REPORT ON PHOSPHORUS REMOVAL
ATHENS, TENNESSEE

August 2015

Athens' two wastewater treatment plants – Oostanaula and North Mouse Creek – were first visited on April 1, 2015 to see if there existing opportunities for improved nitrogen or phosphorus removal. A second (and final) site visit was made July 8, 2015. Remote support consisting of over 50 emails exchanges and almost as many telephone conversations was provided.

Both of Athens two treatment plants provided excellent nitrogen removal before the optimization effort. The focus has, therefore, been biological phosphorus removal. Both facilities have seen periods of excellent biological phosphorus removal (effluent total-phosphorus values below 0.3 mg/L have been achieved) but consistent bio-P removal has not been realized.

The Oostanaula plant has historically used chemicals – ferric chloride – to remove phosphorus during the summer. This summer it has been necessary to chemically remove phosphorus on only two occasions: June 1-26 and August 4-present. Oostanaula was able to meet its 50 lbs/day (65 lbs/day weekly) seasonal limit during July without chemicals. Given Athens' commitment to the project, it is reasonable to believe that plant staff will soon gain control of biological phosphorus removal to the extent that both facilities will produce effluents containing no more than 0.5 mg/L total-P.

WASTEWATER TREATMENT PLANT VISITS

The wastewater treatment plants were visited on two occasions during April and July 2015. A summary of the site visits follows.

