Tributary and Wetland Water Quality Monitoring and Analysis For Palmer Lake, Putnam County, NY

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Introduction

Princeton Hydro, LLC was recently contracted by the Croton Watershed Clean Water Coalition to conduct some limited water quality and wetland sampling in the unnamed tributary that flows from the proposed Kent Manor Development site to Palmer Lake. Specifically, on 3 September 2008 *in-situ* and select nutrient (phosphorus) data were collected at five (5) stations within the perceived stream channel of this tributary, two (2) wetland stations in the immediate vicinity of the tributary, and one (1) upstream reference station that was located on another tributary that enters Lake Carmel. The locations of the sampling stations are shown in Figure 1.

The purpose of this limited study is to obtain a general sense of how phosphorus is processed in the aforementioned tributary that flows from the proposed project site into Palmer Lake, and assess the possible impacts the proposed Waste Water Treatment Plant (already constructed but not yet on-line) will have on the tributary's nutrient spiraling of phosphorus.

Nutrient spiraling refers to the idea that as nutrients enters a stream and are transformed and recycled from the water and streambed they are also simultaneously moving downstream. Under reference conditions (minimal or no human impacts), this spiraling tends to be efficient at processing and retaining nutrients. However, pollutant discharges, point or non-point, tend to distort or stretch the cycling of nutrients. The net effect is more nutrients are transported farther downstream. In addition, it has been shown that the cumulative uptake of nitrate and phosphate increases with stream order (Ensign and Doyle, 2006). Thus, a low order tributary such as the one upstream of Palmer Lake would have a lower natural capacity to uptake nutrients relative to higher order streams.

The early September tributary monitoring event was designed to obtain some cursory data to determine how the tributary currently processes phosphorus and what this may mean for its nutrient spiraling capacity. However, it should be noted that this is not a detailed nutrient spiraling study, which would require the intentional addition of nutrients or actual discharge from the WWTP.

It should also be noted that due to seasonal variability in precipitation, late August / early September was a dry period relative to the inter-annual average. Specifically, August 2008 had a 16% decrease in total precipitation (3.80 inches) relative to the six-year average (4.52 inches) as measured at the CARMEL 4 N CLIMOD Station (ID: 301211) located approximately 1.81 miles NW of the proposed WWTP point of discharge. Thus, while hydrologic conditions during the 3 September 2008 sampling event did not represent long-term, normal conditions relative to precipitation, such conditions do aid in assessing the movement and impact of sub-surface, baseflow that migrates from the wetlands and into the tributary. In the absence of storm events, the minimal amount of flow observed in the tributary was due to the movement of groundwater (baseflow). In a sense, baseflow in tributary can be considered an "out-cropping" of groundwater.

Tributary-1 (Reference)

The first tributary sampling station (TRIB-1) is located on an unnamed tributary that flows into the North Cove of Lake Carmel. It should be noted that this sampling stations is not located in the Palmer Lake watershed but is located in the one immediately adjacent. TRIB-1 serves as an upstream reference station; an upstream station could not be sampled on the Palmer Lake tributary itself due to private property issues. TRIB-1 has historically been used in the past to assess the water quality of the tributaries entering Lake Carmel (Princeton Hydro, 2006).

TRIB-1 is located approximately 200 feet NW of the intersection of Route 52 and the entrance to the Town of Kent Recycling Center. TRIB-1 was selected as a reference upstream station due to its similar topographic and geomorphic setting to the Palmer Lake tributary. TRIB-1 is located in a heavily forested area with an associated wetland complex (NY DEC State Wetland LC-9) that serves as its main source, similar to NY DEC State Wetland LC-57 servicing as the main source for the Palmer Lake tributary (see Tributary-2 section below). TRIB-1 also reflects the minimal amount of human development impacts in the upstream reaches of the tributary similar to the Palmer Lake tributary.

TRIB-1 had very little flow at the time of sampling. Evidence of periods of high flow was observed due to some areas exhibiting streambank erosion. The substrate consisted of a fine layer of silt over cobbles with a few large rocks. This tributary drains NYS DEC State Wetland LC-9 in a heavily forested area.

