Akron WRF Step Feed Phase 2: Design, Operation, Performance and Optimization of Secondary Treatment Wet Weather Expansion and BNR Upgrades

Edward Becker¹, Tom Sanderson²

¹ Arcadis, 10 Friends Lane, Suite 100, Newtown, PA 18940
² City of Akron WRF, 2460 Akron-Peninsula Rd., Akron, OH 44313

ABSTRACT

Many municipalities are facing the challenge to expand the wet weather capacity of their treatment facilities to address collection system overflows, while also meeting nutrient removal requirements. One such municipality is the City of Akron, OH, which operates the 90 mgd (341,000 m³/d) average design flow Akron Water Reclamation Facility. The City recently performed extensive modifications to the facility to address USEPA Consent Order requirements. The path forward required expanding secondary treatment peak capacity from 110 mgd (416,000 m³/d) to 220 mgd (833,000 m³/d) without adding more process units, while also meeting monthly total phosphorus limits of 1 mg/L and seasonal ammonia limits. This paper presents how these competing requirements were addressed for the Akron Water Reclamation Facility and will discuss the design, operation, performance, and lessons learned through the start-up and full-scale operation following implementation of the secondary treatment upgrades at the facility.

KEYWORDS

Wastewater treatment, wet weather, step feed, phosphorus removal, operations optimization

INTRODUCTION

The City of Akron, OH owns and operates a 90 mgd (341,000 m³/d) design average flow Water Reclamation Facility (WRF) which discharges into the Cuyahoga River. The main wet stream processes at the Akron WRF include the headworks (influent screening and detritus grit removal facilities), primary settling tanks (PSTs), secondary treatment comprised of six process trains of aeration basins (ABs) and final settling tanks (FSTs), and seasonal chlorine disinfection. Sludges from primary and secondary treatment are thickened and then sent offsite for further processing. A 10 MG (38,000 m³/d) storm retention tank (SRT) is used for peak flow management. The headworks have a total capacity of 280 mgd (1,060,000 m³/d). Historical peak flow management has included sending 220 mgd (833,000 m³/d) to the PSTs, plus diversion of up to 60 mgd (227,000 m³/d) from the headworks to the SRT. From the PSTs, up to 110 mgd (416,000 m³/d) of primary effluent is sent to secondary treatment with up to 110 mgd (416,000 m³/d) directed through the secondary treatment bypass to disinfection. A site layout of the Akron WRF, along with original peak flow capacities prior to recent upgrades, is provided in Figure 1.
The Akron WRF has weekly and monthly permit limits, but does not have daily effluent limits. Historically, the Akron WRF has operated as a plug flow activated sludge process to achieve seasonal ammonia-nitrogen permit limits, along with monthly and weekly total suspended solids, 5-day Carbonaceous Biochemical Oxygen Demand and total phosphorus (TP) limits.

Pertinent effluent limits from the Akron WRF NPDES permit (No. 3PF00000*OD) are provided in Table 1 for the treated discharge from the plant through secondary treatment. The weekly limits are of particular interest with respect to wet weather treatment and were used for comparison to the predicted peak wet weather flow performance of the secondary treatment system during design.
Table 1: Akron WRF Secondary Effluent Limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Weekly Limits</th>
<th>Monthly Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/L</td>
<td>kg/d</td>
</tr>
<tr>
<td>TSS</td>
<td>23</td>
<td>7,835</td>
</tr>
<tr>
<td>CBOD5</td>
<td>15</td>
<td>5,110</td>
</tr>
<tr>
<td>NH3-N (Jun-Sep)</td>
<td>2.3</td>
<td>784</td>
</tr>
<tr>
<td>NH3-N (Mar-May, Oct-Nov)</td>
<td>7.1</td>
<td>2,419</td>
</tr>
<tr>
<td>NH3-N (Dec-Feb)</td>
<td>11.3</td>
<td>3,850</td>
</tr>
<tr>
<td>TP</td>
<td>1.5</td>
<td>511</td>
</tr>
</tbody>
</table>

The City recently performed extensive modifications to the WRF to address USEPA Consent Order requirements to eliminate secondary bypasses and provide treatment for up to 280 mgd (833,000 m3/d) peak flow rate. The path forward required expanding secondary treatment peak capacity to 220 mgd (492,000 m3/d) without adding more process units, in parallel with a new 60 mgd (227,000 m3/d) peak flow high rate treatment system. The challenge to increasing the secondary treatment capacity involved tackling both process treatment and hydraulic limitations.

