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Enforcing Municipal Sewage Treatment Plant Effluent Quality in an Urban Watershed: New Jersey's Passaic River

In New Jersey, like many densely populated parts of the world, urban rivers serve as both drinking water sources and outfalls for municipal and industrial sewage treatment plants (STPs) and surface runoff. These uses can often coexist and produce safe drinking water, as long as the water is adequately treated. Wastewater can receive treatment at the source, such as sewage treatment plants, before entering enter the river, or when it is withdrawn, such as at filtration plants for public water supply systems. Ideally these users share the financial, technical and regulatory responsibility for a clean water source, but in practice the "balance between wastewater disposal and water resource protection" can be hard to achieve (Carey and Migliaccio 2009). Upstream users are often disconnected from the problems they cause downstream.

New Jersey has a long history of water quality issues due to increasing industrial and, later, suburban development reaching upstream of existing cities and towns. A combination of political fragmentation and climate change have made for a lingering, sometimes worsening water quality situation. The watershed of the Passaic River, the principal river water source in the dense northeastern part of the state, is a leading example, though a similar story could be told about the

Raritan and some of the state's other waterways. In 1902, a water utility serving the city of Paterson built "the first large water filtration plant in the United States" at Little Falls so the city could continue to withdraw its drinking water from the Passaic as the river became polluted (Passaic Valley Water Commission). The facility is still in use today. In the 1920's, Jersey City was obliged to build a sewer system for growing towns along the Rockaway River to protect their reservoir. Urban taxpayers funded infrastructure to support new growth far outside city limits, but in this case they safeguarded a water system that remains one of the state's best (RVRSA). In the same time period, a group of the cities and towns along the Passaic, led by the state's largest city of Newark, financed and built the enormous Wanaque Reservoir in order to secure a cleaner water source (NJDWSC).

Water quality worsened as urban growth spread deep into the state's interior during the 1950s and 60's. Suburban towns throughout the upper Passaic watershed tripled, like Parsippany-Troy Hills, Wayne, and New Providence, or more than doubled in population between 1950 and 1970 (NJDOL). Many of these towns grew together into a vast, continuous urban fabric (Passaic TMDL, Figure 3). The sudden population shift in the region put stress on the water supply system in multiple ways, increasing demand for the river's water and groundwater while polluting it with effluent from these communities' sewage treatment plants and urban surface water runoff (NJ Water Supply Plan, Appendix E). The Passaic is an extreme example of this global trend because "[d]ue to these competing uses…the effluent flow volume accounts for a significant fraction of the total streamflow during typical summer/fall conditions" (Litwack et al 2006). Meanwhile, the community water systems downstream made capital upgrades as their filtration needs increased and technologies improved, like a “major enlargement and modernization” at the Little Falls Water Filtration Plant in 1962. (Passaic Valley Water Commission).

Water pollution gained national attention during this time period, motivating the federal Clean Water Act and state environmental legislation during the 1970’s. The CWA set high standards for wastewater effluent quality, and for a limited time provided grants to help STPs build the infrastructure required to achieve them. These measures cleaned up the nation’s waterways, including the Passaic, but the CWA has not yet fully addressed some water quality issues such as nutrient loading (Carey and Migliaccio 2009).

The state’s response to multi-year droughts in the mid 1960’s and 1980-1981 made the nutrient content of the upper Passaic River into a problem felt by the entire region. Faced with the insufficiency of the current water supply in a metropolis transformed by suburbanization, and increasingly unpredictable summer rainfall, authorities chose to rely even more on the Passaic. During the late 1980’s, water utilities collaborated on the Wanaque South project, building a pipeline to pump water from the river at Two Bridges to fill the Wanaque Reservoir in low water conditions, and another so that the reservoir could supplement an overextended system in the largely suburban Hackensack Watershed, just east of the Passaic (Gerber). This strategy compromised one original purpose of the Wanaque Reservoir, to avoid drinking from the Passaic. It came at a time when the cities along the river that had conceived and built the Wanaque Reservoir to secure their futures were in economic decline.

