Water Quality Monitoring in Van Cortlandt Lake and Tibbetts Brook

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Abstract

Van Cortlandt Park, New York City's third largest park, is a major landmark in the Bronx and features Tibbetts Brook (TB) and Van Cortlandt Lake (VCL), which flow into the municipal sewer system. Through 2016, weekly water quality data was collected and tabulated. The data was analyzed to determine if sampling frequency and location caused the probability of violating criteria to significantly change. Results show that despite falling under state set regulation, chemical concentration of nutrients and dissolved oxygen (DO) routinely violated these guidelines.

Location and Sites

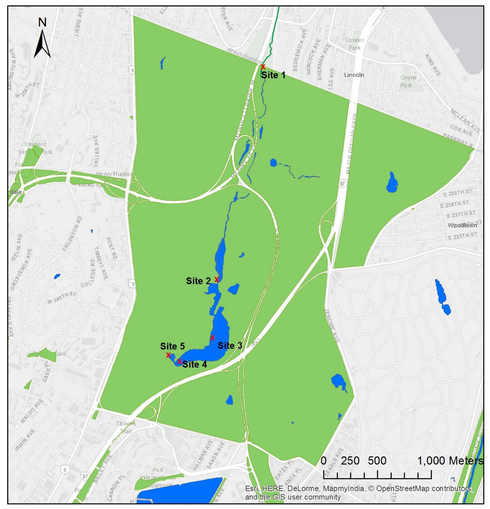


Figure 1. Map of all sampling sites.

- Locations for sampling were selected around TB and VCL in the Park.
- One upstream and one downstream site were selected for TB to see the change in parameters along the distance of the stream.
- Other sites were chosen near pipe outfalls to inspect the water entering the Lake from point-loads and to identify possible illicit discharges.
- Sampling just upstream of the weir where the Lake empties into the sewer system so to inspect the water quality before it enters that system.

Materials and Methods

Figure 2. (left) The pH, DO/Temp, and conductivity probes (left to right) and Figure 3. (right), the nutrient testing kits.

- Both In-situ and lab analysis testing
  - In-situ tests: **DO/water temperature**, **conductivity**, and **pH** probes (all Oakton models) + discharge calculated using **Area-Velocity Method**.
  - Lab Analysis: **Nutrient tests** (Nitrate and Total phosphorus) + **Turbidity**.
- Discharge estimated at Tibbetts Upstream (Site 1) and Tibbetts Downstream (Site 2); typical range can be 0.5 CFS to 50 CFS, depending on the site and rainfall.
- **Secchi Disk** measurements are used to estimate/compare traits like visibility and turbidity.
- Nutrient tests are performed using Hach™ TNT Spectrophotometric vials.
  - NO_3-N (TNT 835)
  - TP (TNT 843)
- Turbidity is measured using a Hach™ 2100P Turbidimeter.

Statistical Analysis: Box Plots

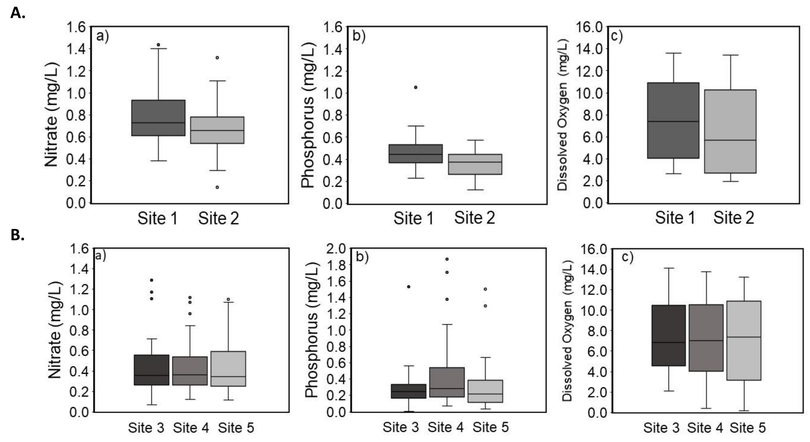


Figure 3A and 3B. Box plots for nitrate (a), total phosphorus (b), and DO (c) for the 2016 dataset. A refers to TB (Sites 1 and 2) and B refers to VCL (Sites 3, 4, 5). Solid line in box is median, box edges are 25th and 75th percentiles, and whiskers extend to 5th and 95th percentiles. Solid dots are outliers beyond the 5-95% range.

Statistical Analysis: TB Upstream vs Downstream

Table 1. Results of the Mann-Whitney Rank Sum Test performed on the 2016 (high frequency) dataset. A p-value <0.05 is significant.

	Site 1 Median Conc. (mg/L)	Site 2 Median Conc. (mg/L)	p
Total Phosphorus	0.446	0.373	<0.001
Nitrate	0.727	0.656	0.030
Dissolved Oxygen	7.42	5.68	0.149

- Total phosphorus and nitrate concentrations between the two sites were significantly different.
- DO concentrations between the two sites was not significantly different.
- It is hypothesized that the median nutrient concentrations are significantly higher at the upstream versus downstream sites because the upstream part of TB experiences higher pollution loadings, is closer to the NYS DEC Class D section of the Brook, and the downstream section is filtered through more distance of natural/emergent wetland.
- DO is controlled by factors like temperature which are roughly the same for both sites in the Brook on any given day.