The objective of the step feed upgrade was to expand the wet weather treatment capacity of the Akron WRF secondary treatment system from 110 mgd (416,000 m3/d) to 220 mgd (492,000 m3/d) to eliminate secondary bypasses, and to do so within the existing tankage. Process and hydraulic models are developed and utilized to determine the existing capacity limits, and then used as a planning tool to develop infrastructure improvements to increase the process and hydraulic capacity, as needed.

During start-up and construction, as upgraded units were brought into service the objective of the operations staff was to achieve stable operation, and then initiate step-feed operation. As construction neared completion, focus shifted toward optimizing the operations and improving the treatment efficiency, particularly with regard to mixed liquor suspended solids (MLSS) levels, dissolved oxygen (DO) control and pH control, while working toward maximizing secondary treatment wet weather capacity.

**STEP FEED PHASE 2 PROCESS DESIGN**

For the secondary treatment improvements, a two-phased approach was deemed acceptable to the USEPA wherein one process train would first be tested to demonstrate proof of concept, before converting the other five process trains in phase two. Unit 6 was selected for conversion in the first construction phase (Step Feed Phase 1 (SFP1)). The SFP1 concept and results have been documented elsewhere (Daigger et al, WER August 2017). The results confirmed the step feed concept could meet the wet weather requirements, and were used to help refine design assumptions for the full system upgrade.
The major design components of the Step Feed Phase 2 (SFP2) were defined through hydraulic modeling of the WRF to identify hydraulic bottlenecks and resolutions, and process modeling to determine improvements and operating strategies necessary to treat peak flows up to 220 mgd (833,000 m3/d) through secondary treatment, as well as support (dry weather) biological phosphorus removal. The major upgrades included:

- New influent channels, mixed liquor conduits and secondary effluent conduit
- Provisions for step feed operation
- Baffled anaerobic zone with mechanical mixing for biological phosphorus removal
- Aeration system (fine bubble) modifications
- Density current baffles, new drives, bridges, launders, scum skimming, and energy dissipating inlets on FSTs

A key aspect of the SFP2 design was the development of site-specific secondary sludge settleability information to be incorporated into the process model and design efforts, which was gained from settling column tests that were conducted during SFP1. The settling column test data was analyzed to determine the zone settling velocity for each sample, which was then plotted versus the solids concentration of the sample and fit to establish a curve using the Vesilind equation (Vesilind, 1968) to describe the settling velocity of the solids in the Akron WRF FSTs as a function of the suspended solids concentration. During client workshop discussions, a slightly conservative approach to settling performance was desired for the SFP2 wet weather capacity evaluations. Therefore, the best fit Vesilind coefficient values were adjusted slightly in order to modify the settling curve to add a bit of conservatism on the settling performance predictions for the wet weather capacity modeling evaluations. The resulting design curve used for the SFP2 is shown on Figure 2, along with the original best fit curve and measured data. The Vesilind coefficient values from the design curve used for the wet weather modeling were $V_0 = 11.426$ m/h and $k = 0.312$ L/g.

![Figure 2: Akron WRF FST Solids Settling Curves](image)

In addition to the sludge settleability information, results of SFP1 stress testing and CFD modeling evaluations provided additional guidance that was incorporated into the SFP2 design. In particular, stress testing demonstrated that fully upgraded Unit 6 FSTs could process at least
15 mgd (57,000 m³/d) per FST with a 20% RAS rate (equivalent to the 220 mgd (833,000 m³/d) peak capacity target of SFP2), when paired with step feed to manage FST solids loading rates. FST operation at this flow rate would equate to a surface overflow rate of approximately 1,560 gpd/sf (2.6 m/h). Based on the SFP1 testing results, a recommend target peak solids loading rate of 35 lbs/d/sf (7.1 kg/m²-h) on the FSTs was utilized for the SFP2 design evaluations.

