Effects of Storm Water Runoff and Overland Flow on Retention Ponds at Georgia Southern University

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Abstract

This study examines the effects of parking lot overland flow and roof runoff inputs on the water chemistry of two retention ponds located near the Recreational Activity Center on the Georgia Southern University campus. The primary input to the ponds was calcium-bicarbonate groundwater pumped from both ponds during the summer and fall of 2010. Samples of overland flow and roof runoff were collected during storm events. Temperature, dissolved oxygen, and specific electrical conductivity were measured onsite; samples were taken to a campus lab and analyzed for major cations and anions using an ion chromatograph. Precipitation data were obtained from a weather station located approximately 13 km from the study site.

The overland flow and runoff were characterized as having relatively low specific conductivity (15-133 µS/cm), acidic pH (4.5 to 6.4), and a high, almost saturated dissolved oxygen content (80-99%). The storm inputs were in marked contrast to the pond water itself, which had relatively high specific conductivity (157-240 µS/cm), alkaline pH (7.5 to 9.2), and dissolved oxygen content that ranged from undersaturated to supersaturated (59-157%). Trilinear (Piper) diagrams show that the ponds contain calcium bicarbonate type water, and while the dominate species in the overland flow and runoff inputs were calcium and bicarbonate, the storm water had a more mixed chemistry and contained elevated levels of sodium, chloride, and sulfate. The overland flow and runoff also contained elevated levels of ammonium, nitrate, and phosphate relative to the ponds. Because the storm water originated from asphalt surfaces, its water chemistry is believed to largely be influenced by atmospheric fallout.

Temporal variations in the general chemistry of the ponds do not appear to be influenced by storm water inputs. This can be explained by the relatively small volume of storm water compared to the pond volume, and by the general chemistry of the storm and pond waters being somewhat similar. In contrast, the overland flow and runoff inputs of nutrients did have a small impact on the nutrient concentration in the ponds, particularly for ammonium. This is attributed to the concentration of nutrients in the storm water being significantly higher than the ponds, despite the small volume of storm water.

Study Location

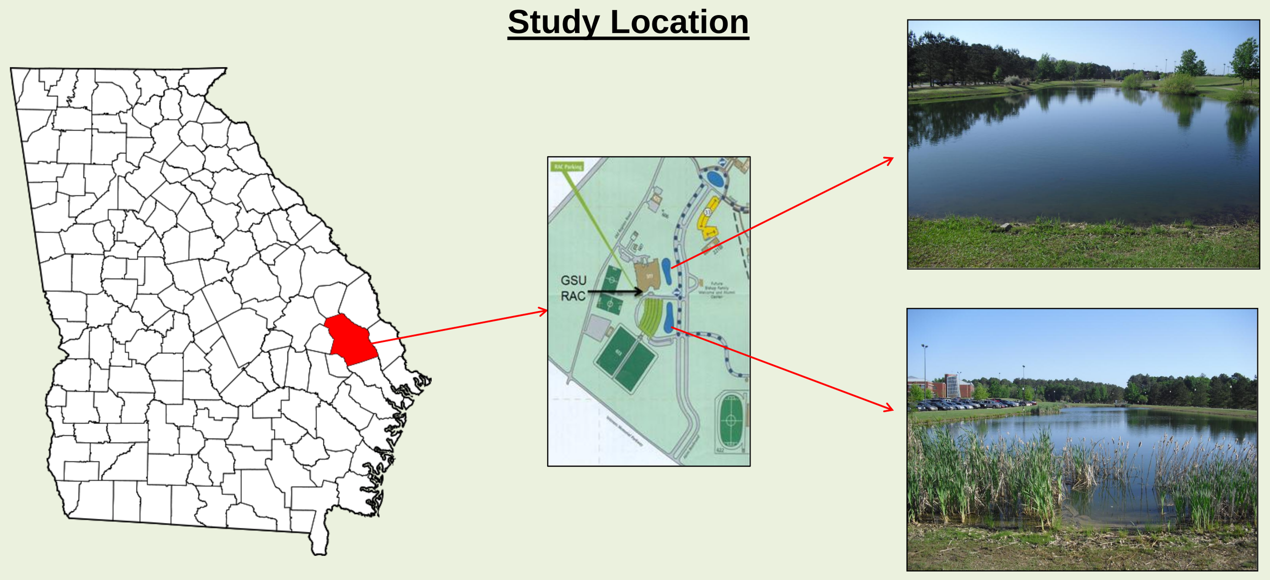

Figure 1. The study was located at the Recreation Activity Center (RAC) on the Georgia Southern University (GSU) campus, in Bulloch County, Georgia. Photos show the north (top) and south (bottom) retention ponds at the RAC.

