.20

- Human Population Density (people km⁻²)
  - 50
  - 53
  - 56
  - 59
  - 62
  - 65

- Annual NO₃-N
- Population Density

Graph showing the relationship between Mean Annual NO₃-N and Human Population Density over the years 2000 to 2012.