Bidding, Testing, and Start-Up of a Reuse UV Disinfection System in Florida

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ABSTRACT

Hillsborough County, Florida recently installed a new UV disinfection system for reuse at the Falkenburg Advanced Wastewater Treatment Plant (AWTP) as part of a plant expansion from 9.0 MGD to 12.0 MGD annual average daily flow (AADF). The Falkenburg AWTP must meet Florida's requirements for high level disinfection (HLD) for both its surface water discharge permit and its public access reuse permit. Construction plans and specifications allowed the UV facility to use equipment with either horizontal or vertical UV lamps and allowed bidders to select from three named manufacturers. During construction, before the bidder-selected UV equipment submittal was approved for fabrication, the UV manufacturer was required to prove the effectiveness of its mechanism for controlling lamp sleeve fouling with a pilot-scale demonstration at the Falkenburg AWTP. Once installed, Hillsborough County was required to obtain approval from the Florida Department of Environmental Protection (FDEP) of a UV Operating Protocol prior to placing the new UV system in service. Performance testing of the UV system is in progress and results to date are summarized.

Key words: UV disinfection; reclaimed water; pipelines; bio-stability

PROJECT BACKGROUND

The Falkenburg AWTP is an advanced domestic wastewater treatment plant using a Type I oxidation ditch. The Hillsborough County Water Resources Department is expanding the Falkenburg AWTP from a rated capacity of 9.0 MGD AADF to 12.0 MGD AADF. The expansion includes replacing the existing gaseous chlorine disinfection system with a UV disinfection system, as part of a County-wide effort to convert several treatment plants to UV disinfection. The UV disinfection system will treat effluent from seven new dual-media deep-bed denitrification filters to Florida's high level disinfection standards.

The Falkenburg AWTP provides reuse water to the Hillsborough County South-Central Master Reuse System. The permitted contribution from the Falkenburg AWTP to the system is 12.0 MGD on an AADF basis. **Table I** summarizes the current effluent limits for discharge to the reuse distribution system.

Table I: PART III REUSE SYSTEM EFFLUENT LIMITS

Parameter	Annual Avg	Monthly Avg	Weekly Avg	Single Sample
Flow, MGD[1, 2]	12.00	Report		
Max. $CBOD_5$, mg/L	20.0	30.0	45.0	60.0
Max. TSS, mg/L				5.0
Fecal Coliform Bacteria, Maximum #/100 mL				25
Fecal Coliform Bacteria, Minimum % non-detect		75		
pH range				6.0-8.5
Min. Operational UV Dose, mJ/cm^2				100
Min. UV Transmittance of effluent, %				55

1. Permitted Maximum Day Flow is 16.7 MGD.
2. Permitted Peak Hour Flow is 27.9 MGD.

Chapter 62-610, Reuse of Reclaimed Water and Land Application, of the Florida Administrative Code (F.A.C.) (1) establishes the requirements for design and operation of reuse water treatment and disposal facilities. The South-Central Master Reuse System is in the category of "Part III Slow-Rate Land Application Systems; Public Access Areas, Residential Irrigation, and Edible Crops". The reclaimed water must meet secondary treatment standards and high level disinfection standards. Total suspended solids (TSS) in the filter effluent must be 5.0 mg/L or less prior to disinfection. Chemical feed facilities for coagulant, coagulant aids or polyelectrolytes (polymers) must be provided. However, such chemical feed facilities may remain idle if TSS limits are being achieved without chemical use. The Falkenburg AWTP has alum feed facilities for phosphorus removal and coagulation.