Problem

Figure 2. Photograph of the south pond looking north towards the RAC.

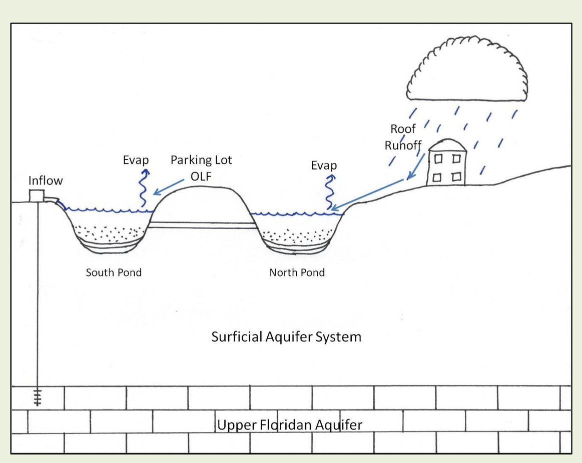

Figure 3. Generalized concept sketch of the study site. Note that the two ponds are joined via an underground pipe.

- Retention ponds are used to irrigate nearby athletic fields.
- North pond receives runoff from the RAC roof, and south pond receives runoff from the parking lot.
- Both ponds are filled primarily with groundwater pumped from the Upper Floridan aquifer.
- Does overland flow from the RAC parking lot and runoff from the roof affect the water chemistry of the ponds?

Goals and Objectives

The goal of this project is to study the effects of storm water runoff and overland flow from the RAC roof and parking lot on the water chemistry of nearby retention ponds.

The objectives of this study are as follows:

- Collect water samples from ponds, overland flow from parking lot, and runoff from RAC roof.
- Determine general chemistry using ion chromatography.
- Determine lead content and nutrients of runoff.

Methodology

Figure 4. Ion chromatograph in GSU hydrogeochemistry lab.

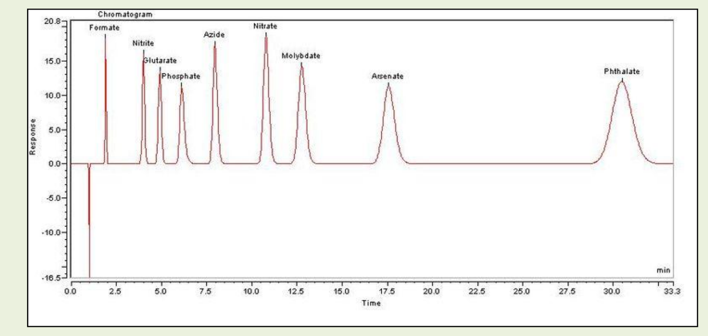

Figure 5. Example ion chromatogram.

Figure 6. Weather station located 13 km from the study site.

- Pond samples were collected twice a month, from May through October, 2010.
- Temperature, pH, electrical conductivity, and dissolved oxygen were measured in the field using electronic meters.
- Samples were collected from the parking lot and roof during four rainfall events that generated overland flow.
- Alkalinity was determined by using titration techniques in the hydrogeochemistry lab.
- General chemistry (major cations and anions) was determined using an ion chromatograph in the lab (Fig. 4).
- Lead (Pb) content of select samples was measured using an anodic stripping voltammetry instrument in GSU Chemistry Department.
- Rainfall data was obtained from a weather station within the Georgia Automated Environmental Monitoring Network (Fig. 6).

Results

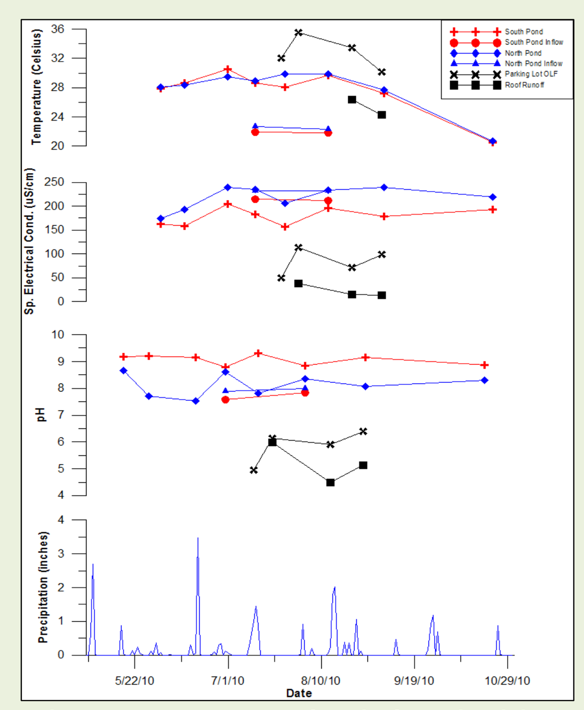

Figure 7. Temperature, electrical conductivity, and pH field measurements along with precipitation data.