The approach to the SFP2 process design and modeling effort included updating and validating the preliminary BioWin™ model developed as part of the SFP1 study, development of the design wet weather hydrograph and associated loading conditions, and performing simulations with the validated model at the design conditions under several step feed operating scenarios and flow limits to the secondary treatment system. The SFP2 process model configuration is presented in Figure 3.

![Figure 3: Revised Model Configuration](image)

To establish design conditions for the wet weather capacity analyses, first the typical year design hydrograph of flow to the Akron WRF was reviewed. The peak 7-day wet weather event from the hydrograph was identified and selected as the influent flow basis for the wet weather capacity modeling evaluation, as presented in Figure 4.
The design peak flow hydrograph was paired with design influent loading conditions developed from historical data and supplemental sampling, to develop the model influent input for the wet weather capacity modeling. The model input is shown in Figure 5, and consists of diurnal input at the maximum month flows and loads for several days leading into the wet weather event (design 7-day storm hydrograph, combined with the first flush loads), followed by a return to diurnal input at maximum month flows and loads. The total duration of the dynamic modeling run is 30 days.
Process modeling was then performed under steady state and dynamic conditions to evaluate the biological phosphorus removal potential and related design aspects, and the capacity of the secondary treatment system to process increased wet weather flows to meet weekly effluent quality targets as well as ability to recover from significant wet weather events to retain nutrient removal performance (nitrification and biological phosphorus removal).

Modeling verified that an anaerobic zone equal to 50 percent of Pass 1 would be appropriate for design. Figure 6 shows the impact of anaerobic selector zone size on biological phosphorus removal predicted through process modeling at average annual (AA) and maximum month (MM) loadings, and recommended sizing for design. As shown on Figure 6, modeling also predicted effluent TP levels well below the monthly effluent limit of 1 mg/L could be achievable with biological phosphorus removal with the recommended configuration, potentially approaching as low as 0.2 mg/L under optimal conditions.

![Figure 6: Anaerobic Zone Size versus Effluent TP](image)

Dynamic modeling of peak wet weather flows and loads was performed to evaluate the secondary treatment capacity and performance under various peak flow rates and step feed operating strategies. Step feed operating strategies included evaluating distributing flows between the different combinations of the four passes, as well as different flow targets for transition between different step feed operating modes, to understand the impact on FST solids loading and secondary treatment performance.

Figure 7 presents predicted secondary effluent based on sequential transition from plug flow to step feed to Passes 1 and 2 as flow initially rises, then to step feed Passes 2 and 4 at peak flows, with the sequence reversed as flows decrease back to normal levels. As shown in Figure 7, the secondary effluent TSS rises significantly from dry weather levels, but is predicted to remain below permit limits (23 mg/L weekly average) due to the management of the FST solids loading rate with step feed operation, which is in agreement with the SFP1 stress testing and CFD...
modeling. There is a slight rise in ammonia and TP during the peak flow periods, due to the direct feed of 50 percent of the primary effluent to Pass 4 and limited time for treatment in this pass at the peak flow conditions. However, the effluent quality is predicted to quickly recover following the wet weather event and resumption of plug flow operation.

![Graph](image)

**Figure 7: Predicted Secondary Effluent Quality with Step Feed to Passes 2 & 4 During Peak Flow**

Figure 8 compares the predicted solids loading rates on the FSTs under two different step feed strategies. Strategy 2 involved a remaining in step feed mode for a longer duration with a slower transition out of step feed operation as flows subsided as compared to Strategy 1. The difference in the predicted solids loading rates is noticeably improved with Strategy 2. This operational strategy allowed the solids loading rates to be better managed and remain below the target 35 lbs/d/sf (7.1 kg/m2-h) throughout the wet weather event, and also avoid a significant spike in solids loads onto the FSTs as the system transitions out of step feed operation due to the push of the solids stored in the ABs during step feed operation.
Summary of Key Design Conclusions and Recommendations

The overarching conclusion of the SFP2 process modeling and design efforts was to confirm that the secondary treatment processes had the potential capacity to treat up to 220 mgd (833,000 m³/d) peak flow and meet secondary effluent permit limits. Some reduction in effluent performance is expected at peak flows, but still within weekly permit limits, and rapid recovery of performance to typical dry weather levels is expected following transition back to plug flow operation following a wet weather event.