Overall, TRIB-1 had the lowest temperature (16.95°C) of the six tributary sampling stations, and the lowest conductivity (0.228 mS/cm). TRIB-1 also displayed the highest pH (7.66) of all tributary sampling stations; however, the pH was still within the optimal range for most aquatic organisms (6.0 to 8.5). The dissolved oxygen (DO) concentration at this station was 5.13 mg/L.

The total phosphorus (TP) concentration was elevated at 0.120 mg/L and the soluble reactive phosphorus (SRP) concentration was somewhat elevated at 0.051 mg/L.

Tributary-2

The TRIB-2 station is located immediately upstream of the culvert on Nichols Road which drains Burr Pond (part of NY DEC State Wetland LC-57) and effectively serves as the source of the unnamed tributary to Palmer Lake. TRIB-2 is located immediately downstream of the proposed WWTP point of discharge. TRIB-2 had very little flow at the time of sampling. Road grit was observed in some areas of the streambed, which was otherwise comprised of medium sized cobbles with a fine layer of sediment/silt.

TRIB-2 had the highest water temperature (20.17°C) and the lowest DO concentration (1.37 mg/L) of the six tributary sampling stations. The pH of TRIB-2 was 7.42 and the conductivity was moderate at 0.248 mS/cm. The elevated temperature as compared with the downstream stations can be attributed to Burr Pond where the water flow is expected to slow, and the open water offers less tree shading. The low DO concentration could also be attributed to both the low seasonal flow and the fact that the water is coming from Burr Pond during the summer when bottom water DO concentrations can be low.

The TP concentration at TRIB-2 was 0.028 mg/L and the SRP concentration was 0.027 mg/L. This effectively means that most of the phosphorus in the tributary at this point in time is dissolved and thus readily available for uptake by algae. In the absence of some significant rain events, little or no particulate phosphorus (phosphorus adsorbed onto sediment particles) in the baseflow is an expected condition.

Wetland-1

The Wetland-1 sampling station is located approximately 125 feet south, southeast of TRIB-2 (Figure 1). This station is located within NY DEC State Wetland LC-57 in a well forested area consisting of green ash, red maple, spicebush, multiflora rose, jewelweed, and sphagnum moss. The wetland at this location is very hummocky and displays secondary drainage patterns indicating that it is wet for a significant part of the year. At the time of sampling, however, no standing water was found in this location and only soil samples were taken and subsequently analyzed for TP and SRP.

The TP concentration of the soil in the Wetland-1 sampling station was 419 mg/Kg, and the SRP concentration of the soil was 0.439 mg/Kg. Essentially, this means that 0.1% of the TP is immediately available for uptake by algae. Thus, most of the phosphorus within the wetland is bound in plant biomass or adsorbed onto soil particles.

Tributary-3

The TRIB-3 sampling station is located approximately 300 feet south, southeast of TRIB-2 (Figure 1). This part of the tributary is more or less surrounded by riparian wetland habitat, consisting mostly of tussock sedge, spicebush, and viburnum. Again, this area is very hummocky. The streambed was comprised of coarse sand and fine sediment. There was very little flow at this location.

The temperature at TRIB-3 was 18.71°C, and the DO concentration subsequently increased to 4.75 mg/L. The conductivity of the water was moderate at 0.291 mS/cm, and the pH was within the optimal range for most aquatic organisms at 7.48.

The TP concentration at TRIB-3 was 0.039 mg/L and the SRP concentration was 0.027 mg/L. At this point in time the SRP concentration remained the same from the TRIB-2

sampling station, but the TP concentration increased by approximately 39%. Thus, since these samples were collected during baseflow conditions, with negegible, short-term impacts due to storm events, the wetland (Wetland-1) appeared to be a source of phosphorus and not a sink at this time.