The change to northeastern NJ's water system made Passaic River's water quality an important topic of study and state regulation. Scientists raised concerns at the time about the effects on the reservoir's water quality, specifically the "accelerated eutrophication through nutrient inputs from the lower quality river water" (Rosensteel and Strom 1991). Eutrophic conditions in a reservoir can cause algal blooms, which require a higher level of treatment, with additional costs and more potentially harmful chemical byproducts, to make the water potable (Passaic TMDL).

The New Jersey Department of Environmental Protection made a detailed study of the river in the mid-80's, which found "degraded conditions with regard to dissolved oxygen, ammonia, nitrogen, and total phosphorus (TP)," all nutrients causing eutrophication, and identified the sources as STP effluent (Litwack et al 2006). As a result of this report, municipal sewerage authorities were required to fund upgrades to their plants, but they resisted reducing phosphorous levels. A group representing the Passaic's STP operators claimed, in contrast with the available research, that "most of the phosphorous in the reservoir is runoff from farms and lawns". The industry group also suggested that water companies share the estimated $200 million of upgrades required. They reached a settlement with the state to delay the enforcement of phosphorous limits until a formal Total Maximum Daily Load (TMDL) study could be made as called for in the Clean Water Act (Diskin), which took over a decade.

In the mean time, chemically treating for algal blooms became a common practice at the Wanaque Reservoir. At the same time, a drought leading to a “water emergency” in 2002 exposed the limitations of the Wanaque South system, as the Passaic’s flow rate and quality can get too low to safely pump from. Another drought that reduced the Wanaque to 40% capacity came in 2016 (Fallon).

In 2006, the state released the promised TMDL study and regulations. It sets an allocation of “a long term average year-round effluent concentration of 0.4 mg/l of total phosphorus for most wastewater discharges” in the non-tidal Passaic watershed. The intent is to end eutrophic conditions in the Wanaque Reservoir and downstream. The report unambiguously calls out each STP (Passaic TMDL).

Enforcing this bold and expensive regulation on 32 or more potentially unwilling municipal sewerage authorities, in various jurisdictions, is challenging. It has been hard to find much analysis on the post-2006 performance of the STPs. The best available source seems to be the raw data on phosphorous concentration that they provide to the NJDEP. Analyzing this data can help us assess the plants’ compliance with the TMDL. As the water system continues to struggle with algal blooms and drought, can the framework of state regulation established under the CWA resolve the longstanding conflicts between upstream and downstream uses of the Passaic River?

Methods

Data on effluent phosphorous loads and concentrations for many STPs, including most of those in the non-tidal Passaic watershed, is available from the NJDEP. Accessible from 2000 and through 2018, this data can help us track the progress of TDML compliance over time.

Data can be found in the NJDEP's Data Miner web app by running a NJPDES DMR Data report for Total Phosphorous (as P) under NJPDES Permitting Program category ("DEP DataMiner"). Each plant reports their effluent phosphorous concentration monthly as a 30-day moving average in mg/L. Because the TDML allocation of 0.4 mg/L is given in terms of a "long term average year-round effluent concentration," and to take into account seasonal variations, I use an average of these monthly values over a calendar year as my unit of comparison. I compare this value for each plant in 2001, the first full calendar year that data is available and five years before the TMDL, with the value in 2018, the most recent year available.

Each STPs 12 month average daily flow can be obtained by another running another NJPDES report. These two values can be multiplied to very roughly estimate the load of phosphorous in kg/day, a measurement employed by Litwack et al and Rosensteel and Strom.

XY coordinate locations of each plant are also available by running an NJPDES Active Permit list report. They are in the New Jersey State Plane Coordinate System, which is the NJDEP's standard (NJDEP "Mapping and Digital Data Standards"). The plants within the Passaic watershed can be identified by clipping them with a shapefile of the non-tidal Passaic watershed covered by the TMDL, available from the NJDEP (NJDEP Bureau of GIS). Locations of the major water diversions are available from the USGS.

Discussion

The comparison between 2001 and 2018 effluent phosphorous levels is summarized in the maps below. Results are positive but mixed overall. By 2018, 12 out of 32 STPs, responsible for 31% of the watershed's average daily flow of effluent, successfully met TDML allocation of 0.4 mg/L. This includes one of the largest plants, Two Bridges (#29 on the maps). Back in 2001, only 8 smaller plants with 3% of daily flow were below that level. In addition, many STPs still not compliant have made considerable progress. The mean STP's phosphorous concentration is down from 1.63 to 0.74 mg/L, and the total estimated daily phosphorous load decreased to 43% of its 2001 levels.