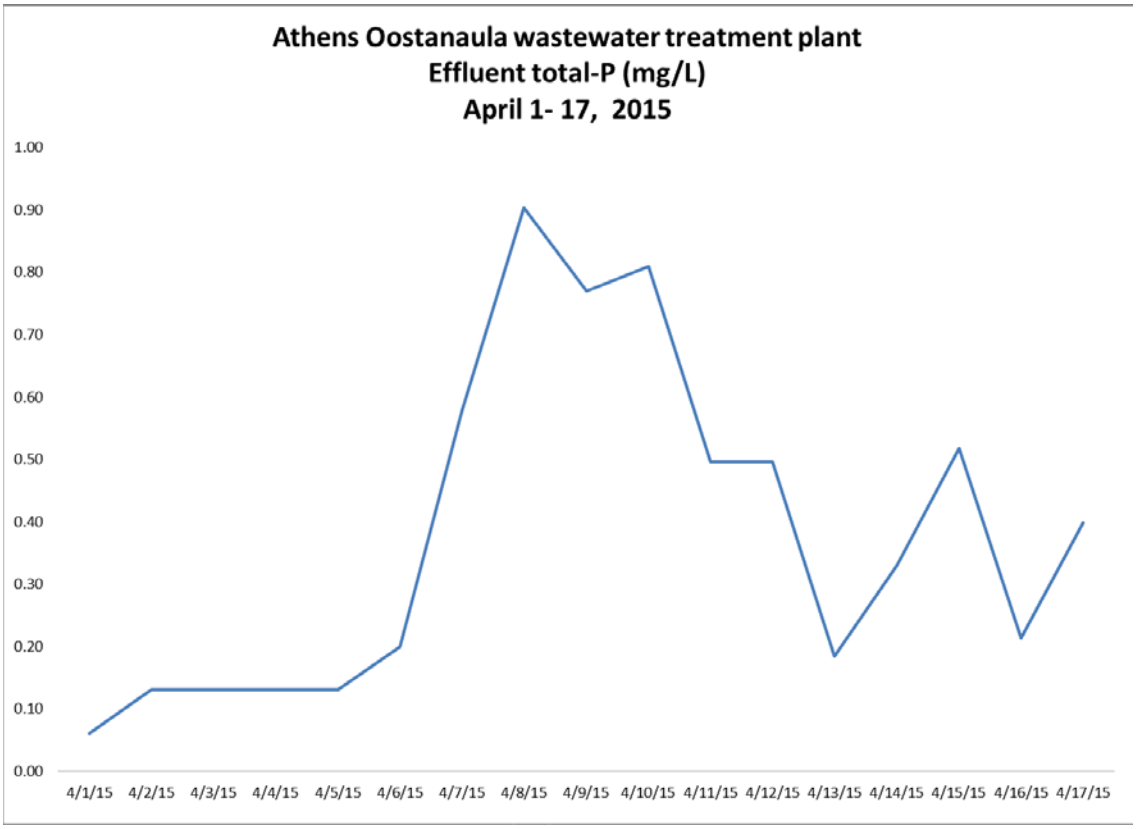
Oostanaula

April 1, 2015. Greg Hayes and Russell Coleman of the City of Athens, Stefanie Farrell of LDA Engineering, and Grant Weaver of The Water Planet Company met at the Oostanaula plant to review plant data and discuss opportunities for improved nutrient removal. Athens Water & Wastewater Superintendent Jill Davis joined us in touring the facility.

With an effluent total-nitrogen typically less than 3 mg/L, the optimization effort zeroed in on biological phosphorus removal. There exists little opportunity for improving upon Oostanaula's excellent nitrogen removal! During summer months, plant personnel have historically added ferric chloride in order to reduce phosphorus to 1.0 mg/L or less. Ironically, during winter months when there is no phosphorus limit, effluent total-P is generally less than 1.0 mg/L without chemicals.

Phosphorus. In advance of the consultant's first visit, plant staff converted an unused clarifier from the old plant to a sludge fermenter. Waste sludge is pumped to the fermenter and after becoming somewhat anaerobic is pumped back into the plant's headworks. The fermenter has an ORP value of approximately -150 mV.

During the first three weeks of recycling sludge (and, in turn, “feeding” and cycling PAOs – phosphate accumulating organisms – through the plant), the effluent ortho-P value initially increased from 0.3 mg/L up to 0.9 mg/L before dropping back down to 0.3 as shown in the graph on the page that follows. Based on these results, and the consultant’s experience with biological phosphorus removal elsewhere, it seemed logical to predict that biological phosphorus removal would allow the Oostanaula staff to consistently meet a 1.0 total-P target without chemicals; and to frequently get the total phosphorus to less than 0.5 mg/L.



To monitor conditions, daily in-house testing was performed using a spectrophotometer for the rest of the study period. Data were compiled and reviewed at least weekly. Samples were collected in the following locations and testing for soluble phosphorus, ortho-P:

Final effluent to monitor overall performance

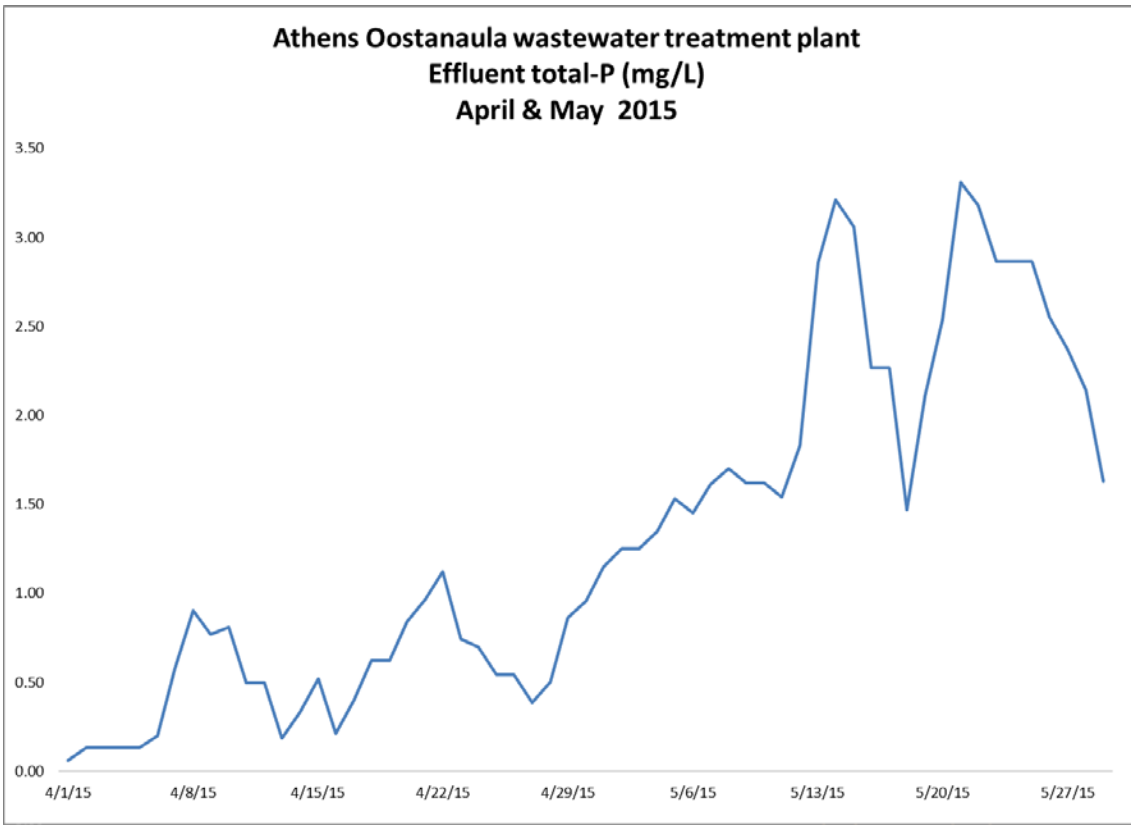
Sludge tank to monitor volatile fatty acid (VFA) production and uptake by the phosphate accumulating organisms (PAOs); the objective being that the ortho-P leaving the sludge tank is 3-4 times the influent ortho-P concentration

