

2025 Septic Analysis Internship

Creating Visualizations of Septic Nutrient Outflow Plumes in the Belgrade Lakes Watershed

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The goal of this internship was to model nutrient contributions to our waterbodies via Subsurface Wastewater Disposal Systems (SWDS), commonly referred to as septic systems. These models will help us develop a detailed understanding of SWDS's significance in terms of surface water quality. Visualizations and estimations were calculated using ArcNLET-Py, a plugin tool for the ArcGIS Pro software. This specialized tool uses soil data, groundwater models, and specifications of individual SWDS's to estimate subsurface effluent movement and create visualizations of nutrient plumes. During this internship nutrient outflows were modeled for nearly 1600 SWDS's around Great Pond and Long Pond. Nutrient load estimates were calculated for both nitrogen (NO3 & NH4) and phosphorus (PO4). Special attention was given to phosphorus because it is the limiting nutrient and most detrimental pollutant in our freshwater ecosystems. As a limiting nutrient, phosphorus, even in small quantities can increase algal growth. This increase in algae can have cascading effects on our ecosystems, including reduction of water clarity, oxygen depletion, and loss of biodiversity in our lakes.

ArcNLET-Py procedures

All parcels within 300m (984ft) of each waterbody were considered. Using Real Estate Tax Commitment documents, satellite imaging, and field surveys, parcels without permanent structures were removed from the study set.



300m Buffer - Long Pond

Individual SWDS specifications were obtained from DHHS (Department of Health and Human Services) HHE-200 (Human Health Evaluation) Forms. SWDS age, number of bedrooms, design flow, location within the parcel, and capacity were the variables used in nutrient estimation. This information was compiled in a spreadsheet, and used to calculate starting nutrient concentrations based on EPA (Environmental Protection Agency) standards. Any SWDS missing an HHE form was given the standard values of 1985 year of construction, 3 bedrooms, 270 gallons per day, and 1000 gal capacity.

The ArcNLET-Py toolkit is broken down into 6 modules.

- 0 - Preprocessing - Aggregates local environmental data to calculate soil type, porosity, and hydraulic conductivity, producing associated raster layers.
- 1 - Groundwater Flow - Estimates groundwater velocity and hydraulic gradients.
- 2 - Particle Tracking - Uses the outputs from modules 0 & 1 to calculate paths particles take to reach water bodies.
- 3 - Vadose Zone Modeling (VZMOD) - Calculates nutrient concentrations after passing through the Vadose Zone (the area between the surface and water table).
- 4 - Transport - Calculates magnitude of SWDS nutrient outflow, outputs plume visualizations.
- 5 - Load Estimation - Calculates the amount of nutrients entering our lakes and streams at an individual and cumulative level.



Nitrate (NO3) Plumes Vs Phosphate (PO4) Plumes - Great Pond

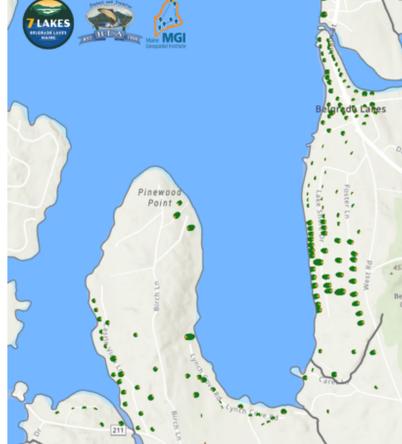
ArcNLET-Py Results

The initial NLET analysis reviewed nearly 1600 SWDS's. Out of all these systems, 291 were estimated to contribute phosphorus (PO4) to the surrounding waterbodies. Of these systems, 132 produced PO4 estimations that we considered to be in the "high pollution" category. SWDS's that are considered "high pollution" produce an estimated nutrient outflow of 700-1000 mg/day, or .25-3 kg/year of PO4. Cumulatively these "high pollution" SWDS's contribute an estimated 39.5 kilograms annually, making up approximately 57% of SWDS derived PO4 entering these waterbodies despite only making up 8% of the SWDS's in the model. The results of the initial NLET analyses estimate SWDS contribute 53.44 kilograms of PO4 per year to Great Pond, and 15.37 kilograms per year to Long Pond. Total estimated SWDS PO4 loads for both waterbodies were notably lower than the septic load estimated in the most recent Watershed-Based Management Plans for **Great Pond (2021)** and **Long Pond (2022)**. The 2021 Great Pond plan estimated SWDS contribute 97 kilograms of total phosphorus to the waterbody per year, and the 2022 Long Pond plan estimated 194 kilograms in the same timeframe.