Some bad news is that 12 plants, responsible for 20% of daily flow, have increased their phosphorous concentrations since 2001, including the watershed's largest, the Rockaway Valley Regional Sewerage Authority (#4). The increases are mostly distributed in the northern half of the watershed. One of the highest phosphorous concentrations, 2.27 mg/L, is found at Parsippany-Troy Hills (#16), the second largest plant, located in a town that relies on its own groundwater for water supply, avoiding the community systems tied up with the Passaic River (Parsippany-Troy Hills).

The considerable progress of the region's STPs gives reason for qualified optimism. State and federal regulation may work to finally shift the responsibility for water pollution onto the polluters. A water quality trading program between STPs has been proposed as an additional measure (citation). On the other hand, fifty years after the Clean Water Act, the regulatory process is still unfolding slowly, decade by decade, as communities in urban New Jersey deal with, and pay for, water quality issues. With the STPs' mixed record of progress and backsliding on phosphorous levels, there is a further concern that long-term enforcement of STP effluent standards is a game of political whack-a-mole.

Urban North Jersey has other more urgent water quality issues that reveal disparities in infrastructure and environmental quality between cities and suburbs more starkly. Lead poisoning from old pipes in Newark and contamination of the lower, tidal Passaic river with poisons such as dioxins from the area's hyper-industrial past, are ongoing crises in this same watershed that attract media attention. On a separate note, wastewater from Newark, Patterson and many towns lower in the watershed receives a lower level of treatment, and outfalls directly into New York Bay, contributing to degraded conditions there. No one is dying from algal blooms in the Wanaque Reservoir, but the decline in water quality there reveals a power imbalance across the decades. During the era of urban decline, the older cities lost the excellent quality of their drinking water, largely to accommodate resource-hungry urban sprawl. A comparison with other urbanized regions, in terms of nutrient loads in reservoirs and the politics of water sharing, would reveal how much New Jersey's situation has exacerbated global trends.

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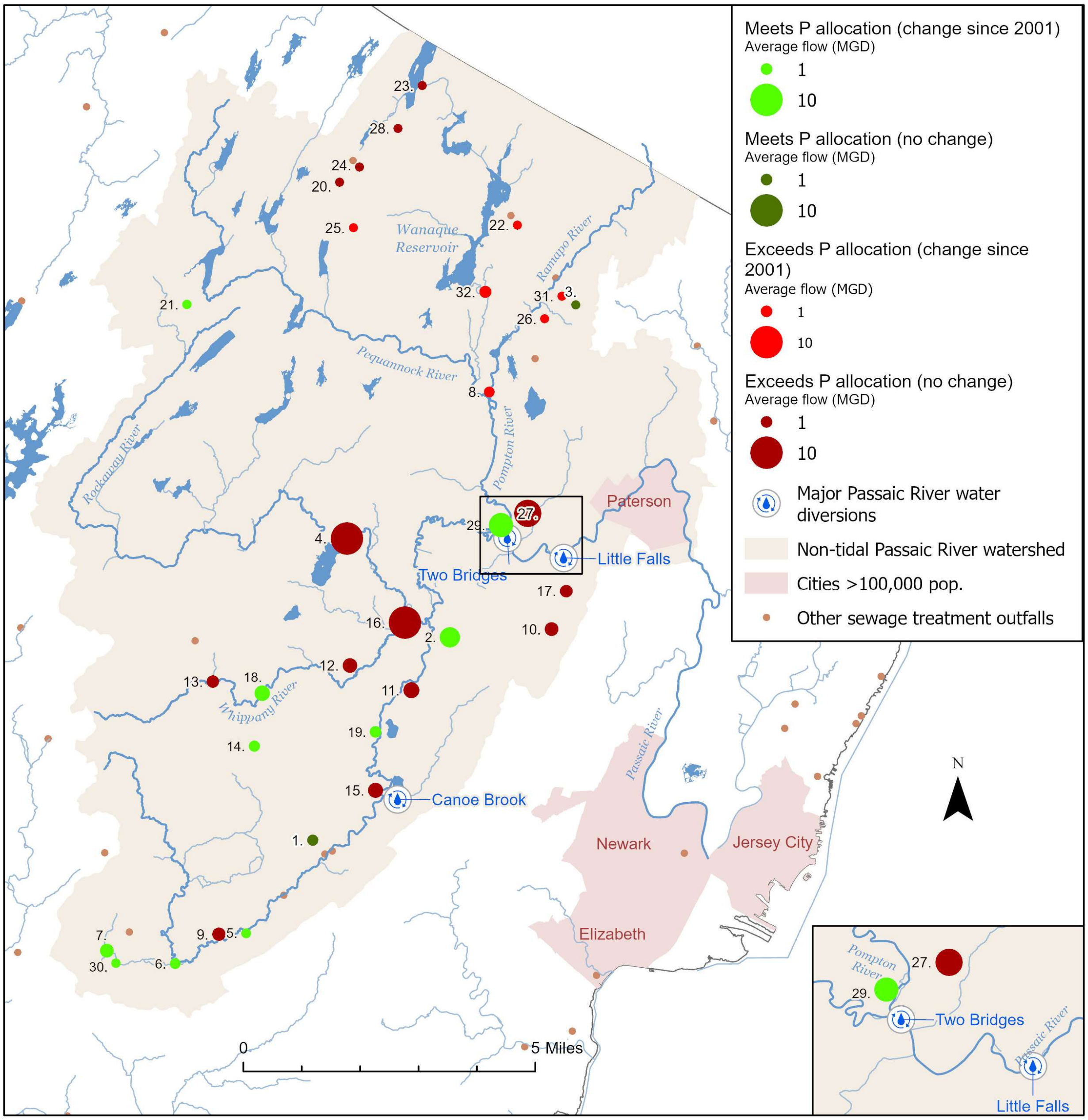
Table 1: Municipal Sewage Treatment Plants Studied in the Passaic Watershed