The process treatment system is limited by the effectiveness of the final settling tanks and other hydraulics restrictions within the secondary treatment facility. The principle limit on secondary treatment capacity under peak wet weather flow conditions is the acceptable solids loading rate, which based on the existing studies was 35 lbs/d/sf (7.1 kg/m²-h). The types of FST improvements completed under the Step Feed Phase 1 project are important for consistently meeting treatment goals at higher flows and, as such, were recommended to be incorporated to upgrade the FSTs of the other treatment trains.

Based on SFP2 design work, the recommended wet weather operation strategy was to open Pass 2 and operate in Pass 1/Pass 2 step feed as a storm hits and plant flows rise; this operating mode may be sufficient for small storms. To manage peak flows in excess of 200 mgd (757,000 m³/d), particularly for a significant duration, splitting flow between Pass 2 and Pass 4 is recommended, in order to maintain acceptable solids loading rates on the FSTs and best manage the solids. Remaining in step feed operation as flows subside is recommended in order to reduce the impact on FST solids loading from converting back from step feed following a storm.

Incorporation of an anaerobic selector zone in the first half of Pass 1 of the aeration tanks was recommended to provide the optimum environment to support efficient biological phosphorus removal, and would also aid in continuing good SVI and mixed liquor settling characteristics.
CONSTRUCTION AND START UP SCHEDULE

Construction began in October 2016 and the last upgraded basin was placed in service November 2018. The major upgrades included:

- Channel, piping and related hydraulic improvements
- Provisions for step feed operation
- Baffled unaerated zone with mechanical mixing
- Aeration system modifications
- Density current baffles, new drives and other FST improvements

Figure 9 presents the construction sequencing of the ABs. ABs #5 and #6 were taken offline in January 2017 the first basins to be upgraded. As shown in Figure 4, as the upgraded ABs were put back into service, subsequent ABs were taken down in sequence, with AB #4 in June 2017, followed AB#3, AB#2 and finally AB#1. Construction was substantially complete with all upgraded ABs in service in November 2018.
LESSONS LEARNED DURING CONSTRUCTION AND START UP

A number of challenges arose and valuable operating insights were gained during the construction and start-up operations of the SFP2 upgrades. The most prominent challenges and respective solutions to address the issues are discussed below.

Reduced FST underflow concentration

Challenge: The FST underflow becomes so dilute that staff cannot waste to the gravity belt thickeners due to hydraulic overload. This situation was only experienced during peak wet weather events, when operating in step feed to Passes 2 and 4, due to the storage of solids in the ABs and reduction in solids loads on the FSTs. The dilution in RAS concentration can be seen in Figure 10, which presents data from sampling performed during a wet weather event in April 2019. Thus far performance has not been adversely impacted, however due to the temporary lack of wasting the mixed liquor suspended solids (MLSS) concentration increases by several hundred mg/L over typical levels after flows drop and plug flow operation is resumed, until additional wasting can catch up to remove the excess solids.

Solution: WRF staff found that running the belt thickener at the lowest speed possible works as a stop-gap measure (several hours), but extended peak flow events the MLSS and RAS become so dilute that staff still have to temporarily stop wasting until plant flows decrease and RAS concentrations increase. Standard operating procedure is to flow-pace the RAS to maintain approximately 18 percent RAS rate during wet weather events. WRF staff have recently initiated efforts to test backing down the RAS rates during peak flow, to determine whether that will help to thicken the underflow concentrations without adversely impacting the sludge blankets or FST effluent quality. This work is just beginning.

Figure 10: Train 6 RAS and MLSS Concentrations during High Flow Event
Elevated effluent phosphorus levels on start-up

Challenge: Effluent TP performance of upgraded ABs was inconsistent and often high (1 mg/L or greater) when the upgraded ABs were placed back into service.