The surface water discharge is permitted through the National Pollutant Discharge Elimination System (NPDES). The Falkenburg AWTP is currently permitted to discharge up to 6.0 MGD AADF to the Palm River / Hillsborough Bypass Canal. The Palm River flows to Hillsborough Bay and ultimately to Tampa Bay (Class III

Table II: SURFACE WATER DISCHARGE EFFLUENT LIMITS

Parameter	Annual Avg	Monthly Avg	Weekly Avg	Single Sample
Flow, MGD	6.00	Report		
$CBOD_5$, mg/L	5.0	6.25	7.5	10.0
TSS, mg/L	5.0	6.25	7.5	10.0[1]
Total Nitrogen, mg/L	3.0	3.75	4.5	6.0
Total Phosphorus, mg/L	1.0	1.25	1.5	2.0
pH				6.5-8.5
Min. Dissolved O_2, mg/L				5.0
Fecal Coliform Bacteria, Maximum #/100 mL				25
Fecal Coliform Bacteria, Minimum % non-detect	NL[2]	75	NL	NL
Chronic Whole Effluent Toxicity[3]				
Dichloro-bromomethane, mg/L	22	NL	NL	NL

1. There is also a 5.0 mg/L TSS grab sample max limit after filtration and before chlorination.
2. NL = No limit
3. The effluent is to be tested for chronic toxicity every six months.

marine waters). The capacity limit is a rolling annual average. Strict effluent limits apply to the surface water discharge system. Since Tampa Bay is a designated Grizzle-Figg water body, advanced treatment including nutrient removal and high level disinfection is required. **Table II** summarizes the permitted effluent limits for surface water disposal for the Falkenburg AWTP.

In addition to treatment standards, F.A.C. 62-610 (1) includes requirements for the storage of reuse and reject water. These requirements ensure that disposal or storage of effluent is possible when the reuse water does not meet the standards described above and when the reuse water produced exceeds demand. Effluent which meets Part III reuse water quality standards is stored on site in two above ground storage tanks for a total of 10 MG of Part III reuse water storage. Effluent failing to meet Part III public access reuse quality standards is directed to storage in two separate above ground storage tanks for a total of 12 MG of reject water storage. The reject water can be returned to either the filters or the head of the plant. Effluent is sent to reject upon detection of high turbidity or if the UV system cannot meet minimum dose (not enough healthy channels, low UVT, flow meter failure, etc.).

The FDEP does not specify requirements governing the design and operation of UV disinfection facilities for high-level disinfection suitable for Part III Public Access Reuse. Instead, the FDEP references the 2003 NWRI/AwwaRF Guidelines (2) in their Program Guidance Memo (3). The 2003 NWRI Guidelines require the UV transmittance (UVT) of granular media filtered effluent to be 55 percent or greater at 254 nanometers (nm) to be suitable for UV disinfection for reuse. The 2003 NWRI Guidelines allow the UV system to be designed based on a higher UVT value if the design UVT is supported by a minimum of six months of UVT data, with a minimum of three samples per day, including wet weather periods. In this case, the 10th percentile value of the UVT data set can be used to design the UV system. The Falkenburg AWTP staff performed the required six months of UVT monitoring from May 2005 through November 2005. The 10th-percentile UVT value during this period was 68 percent. **Figure 1** presents a percentile plot of the UV transmittance data. To maintain a conservative design approach, a design UVT of 65 percent was used for the UV disinfection facilities at the Falkenburg AWTP.

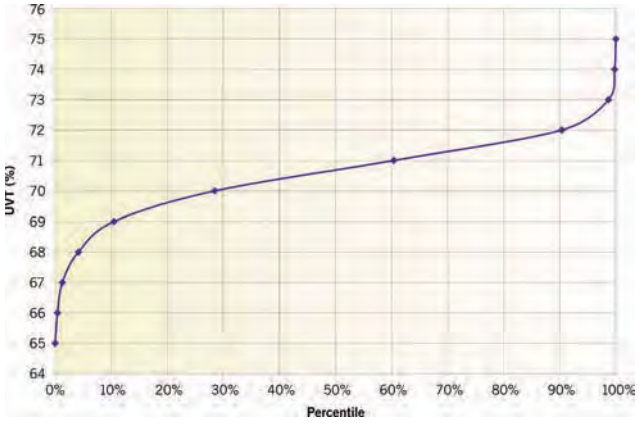

Figure 1: UV Transmittance Data

Laboratory dose-response data from collimated-beam tests are used to confirm the necessary UV dose for full-scale UV systems. Collimated beam testing was performed on a sample of secondary effluent from the Falkenburg AWTP taken on September 19, 2005. **Table III** presents the collimated beam test results. The collimated beam test results confirmed that the minimum design UV dose of 100 mJ/cm^2 was acceptable.