Map #	STP Name	mg/L P, 2018
1	Chatham Twp Main STP	0.31
2	Caldwell Wastewater Treatment Plant	0.25
3	Skyview / Hibrook Wtp	0.32
4	Rockaway Valley Reg Sa	1.78
5	Warren Twp Sewerage Auth Stage I-Ii STP	0.28
6	Warren Stage Iv STP	0.15
7	Harrison Brook STP	0.18
8	Pompton Lakes Boro Mua	0.58
9	Long Hill Township STP	1.67
10	Verona Twp Wtp	0.95
11	Livingston Water Pollution Control Facility	0.44
12	Hanover Sewerage Authority Wtp	1.05
13	Butterworth Water Pollution Control Utility	0.40
14	Woodland Water Pollution Control Utility(Wpcu)	0.38
15	Molitor Water Pollution Control Facility	2.53
16	Parsippany Troy Hills	2.27
17	Cedar Grove STP	0.44
18	Morristown Sewer Utility	0.32
19	Florham Park Water Pollution Control Facility	0.29
20	Suez Water NJ Crescent Park WWTP	0.82
21	White Rock STP	0.15
22	Ringwood Acres Treatment Plant	0.44
23	Suez Water NJ Awosting WWTP	1.37
24	Suez Water NJ Olde Milford Estates WWTP	0.78
25	Suez Water NJ Highview Acres WWTP	1.10
26	Oakwood Knolls WWTP	0.55
27	Mountain View STP	0.80
28	Suez Water Nj Birch Hill Park WWTP	1.41
29	Two Bridges Wastewater Treatment Plant	0.35
30	Warren Stage V STP	0.18
31	Chapel Hill Estates STP	0.72
32	Wanaque Valley Regional Sewerage Authority	0.47

Map 1

Passaic River Watershed: Municipal Sewage Treatment Plant Phosphorous Compliance

Compliance with State TDML Phosphorous Allocation in 2018, change since 2001, and plant total average flow in millions of gallons per day