Solution: Staff noted that it took approximately one and a half months to two months (four to five sludge ages) after being placed into service for the upgraded tanks to stabilize and achieve consistent low biological phosphorus removal operation. The good TP performance of the other ABs in service helped to balance the lesser performance of the ABs newly in service until the new ABs could acclimate and stabilize. The effluent TP permit was never violated, but came close on a few occasions. Staff also found that operating at MLSS concentrations higher than historical levels (above 2,000 mg/l) helped optimize the TP removal performance. Now that all ABs have been in service for some time and are fully acclimated, staff report effluent TP is regularly 0.2 mg/L or even lower during dry weather, and only up to 0.3 mg/L to 0.5 mg/L or so in wet weather.

Operating strategies for MLSS

Challenge: Historically, the MLSS was operated in the 1,600 mg/L to 1,800 mg/L range, perhaps slightly higher in cold months. Was this still an appropriate MLSS operating range for the upgraded facilities?

Solution: The first upgraded ABs (AB #5 and AB#6) were initially operated at historical MLSS levels when first brought online. In response to the inconsistent TP performance issues noted above, WRF staff began testing alternate MLSS levels. Ultimately WRF staff found that operating at a MLSS range of 2,000 mg/L to 2,200 provided optimal balance of both biological phosphorus removal and nitrification performance, with current performance achieving effluent ammonia often below 0.1 mg/L and effluent TP of 0.2 mg/L or less.

Excess air and high DO

Challenge: Operation at the minimum diffuser airflow rate of 1 scfm/diffuser recommended by the diffuser manufacturer resulted in high dissolved oxygen (DO) levels, often near saturation in Pass 4, excess (wasted) air and floc shear and settling problems.

The diffusers layout was modified to accommodate step feed operation, in particular additional diffusers added to Pass 4 to support treating direct feed of primary effluent during wet weather step feed operation. However, dry weather plug flow operation typically has low loads and oxygen demand on Pass 4.

Solution: The solution was to reduce air and operate at 0.5 scfm/diffuser, with bi-weekly purging of diffusers (2 scfm/diffuser for 20 minutes) to prevent diffuser fouling. This has resulted in much lower operating DO levels of 2 to 3 mg/L.
Challenge: SFP2 modifications removed an unintentional “grease trap” in the primary effluent channel, and grease that used to be captured in the primary effluent channel now passes to the ABs and coats the DO probes causing faulty readings and air control issues.

Solution: WRF staff schedule DO probe cleaning more frequently.

Challenge: Original operation of the blowers involved a large (900 hp) centrifugal blower to be operated with two turbo blowers, which was energy inefficient. Installation of the new diffusers and anaerobic zone in the SFP2 upgrades and subsequent operation with reduced scfm/diffuser rates to better manage the DO levels, required overall less air than previously.

Solution: WRF staff adjusted blower operation to run only using turbo blowers and not operate the centrifugal blower. This requires staff to manually start the spare (fourth) turbo blower for peak demands. Programming is being investigated to start the fourth turbo blower automatically. However, running with just turbo blowers saves significant energy compared to the centrifugal blower, which has resulted in savings of approximately $16,500/month.

Low pH excursions

Challenge: Secondary influent typically has low pH of 6.5, and the pH drops even lower during wet weather, causing concerns with meeting effluent permit minimum limit of pH 6.5.

Solution: WRF staff reduced the RAS rate from 20% to 17%, with two- to three-foot sludge blanket in the FSTs. The increased blanket HRT promotes some denitrification and alkalinity recovery without causing rising sludge issues, allowing recovery of pH to near-neutral levels.

Figure 11 shows pH data from a recent wet weather event. The pH data show that the secondary influent pH is near or below the permitted minimum pH 6.5, and then drops slightly further during peak flows. However, the pH consistently increases across secondary treatment to typically reach an effluent of approximately pH 7. This change was consistent across all flows (dry weather and peak) and plug flow or step feed operating modes.
Equipment issues

*Challenge:* The FST center column seals were found to be tearing. The seal on some FSTs would tear within a few weeks, other FSTs would last a few months.