Table III: COLLIMATED BEAM TEST RESULTS

UV Dose (mJ/cm^2)	Fecal Coliform CFU/100 mL
0	3,500
5	210
10	3
20	<2
40	<2
80	<2
100	<2

Bid Approach

Four UV disinfection products were initially considered for the Falkenburg AWTP, as listed in **Table IV**. All were intended for installation in open channels for wastewater disinfection. All had third-party validation testing for reuse applications in accordance with the 2003 NWRI Guidelines (2), and all were acceptable to the FDEP for reuse disinfection projects in Florida.

Table IV: UV DISINFECTION PRODUCTS INITIALLY CONSIDERED

Manufacturer	Model	Lamp Type
ITT-Wedeco	TAK55HP	Low pressure, high output Amalgam Horizontal, parallel to flow
Ozonia – Degremont Technologies	Aquaray 40HO	Low pressure, high output Mercury vapor Vertical, perpendicular to flow
Trojan Technologies	UV3000Plus	Low pressure, high output Amalgam Horizontal, parallel to flow
Trojan Technologies	UV4000Plus	Medium pressure Horizontal, parallel to flow

A cost comparison was made of the estimated installed cost of each type of UV equipment and the 20-year present worth of estimated annual costs for operation and maintenance. Estimated costs are summarized in **Table V** in year 2005 dollars. The three low pressure, high output (LPHO) lamp systems had significantly lower estimated present worth than the medium pressure (MP) system, and the medium pressure system was eliminated from further consideration. Hillsborough County staff visited a number of existing installations for each of the three LPHO UV suppliers and found that any of the three LPHO systems were acceptable to the County.

Table V: UV FACILITY PRELIMINARY COST ESTIMATES

	Capital Cost	Present Worth O&M Costs	Total
ITT-Wedeco TAK55HP	$3,000,000	$2,250,000	$5,250,000
Ozonia Aquaray 40HO	$2,850,000	$1,950,000	$4,800,000
Trojan UV3000Plus	$2,200,000	$1,400,000	$3,600,000
Trojan UV4000Plus (MP)	$4,800,000	$4,800,000	$9,600,000

Hillsborough County initially pursued a pre-purchase method for procurement of the UV disinfection system. The County planned to issue a request for proposals (RFP) to the approved UV manufacturers and select the UV manufacturer before finalizing the construction plans and specifications. Three of the County's wastewater treatment facilities were undergoing design for expansions including conversion to UV disinfection: the Falkenburg AWTP, the Valrico AWTP, and the Northwest AWTP. The pre-purchase approach was intended to ensure that the UV equipment for all three plants would be supplied by a single manufacturer for ease of training and operations and maintenance, and for spare part compatibility. The County planned to pre-purchase UV equipment that would later be installed, tested and placed into operation by the Contractors selected to construct the expansions at each of these plants.

A single technical specification for the UV disinfection equipment at all three plants was developed by the three engineering firms involved in the expansions and was submitted to the County for developing the pre-purchase RFP. The three LPHO UV products listed herein were named as approved in the specification. It was determined that the County's processes for RFP development, release, bid and the subsequent selection process would take approximately 6 to 10 months. This would cause a delay in each of the three plant expansion designs, because the selected UV vendor might not be known before the contract deadlines for submitting final design documents. As a result, the County decided not to proceed with pre-purchasing the UV equipment. The design firms for the three treatment plants were directed to specify the UV system as part of each plant expansion project. The UV specification developed for the joint pre-purchase approach was modified for use in the Falkenburg AWTP construction contract documents, and remained open to any of the three named vendors. Contractors were required to name in their proposals the UV manufacturer that their bid was based upon, and were not allowed to change UV manufacturers after the bid. The UV equipment included in the bid of the lowest responsible bidder would be installed.