In order to monitor habitats / environmental conditions (fermentive conditions in the sludge holding tank and strongly aerobic conditions in the aeration tank), plant staff monitored ORP (oxidation reduction potential) in the sludge tank and orbital rings.

Nitrogen. The plant’s absence of ammonia and typical total-nitrogen of 3 mg/L is excellent. There is no room for optimizing and no attempt to do so was made.

July 8, 2015. Greg Hayes, Russell Coleman, and John Sullivan of the City of Athens, Stefanie Farrell of LDA Engineering, and Grant Weaver of The Water Planet Company met at the Oostanaula plant to review plant data, discuss opportunities for improved nutrient removal, and tour the facility.

As the graph that follows illustrates, early April's encouraging results did not last. After holding at 0.5 mg/L or less for a week, the effluent total-P concentration climbed to 1.0 mg/L at the end of April and was over 3.0 mg/L at times during May. To maintain May through October permit compliance, Oostanaula had to begin adding ferric chloride on June 1st and continued doing so for most of the month. Biological phosphorus removal improved and all use of chemicals stopped for the entire month of July. In August it became necessary to again add chemicals. Since beginning the optimization effort, Athens has enjoyed periods of excellent bio-P removal and periods of frustratingly ineffective bio-P removal. As of the writing of this report (mid-August 2015), consistent biological phosphorus has not been achieved; however, given the commitment shown by Athens' talented staff there is little doubt that both facilities will, in the not too distant future, provide consistent biological phosphorus removal.



In-house testing documents that the fermentation tank is effectively releasing ortho-P. And, at times, too much ortho-P is released. Conditions are suitable for aerobic ortho-P uptake: high dissolved oxygen (DO) and pH of 7.0 or higher. It appears that phosphorus is being re-released in the plant but plant staff has not been able to locate where the release is occurring. Monitoring of the ortho-P concentration in the RAS (return activated sludge) is performed to see if the over-