Statistical Analysis: Proposed Criteria

Table 2. Higher frequency dataset lognormal probability of sites not meeting suggested criteria in Table 4.

Site	Total Phosphorus	Nitrate	Dissolved Oxygen
1	>99.9%	99.3%	13.7%
2	>99.9%	94.6%	31.9%
3	>99.9%	51.8%	16.6%
4	>99.9%	54.2%	35.3%
5	>99.9%	53.5%	45.3%

Table 3. Lower frequency dataset lognormal probability of sites not meeting suggested criteria in Table 4.

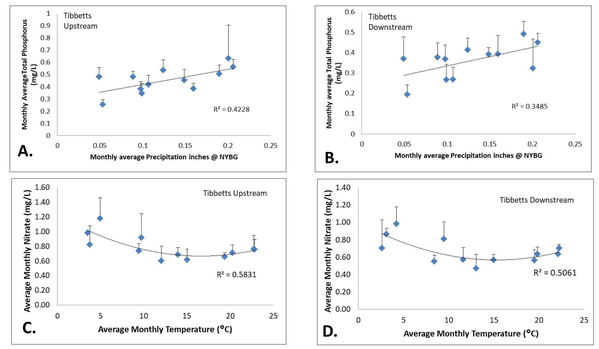
Site	Total Phosphorus	Nitrate	Dissolved Oxygen
1	>99.9%	99.6%	12.7%
2	>99.9%	98.9%	30.7%
3	98.4%	60.6%	7.98%
4	>99.9%	51.0%	35.3%
5	>99.9%	64.6%	43.2%

Table 4. Suggested water quality criteria for wadeable streams in New York State.

Parameter	Proposed Standard (mg/L)	
Total Phosphorus	0.017	Smith et al., 2013
Nitrate	0.356	Smith et al., 2013
Dissolved Oxygen	4.0	NYS DEC, 2017

- It was proposed by Smith and others that criteria for wadeable streams in New York State (Table 4) be held to criteria that are more protective of aquatic life.
  - **It is assumed that if these ecological thresholds are violated the health and biotic diversity of the community will be threatened.**
- Total Phosphorus was ALWAYS violating the criteria in Tibbetts Brook for both the LF and HF datasets. For the Lake sites, Total Phosphorus was ALWAYS violating for the HF dataset and for Sites 4 and 5 in the LF dataset.
- Nitrate was in violation of the criteria by over 90% in the Brook sites for both datasets and by over 50% in the Lake sites for both datasets.
- DO tended to violate the proposed criteria the least, except on the two most southern Lake sites, which were routinely observed to be inundated by dense summer algal blooms.
- For Site 3, the chances of the DO criteria being violated is approximately halved moving from a weekly to a biweekly dataset.

Trends Observed in Precipitation and Temperature



- Precipitation seems to be a site-dependent predictor and has a larger impact on nutrient concentrations in TB than in VCL.
- Temperature provides a predictor for nitrate in the Brook throughout the year (most predictable model).

Figure 4A, 4B, 4C, and 4D. Models showing the relationship between locally measured precipitation and total phosphorus concentration at Site 1 (A) and Site 2 (B); models that show the relationship between average monthly temperature and average monthly nitrate concentration at Site 1 (C) and Site 2 (D)

Volunteer and Student Training

Figure 5. and 6. Citizen science and environmental education in Van Cortlandt Park.

- Project has trained and educated over 70 different people. This includes students from Manhattan College's Environmental Science and Civil/Environmental Engineering programs, DeWitt Clinton H.S., Bronx Arena H.S., Cornell Academy M.S., and employees of NYC Department of Parks and Recreation.

Findings and Assessment

- **Trophic Status:** Lake is eutrophic; excessive nutrient concentrations and phosphorus-impairment (DEC guidance value = 0.020 mg/L; VCL and TB > 0.20 mg/L (typical). Can be exhibited by the excessive summer algal growth and low D.O.
- **Sedimentation:** High runoff and storm water conveyance has inundated the Lake and many parts of the Brook with sediment and silt. Sediment contributes to addition of nutrients (i.e. higher P levels detected during/after wet weather).
- **Biodiversity and Aquatic Habitat:** As part of a co-study, benthic macroinvertebrate (BMI) habitat is observably destroyed by sediment accumulation (siltation) and poisoned by water quality (i.e. high conductivity).

Expanding the Project Scope and Goals

- **Sediment Study:** May change project to investigation of lake sediments for phosphorus levels (potentially metals like Iron and Aluminum as well).
- Obtaining a stable, bona fide source for **weather data**, improving hydrological understanding.
- Performing **dye tests** or similar to determine which drains along which highways transmit water to outfalls entering the Lake or Brook.

Acknowledgements & References

- The following texts were consulted on this project: Surface Water-Quality Modeling, Chapra (2008). Water-Resources Engineering, 2nd Ed., Linsley, Franzini (1972). Limnological Analyses, 2nd Ed., Wetzel, Likens (1991). Diagnostic Study and Feasibility Study For Lake Restoration of Van Cortlandt Lake, Van Cortlandt Park, Baystate Environmental Consultants, Inc. and Storch Associates (1985), LCI Lake Water Quality Summary, NYS DEC (2009).
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