Contract drawings included two alternative layouts for the UV facility. The horizontal lamp configuration depicted in **Figure 2** was applicable to the Trojan and ITT-Wedeco systems, and the vertical lamp configuration depicted in **Figure 3** was applicable to the Ozonia system. All systems were capable of providing a validated UV dose of 100 mJ/cm^2 at the maximum day flow of 16.7 mgd, with one channel out of service or one bank of lamps per channel out of service for redundancy.

The UV facility was designed for installation of UV equipment in one of two existing chlorine contact tanks. The UV system was specified to be installed in up to three channels, which left space in the tank for adding a fourth channel of UV equipment if needed in the future. For horizontal lamp systems, a minimum of two duty banks of lamps per channel were required, and space was available for up to four banks of horizontal lamps per channel if needed by the manufacturers. For the vertical lamp layout, three channels with seven duty banks of lamps per channel were required to meet the design UV dose, and an eighth bank of lamps was required per channel for redundancy. Space was available for these 24 banks of vertical lamps in three channels now, with room for two additional banks per channel if needed in the future. The UV facility design included space for additional UV equipment in each channel and/or in the fourth channel to allow for expansion to a future plant capacity of 15.0 MGD AADF. Alternatively, currently unused space in the UV facility can be used if a higher UV dose becomes necessary or if the UV transmittance of the plant effluent becomes lower in the future.

Bid packaging played a role in the Contractor's selection of the UV equipment. Two of the three named UV suppliers