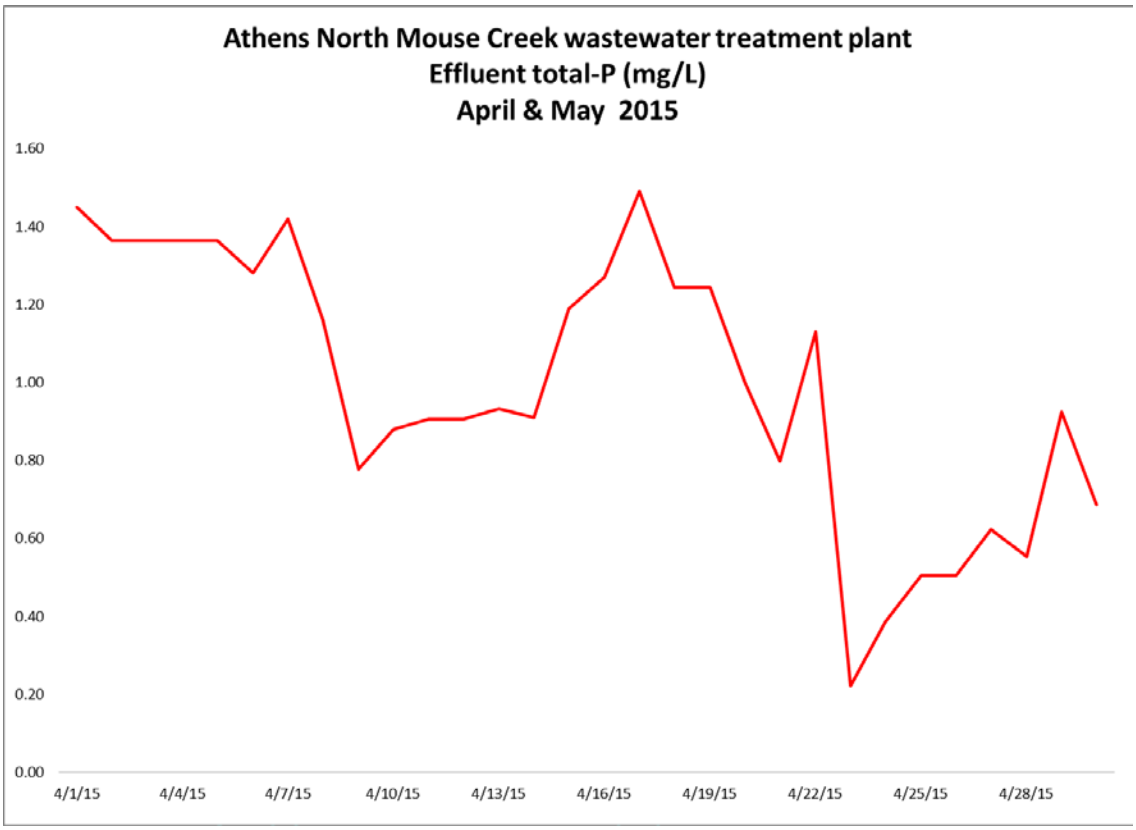
sized clarifiers are allowing phosphorus release. Almost all of the effluent total-P is soluble as there is very little TSS (total suspended solids) in the effluent. Water temperature appears to be a major factor; as a general rule the warmer the water, the higher the effluent ortho-P.

Absent a better strategy, beginning November when the seasonal phosphorus limit is no longer in effect, plant staff will terminate all use of ferric chloride and will continue experimenting with returning fermented sludge to see if biological phosphorus removal can be achieved. If so, with several months of cooler water temperature, plant staff will seek to gain an understanding of what causes the ortho-P concentrations to fluctuate. And, to then implement control measures.

North Mouse Creek

April 1, 2015. Greg Hayes, Russell Coleman, and John Sullivan of the City of Athens, Stefanie Farrell of LDA Engineering, and Grant Weaver of The Water Planet Company met at the North Mouse Creek plant to review plant data and discuss opportunities for improved nutrient removal.

With an effluent total-nitrogen typically less than 5 mg/L (excellent nitrogen removal!), the optimization effort concentrated on biological phosphorus removal. Unlike Athens' other plant, Oostanaula, the North Mouse Creek plant does not have a phosphorus limit. Prior to the study, year-around effluent total-phosphorus averaged 1.3 mg/L.