Tributary-4

The TRIB-4 sampling station is located approximately 450 feet south, southeast of TRIB-3 (Figure 1). This part of the tributary is surrounded by a more typical forest community with witch hazel and spicebush in the understory. There is an old rock dam or what appears to the remnants of an old property line that traverses the tributary and slightly impedes flow. The streambed displayed very heavy siltation both upstream and downstream of the rock dam. There was very little flow at this location.

The temperature at this station was cooler than TRIB-3 at 17.81°C, with a subsequent increase in the DO concentration to 5.63 mg/L. This is to be expected as the shallow tributary flows through a heavily wooded area. The conductivity was again moderate, though increased slightly to 0.344 mS/cm most likely due to the increase in siltation. The pH at this station remained within the optimal range at 7.57.

The TP concentration at TRIB-4 was 0.031 mg/L and the SRP concentration was 0.023 mg/L. At this point in time both the SRP and the TP concentrations were slightly lower than those respective concentrations measured at TRIB-3. The TP concentration decreased approximately 20.5% and the SRP concentration decreased approximately 15%. The rock dam maybe contributing to this, allowing particulate phosphorus to settle and dissolved phosphorus to be assimilated by in-stream plants and/or periphyton (algae attached to rocks / streambed).

Tributary-5

The TRIB-5 sampling station is located approximately 460 feet south, southeast of TRIB-4 and represents a more open canopy wetland dominated by Phragmites, viburnum, sensitive fern, tussock sedge, jewelweed, purple loosestrife, and sphagnum moss. At this point the tributary begins to fan out into rivulets before forming a more defined channel downstream. There was very little flow observed at this station due to the lack of a well defined stream channel.

The temperature at the TRIB-5 station increased from that recorded at TRIB-4 to 19.35°C due to the lack of tree canopy cover and even less flow than observed at the upstream stations. The DO concentration, however, remained similar to that at TRIB-4 at 5.46 mg/L. The conductivity was moderate at 0.237 mS/cm (a decrease from TRIB-4) and the pH fell within the optimal range for most aquatic life at 7.60.

The TP concentration at TRIB-5 was 0.080 mg/L and the SRP concentration was 0.053 mg/L. At this point in time both the SRP and the TP concentration increased from those measured at TRIB-3 and TRIB-4. Specifically, the TP concentration rose approximately 158% from TRIB-4, and the SRP rose approximately 130% from TRIB-4. Approximately 66% of the TP is readily available for uptake, as SRP, by algae at this point.

Wetland-2

The Wetland-2 sampling station is located approximately 360 feet south, southeast of TRIB-5 (Figure 1). This station is located within NYS DEC State Wetland LC-57 in a relatively narrow riparian corridor nestled between a stone cutting operation to the west and mowed lawn to the east. The plant community was dominated by viburnum, spicebush, jewelweed, and skunk cabbage. At the time of sampling no standing water was found in this location and only soil samples were taken and subsequently analyzed for TP and SRP. The sample consisted of moist rich loam relatively high in organic content, though not considered muck.

The TP concentration of the soil in the Wetland-2 sampling station was 1,820 mg/Kg, and the SRP concentration of the soil was 0.542 mg/Kg. This is a significant increase in TP from the Wetland-1 sampling station (an approximate 334% increase), but only an increase of approximately 23% in SRP. Essentially, this means that at this point 0.03% of the TP is immediately available for uptake by algae, as SRP. It also indicates that compared to Wetland-1, Wetland-2 has more phosphorus either incorporated in plant biomass or adsorbed onto soil particles. Thus, Wetland-2 has more "reserve", sequestered phosphorus that has the potential to be released into the tributary water and flow downstream.

Tributary-6

The TRIB-6 sampling station is located approximately 560 feet south, southeast of TRIB-5 and about 80 feet NW of Route 52 (Figure 1). At this point the tributary is in more of a defined channel with the highest volume of all tributary stations. There was little flow observed at this station. The water was very turbid with water starwort, blue-flag iris, arrowhead, Phragmites, purple loosestrife, and viburnum being the dominant plant species.