*Solution:* The equipment manufacturer supplied different fiber-reinforce seal, to replace original seals as they tear. So far, no problems have been encountered with new seals.

*Challenge:* The gear box on the Pass 1 influent gates experienced mechanical failures. Investigation showed that grease couldn’t get to the upper bearings of the gear box, causing the failure.

*Solution:* The manufacturer was contacted regarding the issue, and will be coming to the WRF to replace the faulty equipment.

*Challenge:* The motors on the hyperbolic mixers in the anaerobic zones kept overloading and would trip out frequently.

*Solution:* The 5hp motors were undersized for the operating conditions actually experienced, and were operating at maximum essentially full-time. The motors were replaced with larger 7.5 hp motors, which have worked fine and have had no issues to date.

*Challenge:* The baffle wall between the anaerobic zone & aerobic zone on AB 6 bowed backwards at the top (toward the downstream aerobic zone) after AB 6 was filled and put into service.

![Figure 11: Secondary Treatment pH](image-url)
Solution: Two box supports were added at top of the baffle wall on the downstream side (aerobic zone). This additional support solved the structural issue. AB 6 was the first basin upgraded and put into service; the additional baffle wall support was subsequently incorporated into the baffle wall designs on the other five ABs as they were upgraded.

Hydraulic issues affecting step feed functionality

Challenge: Difficulty balancing flow between AB 5 and AB 6. In order to control flow to AB 5 and AB6, the gate originally intended to be an isolation gate for AB 6 must now be operated as a modulating gate.

Solution: The first attempt was to try to maintain a constant sidewater depth (SWD) in the channel upstream of the gate. This proved ineffective, and flows to AB 5 and AB 6 fluctuated dramatically. The second attempt changed the gate control programming to control the SWD in the channel to AB 6 downstream of the gate. This programming change was successful in balancing the flow distribution between AB 5 and AB 6.

Challenge: Flow was lost over the secondary bypass overflow weirs at peak flows, which limited the peak flow that could be sent to the secondary treatment to approximately 210 mgd (795,000 m3/d). The overflow weirs were adjusted per hydraulic modeling performed during design to allow 220 mgd (833,000 m3/d) to flow to secondary treatment, but this setting has proved to be too low.

Solution: WRF staff are adjusting the overflow weirs higher in an iterative, trial and error, method. Following the latest adjustments, secondary flow has now reached approximately 218 mgd (825,000 m3/d). Further refinements to the overflow weir position are expected to allow the target peak flow of 220 mgd (833,000 m3/d) to secondary treatment to be realized.

Challenge: Step feed control programming proved to be more complicated and took longer than originally anticipated. Programming to open AB pass gates to enter into a given step feed mode as flows increased was not too difficult, but transitioning out of step feed mode as flows decreased involved more factors to take into account and proved quite cumbersome and time-consuming.

Solution: The solution was to deviate somewhat from the original recommended step feed operating strategy that was proving too difficult and complex to program. This involved abandoning the step feed operating mode where flow was evenly split between Passes 1, 2 and 4, and only programming three operating modes – Mode 0 (plug flow operation), Mode 1 (even step feed flow split between Passes 1 and 2) and Mode 2 (even step feed flow split between Passes 2 and 4). Additionally, the programming logic basis was changed from using a combination of a flow setpoint and time delay, to timer-only based operation for transitioning between operating modes. This adjusted step feed control was less complicated to program, and thus far has shown to work well for supporting secondary treatment wet weather operation and performance.
RESULTS AND DISCUSSION

The objective of the SFP2 upgrade was to increase the secondary treatment peak flow capacity from the SFP1 capacity of 130 mgd (492,000 m³/d) up to 220 mgd (833,000 m³/d), as well as incorporate formal biological phosphorus removal. Since the completion of the SFP2 upgrades, the facilities have performed well, meeting the effluent weekly and monthly permit limits for all parameters. The anaerobic selector zone has helped maintain the excellent historical settleability levels and support biological phosphorus removal to meet the effluent permit TP levels. Figure 12 presents the TP removal performance of the upgraded basins as the SFP2 upgrades came online. Even with just four out of six basins upgraded and in service, excellent treatment performance was achieved, with effluent TP consistently well below 0.5 mg/L. In recent months, since all six upgraded basins were placed in service and the biomass fully acclimated and matured, effluent TP has continued to drop even further with concentrations as low as 0.1 to 0.2 mg/L regularly achieved.