Nearest Waterbody	Number of Parcels analyzed
Great Pond	918
Long Pond	680
Total	1598

Parcels analyzed by nearest waterbody.

Initial PO4 Estimations	Great Pond	Long Pond
Greater than 0 mg/day	236	55
0-500 mg/day	61	16
500-700 mg/day	80	2
700-1000 mg/day	95	37



Visualization of PO4 Plumes along Lake Shore Dr. and Pinewood Point - Long Pond

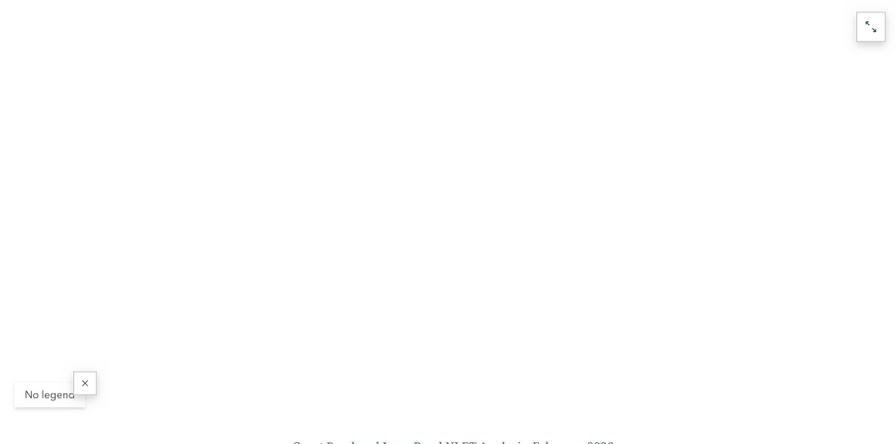
Secondary Analysis

After initial analyses on the two waterbodies, secondary analyses were conducted to verify the results. The revised analyses included only SWDS's with initial calculated PO4 loads greater than 700 mg/day. ArcNLET-Py struggled computing larger data sets, often resulting in the system skipping inputs during crucial calculations. A small number of SWDS points in the initial study were erroneously placed on or near stream features, artificially increasing nutrient load values. These SWDS points were moved to better represent their on the ground location based on HHE-200 forms, and produce more accurate load values. After updating the location of the 132 high pollution points; 67 were still categorized as "high pollution". After secondary analysis, the total estimated phosphorus load for Great Pond was 66.34 kg/year, and Long Pond was 16.42 kg/year. While these results are higher than the findings of the initial analysis, estimated phosphorus loads are far lower than the estimations found in watershed based management plans.

	Great Pond	Long Pond
Number of Revised Points	50	17
Revised Point PO4 Output (Kg/Year)	15.4	5.3
Total Estimated PO4 Output (Kg/Year)	66.34	16.42

Interactive Map

Below is an interactive map that contains phosphorus load estimations produced using the ArcNLET-Py software. Each point represents a septic system within the 300m buffer.



Great Pond and Long Pond NLET Analysis, February 2026

Based on the findings of the Great Pond NLET of revision, 50 points are still categorized as "high pollution". Despite making up only 5% of all septic points around Great Pond, these points are estimated to contribute roughly half of the estimated septic PO4 outflow.

Next Steps

To fully characterize the SWDS load on Great and Long Pond, analysis of upstream waterbodies, chiefly Watson Pond and Ingham Pond will commence. A complete rework of the North Pond analysis will occur, to better represent the current NLET software. Analyses will be performed by an intern from MGI (Maine Geographic Institute) on other waterbodies within the 7 Lakes watershed in summer of 2026.

While PO4 is the major focus in discourse surrounding freshwater waterbodies, consideration of nitrogen is still important. When PO4 reaches critical levels in a freshwater ecosystem, nutrients containing nitrogen become available nutrients for algae, worsening blooms. Nitrogen also travels further in groundwater than phosphorus, which can lead to contamination of well water, depending on the proximity of the SWDS to nearby well heads. Future plans for the NLET project involve creation of similar tools for visualizing NO3 and NH4 outputs from SWDS.

Thank You

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