The temperature at the TRIB-6 station increased from that recorded at TRIB-5 to 20.05°C. The DO concentration subsequently decreased to 1.60 mg/L. The conductivity was moderate at 0.345 mS/cm (an increase from TRIB-5) and the pH fell within the normal range at 7.50.

The TP concentration at TRIB-6 was 0.118 mg/L and the SRP concentration was 0.076 mg/L. At this point in time both the SRP and the TP concentration increased from those measured at TRIB-5. Specifically, the TP concentration rose 47.5% from TRIB-5, and the SRP rose approximately 43% from TRIB-5. Approximately 64% of the TP is readily available for uptake by algae at this point, as SRP. Again, based on the relatively dry conditions experienced in early September, it appears that Wetland-2 serves as a net source of phosphorus and not a net sink.

The TP concentration increased approximately 321% from the TRIB-2 sampling station to the TRIB-6 sampling station. The SRP concentration increased approximately 181% from the TRIB-2 sampling station to the TRIB-6 sampling station.

Conclusions

Of the six tributary sampling stations, the reference site (TRIB-1) had the highest TP concentration. The elevated TP concentration at the reference station was more than likely due to the streambank erosion observed on site. Soil particles have a high amount of phosphorus absorbed onto their surfaces.

The late summer season of 2008 was dry relative to long-term, normal precipitation patterns. Thus, the water quality data collected from the tributary and wetland sites on 3 September 2008 were more representative of baseflow, sub-surface groundwater, with a negligible amount of influence from stormwater / surface runoff. Thus, these data provide an opportunity to assess the potential water quality impacts of the wetland "on-line" with the tributary.

In general TP, and to a lesser extent SRP, concentrations increased moving downstream the tributary. Under the baseline (non-storm event) conditions experienced in early September 2008, the wetland complex appeared to be a source of phosphorus and not a sink. For both wetland sampling sites, downstream TP concentrations were higher relative to upstream concentrations.

As nutrient spiraling indicates, even a moderate increase in the tributary nutrient load can reduce the transformation and sequestering of nutrients, resulting in more nutrients traveling further downstream. In addition, there are some positive feedback loop ecosystem functions that may exacerbate the movement of nutrients downstream. For example, a substantial increase in the amount of phosphorus leaving a wetland can occur if its overlying waters become anoxic (dissolved oxygen falls below 1 mg/L). Phosphorus bound to soil particles becomes soluble in the absence of dissolved oxygen and could travel further downstream. As this study has shown, the wetland complex has a large amount of sequestered phosphorus that has the potential to migrate downstream if its waters become anoxic. An increase in the organic load into the wetland could create these conditions.

In conclusion, based on the limited amount of data collected on 3 September 2008, the wetland complex along the tributary of Palmer Lake appeared to function as a source of phosphorus and not a sink during the late summer season.

In-situ and Discrete Data

Palmer Lake Tributary In-situ 9/3/2008					
Station	**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH**	**Dissolved Oxygen Saturation**
	(C°)	**(mS/cm)**	**(mg/L)**	**(units)**	**(%)**
Trib-1 (ref)	16.95	0.228	5.13	7.66	51.9
Trib-2	20.17	0.248	1.37	7.42	9.8
Trib-3	18.71	0.291	4.75	7.48	49.7
Trib-4	17.81	0.344	5.63	7.57	58.3
Trib-5	19.35	0.237	5.46	7.6	56.7
Trib-6	20.05	0.345	1.6	7.5	16.2

Palmer Lake Tributary and Wetland Discrete Data 9/3/2008		
Station	**TP**	**SRP**
	(mg/L)	**(mg/L)**
Trib-1 (ref)	0.120	0.051
Trib-2	0.028	0.027
Trib-3	0.039	0.027
Trib-4	0.031	0.023
Trib-5	0.080	0.053
Trib-6	0.118	0.076
Station	**TP**	**SRP**
	(mg/Kg)	**(mg/Kg)**
Wetland-1	419	0.439
Wetland-2	1,820	0.542