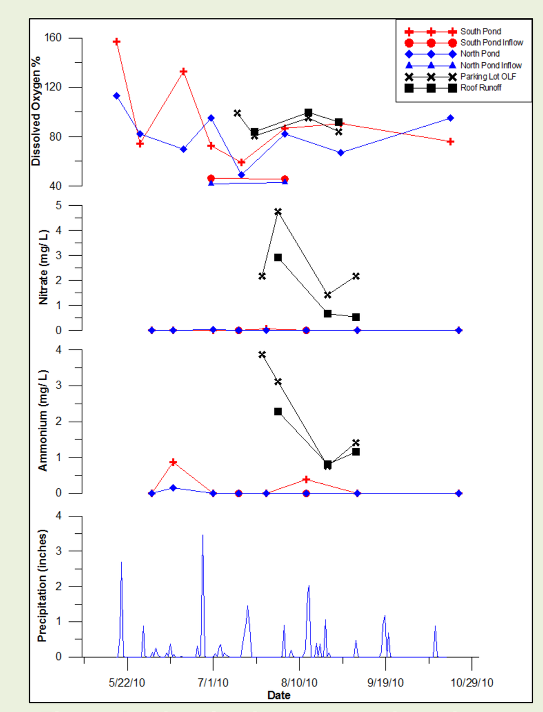

Figure 8. Dissolved oxygen and nutrient data plotted along with precipitation data.

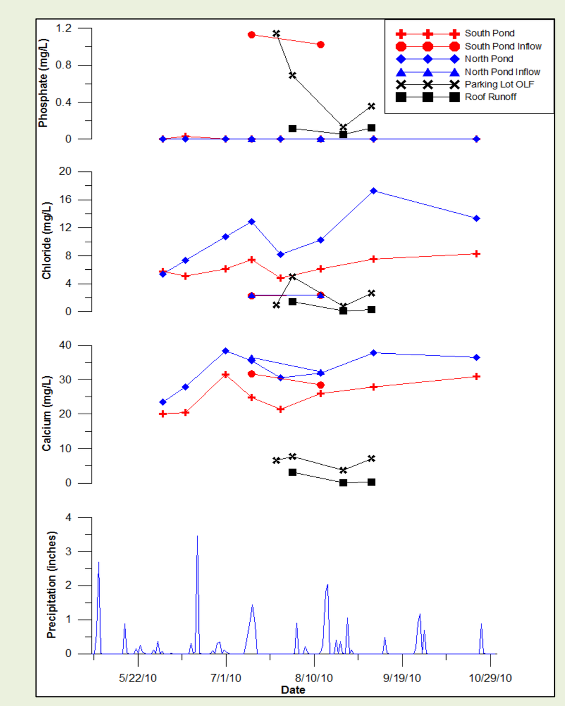

Figure 9. Calcium, chloride, and phosphate concentrations plotted with precipitation data.

- Temperature (Fig. 7) shows that parking lot runoff could be a source of thermal pollution during the summer.
- The salinity and pH of the ponds are relatively high due to groundwater inputs.
- Dissolved oxygen content of ponds (Fig. 8) varies with biological activity, whereas storm water is naturally saturated and groundwater under saturated.
- Storm water is elevated in both nitrate (NO_3^-) and ammonium (NH_4^+), causing nitrogen spikes in the south pond.
- Phosphate (PO_4^{3-}) is much higher in the parking lot overland flow than in the roof runoff (Fig. 9).
- Chloride (Cl^-) in ponds is higher than the Upper Floridan makeup water; possibly due to evaporation.
- Calcium (Ca^{2+}) in the south pond is lower than the makeup water; likely due to calcite precipitation.
- Lead concentrations (Table 1) in the storm water samples and makeup water are considerable higher than the ponds themselves, possibly due to removal of lead by oxidation-reduction reactions in ponds.

Location	Lead Concentration (ppb)
Parking Lot	4.5
Roof	5.1
South Pond	.64
North Pond	1.0
South Pond Inflow	5.5

Table 1. Lead concentrations determined from anodic stripping voltammetry instrument.

Conclusions

- Most of the storm water inputs had only a negligible effect on pond chemistry due to the relatively large pond volumes and the rapid replenishment of the ponds via pumping of groundwater from the Upper Floridan aquifer.
- Nutrients from the storm water did have a measurable impact on pond chemistry, and may help explain the observed algae growth and variable dissolved oxygen levels.

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