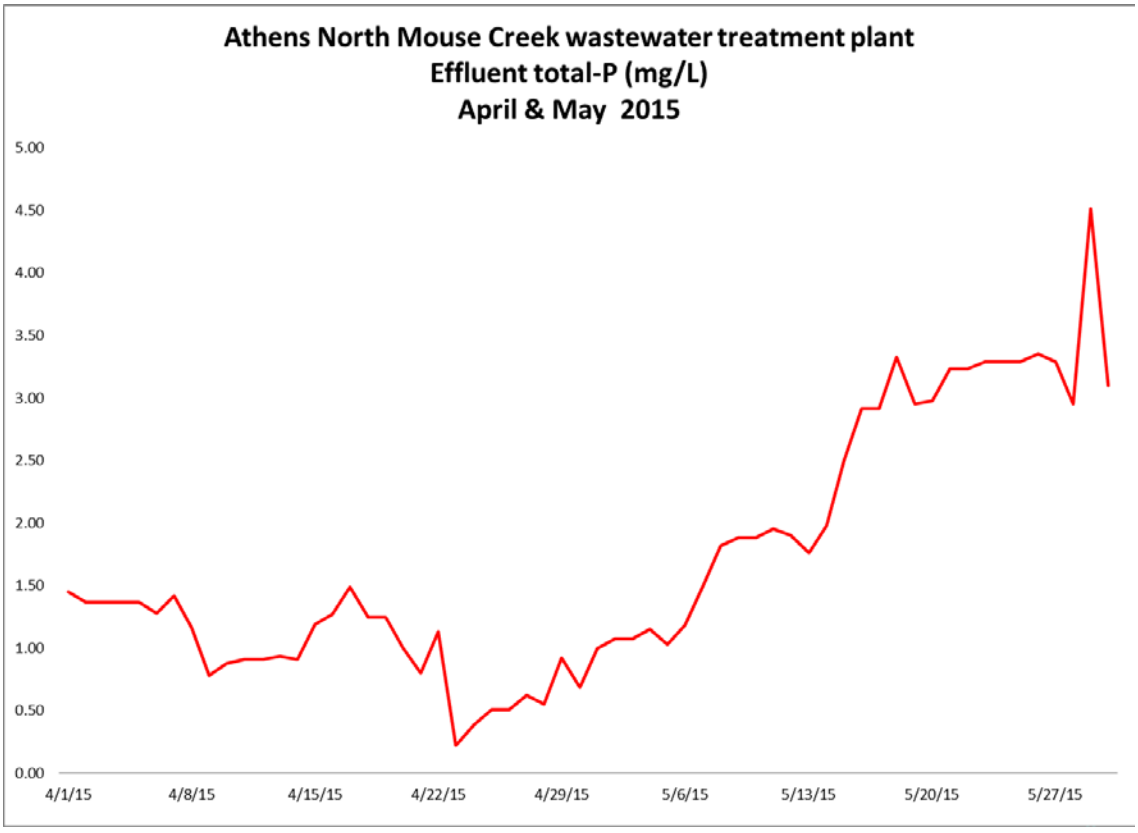
Phosphorus. In advance of the consultant's first visit, plant staff installed a pump in a thickened sludge holding tank and pumped a small amount back into the plant's headworks daily. As with Oostanaula, the early results were encouraging. By late-April effluent total-P was the lowest that plant staff ever recalled seeing. For almost a week, the concentration remained below 0.5 mg/L.

As happened at the Oostanaula plant, effluent phosphorus increased throughout May until it climbed to over 4 mg/L. The same sampling protocols put in place at Oostanaula were followed at the North Mouse Creek plant. Because both plants were tracking similarly and because the Oostanaula plant has a summertime limit, by late May the majority of the study efforts were concentrated on the Oostanaula plant.

Nitrogen. The plant's absence of ammonia and typical effluent total-nitrogen concentration of 5 mg/L is excellent. There is little room for optimizing and no attempt to do so was made.

July 8, 2015. Greg Hayes, Russell Coleman, and John Sullivan of the City of Athens, Stefanie Farrell of LDA Engineering, and Grant Weaver of The Water Planet Company met at the Oostanaula plant to review data from both plants. However, the focus was on the Oostanaula plant, not North Mouse Creek.

As the graph below illustrates, April's encouraging results did not last. After holding at 0.5 mg/L or less for a week, the effluent total-P concentration climbed throughout May.



And, as the graph on the following page illustrates, the June and July results were better than those of May but quite variable. At times, effluent total-P was well below 1.0 mg/L (going below 0.5 on five occasions) and well above 2.0 mg/L at other times; going as high as 3.0 mg/L.

To test the effects of water temperature on biological phosphorus removal, the experiment will continue through the cooler months to see if more consistent, lower effluent total-P values

result. If so, plant staff will seek to gain an understanding of what causes the ortho-P concentrations to fluctuate. And, to then implement control measures.