![Figure 12: Total Phosphorus Removal Performance of Upgraded Aeration Basins](image)

The WRF has successfully processed up to approximately 218 mgd (825,000 m³/d) through secondary treatment to date, a substantial increase over historical levels, and has shown excellent resilience to peak flows due to the step feed operation, with rapid recovery of dry weather system performance within a day or two following wet weather events. Final adjustments to PST weirs are expected to allow the targeted 220 mgd (825,000 m³/d) peak secondary treatment flow to be reached.
Wet Weather Demonstration Testing Results

Formal demonstration testing is included in the SFP2 project, and is currently underway. The purpose is to perform testing and evaluation under peak flow conditions of the Akron WRF secondary treatment processes that were upgraded as part of SFP2, in order to perform a detailed assessment of the secondary treatment wet weather performance and identify optimum wet weather operating procedures. The demonstration testing will include up to six wet weather test events, to be completed in 2019. Three tests have been completed to date, two in April 2019 and one in June 2019. Detailed sampling information from the June event was not yet available at the time of publishing and thus unable to be included in this paper; however, preliminary WRF flow data indicates flows up to the target peak flow of 220 mgd (833,000 m³/d) and even slightly higher were processed through secondary treatment, with no obvious issues. Sampling results from the two April events are discussed below.

The first demonstration testing event (Event #1, April 14-15, 2019) saw sustained heavy flows, with flow through secondary treatment peaking at 213 mgd (806,000 m³/d) (hydraulic issues preventing going higher) and staying above 200 mgd (757,000 m³/d) for 6 hours. The second event (Event #2, April 25-26, 2019) was less intense, and only brought two brief one- to two-hour peaks of approximately 190 mgd (719,000 m³/d) to secondary treatment. Figure 13 shows the event hydrograph and the step feed operating mode during the event. Note that Mode 0 is plug flow operation, Mode 1 is step feed with equal split of flow to Passes 1 and 2, Mode 2 is step feed with equal split of flow to Passes 2 and 4. The rise in flows from dry weather levels to peak wet weather flows is very rapid, occurring within one to two hours. The time to drop from peak flow to typical daily levels (<100 mgd (379,000 m³/d)) was three to four hours for the smaller storms sampled. For the large (213 mgd (806,000 m³/d)) storm in Event #1, special monitoring ended three hours after the peak flows passed and before flows returned to normal, at which point flow had only dropped to 150 mgd (568,000 m³/d).

![Event #1 - Flow and Step Feed Operation](image1.png)

![Event #2 - Flow and Step Feed Operation](image2.png)

Figure 13: Demonstration Testing Events Hydrograph and Step Feed Operation

Hourly grab sample data were collected on the secondary influent and effluent, and are shown in Figures 14, 15 and 16. The sampling data showed an initial increase in the effluent concentrations of TSS, TP, and Ammonia at the start of the wet weather event. These effluent concentrations peaked about 3 hours into the high flow period for both events, which is attributed
to the initial surge in flow combined with switching to step feed operation. Once higher concentrations initially residing in the ABs and FSTs prior to the event were pushed through the system and the solids blankets and MLSS stabilized, the effluent concentrations dropped, being replaced by dilute incoming wet weather flow. Nitrification and biological phosphorus removal were reduced during peak flows while operating in step feed mode with flows to Passes 2 and 4. Effluent NH3-N was equal to aeration influent NH3-N in step feed Mode 2, while effluent TP was slightly less than aeration influent TP – most likely due to some additional particulate TP capture in secondary treatment. Both NH3-N and TP removal showed rapid return to typical levels following the storm events and transitioning out of step feed operation. All of the hourly effluent concentrations were well below the weekly permit values of TSS 45 mg/L, CBOD5 40 mg/L, TP 1.5 mg/L and NH3-N 7.1 mg/L (seasonal – April).