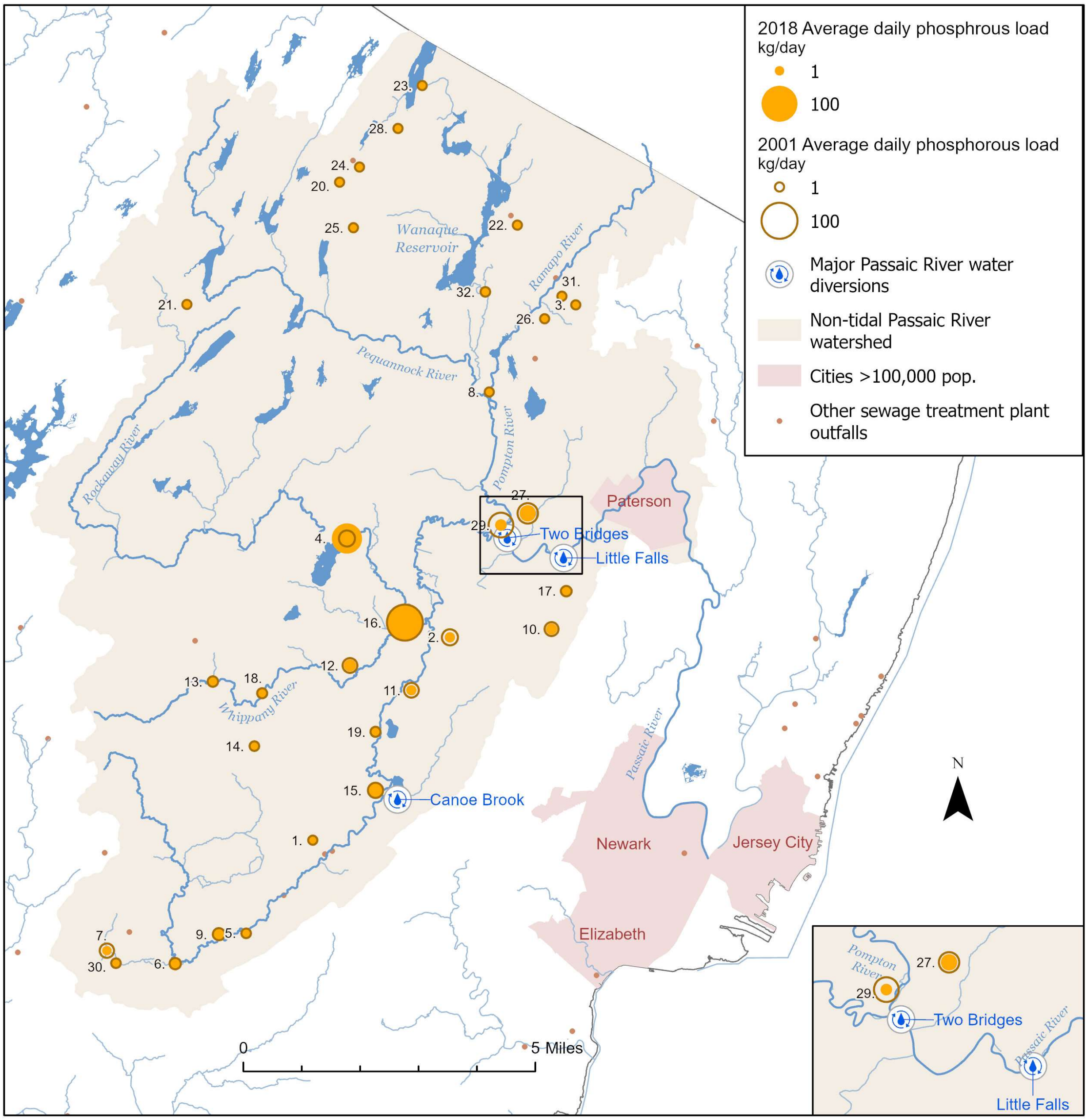


Map projection: NAD 1983 (2011) StatePlane New Jersey FIPS 2900 (US Feet)
Map source: NJ Department of Environmental Protection DataMiner and shapefiles, NJ Geographic Information Network, USGS
Map by Jesse Fried for Intro GIS Final Project, 4/9/21

Map 2

Passaic River Watershed: Municipal Sewage Treatment Plant Effluent Phosphorous Loads

Estimated average phosphorous loads for 2018 and 2001 in kilograms per day



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