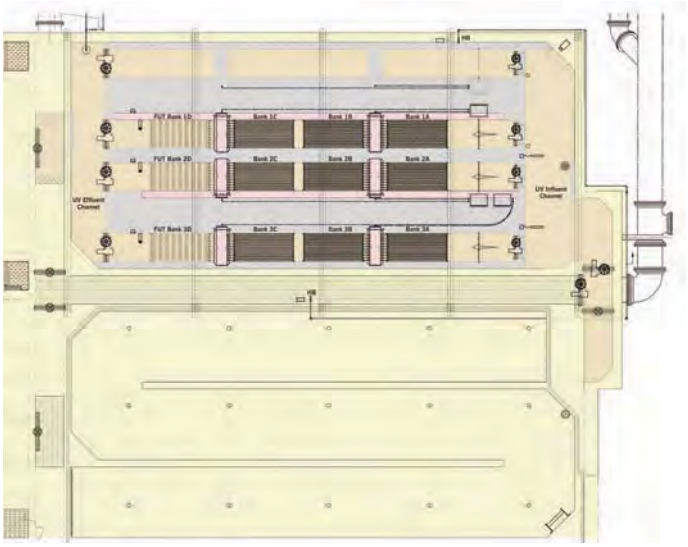

Figure 2: Horizontal Lamp Layout Configuration

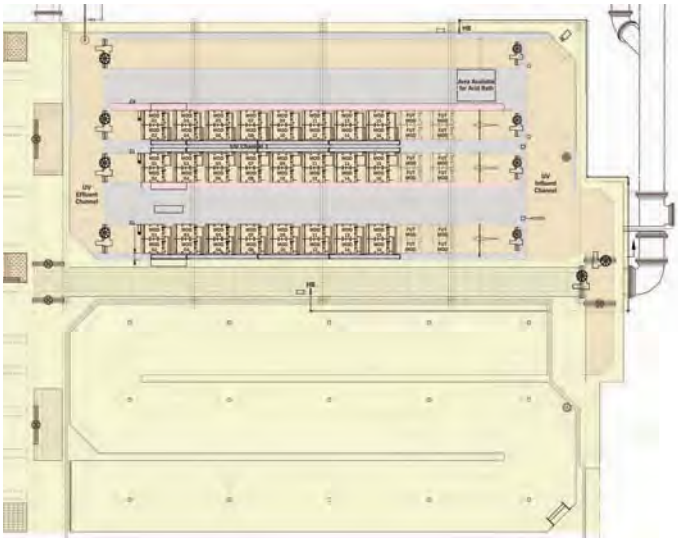

Figure 3: Vertical Lamp Layout Configuration

were represented by the same sales firms that represent the two major aeration and clarifier equipment vendors. This gave these two suppliers an advantage during the bid. Only two contractors bid on the construction contract, and both based their bids on Trojan UV equipment. The lowest responsible bid was based on the Trojan UV3000Plus LPHO system, and this system was installed.

Lamp Sleeve Fouling Factor Demonstration Test

UV disinfection designs must account for reduced effectiveness as a result of UV lamp sleeve fouling, which is the accumulation of material on UV lamp sleeves that inhibits transmitting UV light to the effluent. A "fouling factor", expressed as a decimal less than 1.00, is used to estimate this reduced effectiveness. The 2003 NWRI Guidelines allow the use of a fouling factor of 0.80 for manually cleaned UV systems and for automatically cleaned UV systems that have not demonstrated a higher fouling factor with third-party testing. Higher fouling factors may be used when appropriate third-party testing has been performed.

Bid documentation for the Falkenburg AWTP included submitting the lamp fouling factor used by the manufacturer at the time of the bid and the number of UV lamps required based on that fouling factor. The County required the UV manufacturer to provide a pilot unit for a six-month test to determine a site-specific fouling factor. The fouling test was required because two of the three named UV vendors were using the unproven 0.80 fouling factor in their designs. The Trojan scope was based on a fouling factor of 0.95. The UV manufacturer was required to provide a pilot unit with at least eight lamps with the same lamp model and lamp cleaning mechanism as proposed for the full scale UV facility. A feed pump was used to transfer effluent from the filter clearwell to the UV pilot unit at a flow rate that provided velocity through the UV lamps equal to the average velocity through UV lamps in full scale at the UV facility. **Figure 4** is a photograph of the pilot unit provided by Trojan.

Figure 4: Photograph of On-site Fouling Factor Pilot Unit

Trojan provided a pilot unit with twelve lamps which were operated continuously at 100 percent power using the wiping frequency recommended for the full scale installation. Also provided by the UV manufacturer was a spectrophotometer fitted for measuring the UV transmittance of the sleeves. UV transmittance measurements were made at a wavelength of 254 nanometers. Twenty-five random measurements along the length and around the circumference of each sleeve were taken at 0 days, 30 days, 60 days, 90 days, 120 days and 180 days of operation. **Figure 5** is a photograph of the spectrophotometer used for measuring the sleeve transmittance.

The spectrophotometer measured the UV transmittance through both walls of the round lamp sleeves, giving "double-wall" sleeve transmittance data. The single-wall sleeve transmittance was calculated by taking the square root of the double-wall sleeve transmittance value. The average of all transmittance measurements taken from one sleeve was considered the fouled UV transmittance for that