Figure 14: Wet Weather Secondary Influent and Effluent TSS

Figure 15: Wet Weather Secondary Influent and Effluent Ammonia
Figure 16: Wet Weather Secondary Influent and Effluent TP

Overall, the first two demonstration tests have shown that the performance metric goals are being met as expected, and secondary treatment is able to adequately treat peak flows of 210 mgd (795,000 m3/d) or slightly higher for a sustained period of time (approximately 6 hours).

The Consent Order stipulates that after April 30, 2019, 220 mgd (833,000 m3/d) is to be treated through secondary treatment. However, Akron WRF staff have taken it upon themselves and worked diligently to maximize the flow taken through secondary treatment to the extent possible, often treating more than the 110 mgd (416,000 m3/d) required per the NPDES permit prior to the completion of the SFP1 and SFP2 upgrades. From the completion of SFP1 in July 2013 through the end of April 2019, WRF staff have estimated that 863,744,553 gallons (3,270,000 m3) (equivalent to more than 11 days of current average daily flow) has been treated through secondary treatment above the minimum flow required to be processed, a truly commendable achievement.

Future Work

Demonstration testing is planned to continue through the summer of 2019, with detailed sampling of up to four additional wet weather events targeting 220 mgd (833,000 m3/d) peak secondary flow. Also, a new parallel high rate wet weather treatment system is under construction for treating flows above 220 mgd (833,000 m3/d), which is expected to be completed in late 2021, and will require testing and coordination with secondary treatment to optimize both processes once the new system is online.

Having an attitude of continued process improvement, the staff at the Akron WRF continually seek ways to further optimize operations. WRF staff are currently working with the blower manufacturer to reprogram the turbo blowers to allow the option of all four blowers to be automatically put in service to run simultaneously, for greater operational flexibility and eliminate the need to manually start the fourth blower when required. In addition, staff are beginning to look into reducing RAS rates during peak flow events, seeking to understand the impact on sludge blanket levels and the potential to increase the FST underflow concentration. Additional optimization efforts will continue to be explored in the future as other areas of opportunity are targeted.
CONCLUSIONS

The Step Feed Phase 2 upgrades at the Akron WRF have been successful, meeting performance goals. However, the upgraded treatment systems presented staff with new challenges, including biomass acclimation and performance during start-up, and developing new operating protocols, along with troubleshooting instrumentation and equipment issues and hydraulic bottlenecks that were uncovered after the upgraded tanks were placed into service.

Utilizing construction phasing and staying engaged (both plant staff and designers) during construction and start up promoted early identification of operational and performance concerns and mitigation strategies, that in turn allowed for greater understanding of expectations and operational strategies when subsequent offline tanks were placed back into service.

Continued process improvement efforts by the staff have substantially reduced air requirements, increased effluent pH, maintained excellent sludge settleability, and achieved excellent effluent TP and ammonia treatment performance, while increasing the peak wet weather flow processed through secondary treatment from 110 mgd (416,000 m3/d) to 220 mgd (833,000 m3/d). These excellent results reflect the dedication of the Akron WRF staff to monitor and continually optimize the treatment process.

These projects are significant as they demonstrate how the combination of an open dialogue between engineers and plant staff regarding the rationale for operating strategies during and following construction, and staff constantly seeking improvement, can work together to result in treatment and operational enhancements and development of optimal operating strategies. The challenges and lessons learned through the start-up and operation of the upgraded processes will serve as a source of information and experience for other facilities facing similar capacity expansion requirements.

ACKNOWLEDGMENTS

The authors would like to thank the staff at the City of Akron WRF for their excellent efforts and valuable feedback and assistance during these projects.

REFERENCES

Marrying Step Feed with Secondary Clarifier Improvements to Significantly Increase Peak Wet Weather Treatment Capacity: An Integrated Methodology, Daigger et al, Water Environment Research, August 2017