Figure 5: Photograph of Spectrophotometer

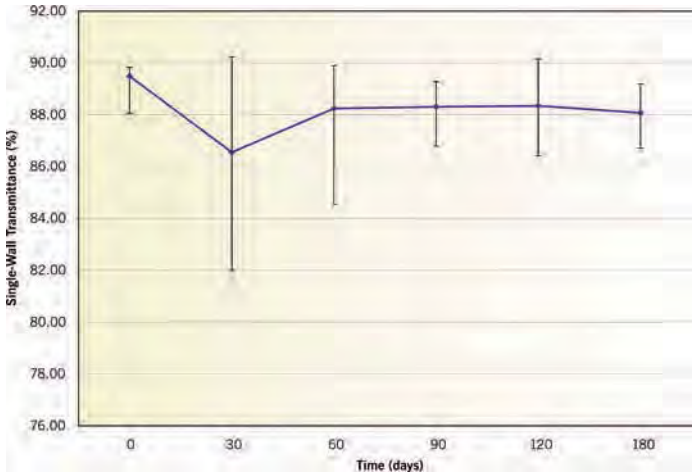

Figure 6: Single-Wall Sleeve UV Transmittance

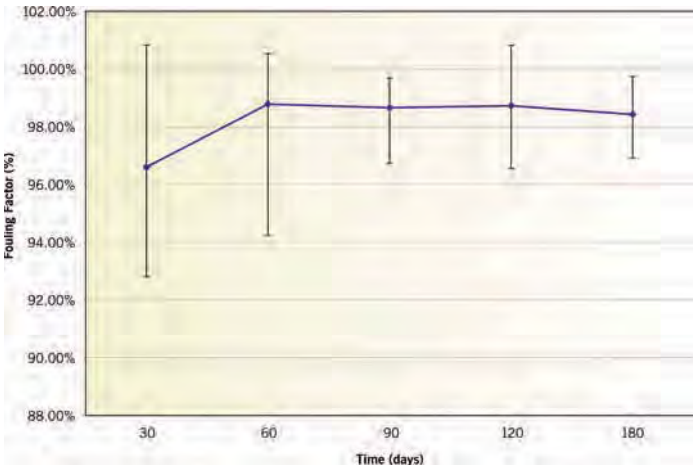

Figure 7: On-site Determination of Fouling Factor

sleeve for that operating time period. **Figure 6** depicts the trend of the average single-wall percent transmittance for all sleeves for each time period, and shows the range of transmittance values for each sleeve for each time period. Single-wall UVT ranged from 88% to 90% for new, clean sleeves.

The fouling factor was determined by dividing the transmittance of each fouled sleeve after each operating period by the original, clean transmittance for that sleeve at 0 days. The average fouling factor was determined for all of the sleeves for each time period. The lowest of the fouling factors from the 30, 60, and 90 day periods was then used to confirm the final sizing of the UV system in the main submittal for the UV equipment.

Trojan came to the site after 120 and 180 days of operation of the fouling factor pilot unit to repeat the above tests to fulfill the full 6-month testing requirement of the 2003 NWRI Guidelines (2) and that measurements be taken every two months. If the fouling factor was found to be lower than that reported in the first 90 days, the UV equipment submittal would be revised to reflect the lowest fouling factor measured. **Figure 7** presents the fouling factor calculated for each time period. The fouling factor was lowest when it was 0.965 after 30 days of operation, and it had increased to 0.984 after 180 days of testing.

Trojan demonstrated the effectiveness of their quartz sleeve chemical/mechanical cleaning system with respect to its ability to maintain relative quartz sleeve transmittance greater than 0.95 as claimed in the bid. The number of lamps provided for the project was not reduced as a result of the on-site fouling test. If the site-specific fouling factor had been less than that used by the manufacturer in the bid, additional lamps would have been required at no additional cost to the Owner.

UV Operating Protocol

The County submitted to the FDEP a revised Operating Protocol designed to comply with the requirements of Rule 62-610.320(6)(d), of the F.A.C. (1) and provide reasonable assurance that the high-level disinfection requirements will be met. The operating protocol was approved by the Department before the startup performance testing began. The reuse protocol developed for the Falkenburg AWTP includes the following sections:

- Background
- UV Disinfection System (UVDS) Standard Operational Procedure
- Training
- UVDS Monitoring and Alarm System Design
- UVDS Operating Parameters – Continuous Monitoring
- UVDS – System Component Status Monitoring
- Steps and Procedures – Alarm Conditions
- Return to Normal Operation

The protocol was developed to be used as a tool for operators to understand the UV disinfection system, monitor if the system is operating correctly, maintain the system, and direct the necessary steps to be taken if the system goes into a reject condition. The implementation of alarms classified as low-priority alarms assist operators in maintaining a healthy system without causing a reject condition. The low-priority alarms are:

1. Individual Lamp Failure
2. Low UV Intensity
3. Low UV Transmittance
4. High Turbidity
5. Near Capacity Alarm

Turbidity is monitored as a surrogate for TSS in the filter effluent (UV influent) water. The measured turbidity value correlates to the level of solids removal prior to disinfection. Alarm set points were established at 1.5 NTU for high turbidity and 2.4 NTU for high-high turbidity to indicate that operational compliance with treatment standards is not being met.

The high-priority alarms are listed below. All the high-priority alarms require immediate attention, but only the five bolded alarms will initiate an immediate reject event. If left unattended, conditions can escalate and compromise the performance of the UV system resulting in the initiation of a reject event. For example, if an *Adjacent Lamp Failure* alarm is generated, the lamp failure must be attended to or multiple *Adjacent Lamp Failure* alarms will result in a *Multiple Lamp Failure* alarm and an unhealthy bank. Multiple Unhealthy Bank alarms will result in an unhealthy channel. If flow conditions require both channels to be healthy for proper disinfection, a *Not Enough Healthy Channels Available* alarm will be generated and a reject event will automatically be initiated.

1. Adjacent Lamp Failure
2. Multiple Lamp Failure
3. Low-low UV Intensity
4. **Low-low UV Transmittance**
5. **Low Operational UV Dose**
6. **High-high Turbidity**
7. High Water Level
8. Low Water Level
9. **Flow Meter Fault**
10. **Not Enough Healthy Channels Available**
11. Not Enough Healthy Banks Available

When the on-line continuous monitoring devices register the alarms that initiate a reject condition for five minutes, the alarm is considered valid and the reject protocol valve closing sequence is automatically activated which directs the flow to the reject water storage tanks. In the event the reject storage tanks are no longer available due to limited storage tank capacity, the reject water will be directed to the Palm River discharge through the permitted Palm River outfall. The applicable reuse parameters must be met on a continuous basis for two hours, and the UV disinfection chamber flushed before the system is automatically reset out of reject mode.

Performance Testing

After approval of the operating protocol by FDEP, installation of the equipment, and successful functional testing, the performance testing commenced. Performance testing included head loss measurements, power consumption measurements, and intensive effluent quality testing. The primary goal of this testing was to demonstrate that all aspects of the systems were functioning properly to disinfect the plant wastewater flow and that all performance and design criteria were met, most importantly:

1. At least 75 percent of fecal coliform values are non-detectable (below the detection limit of <1 cfu/100mL);
2. No single fecal coliform value exceeds 25 cfu/100 mL; and
3. The system is capable of delivering the specified minimum UV dose (100 mJ/cm2) at all times.

The testing was required to continue for 30 continuous days without significant interruption. A significant interruption would require the test, then in progress, to be stopped and restarted after corrections were made, beginning a new 30 day test. Significant interruptions could include any of the following events:

- Failure to provide operational dose at any time and failure to meet specified performance, provided that the minimum wastewater characteristics were equal to or better than the design criteria;
- Failure of any critical equipment unit, system, or subsystem; and/or
- Failure of noncritical unit, system, or subsystem that was not satisfactorily corrected within 48 hours after failure.

Water quality testing was performed by the Hillsborough County Environmental laboratory (HC) and the Contractor's laboratory, Advanced Environmental Laboratories (AEL). Samples were collected from the influent and effluent channels of the UV system. The following parameters were recorded when samples were collected:

- Filter Effluent Flow (MGD)
- UV Transmittance (%)
- UV Intensity (%) for each operating bank of lamps
- UV Dose (mJ/cm^2)
- Turbidity (NTU)

The performance testing commenced October 15, 2008 and ceased November 12, 2008. Table VI presents a summary of the fecal coliform test results. The notation NS in the table indicates no samples were taken, which occurred once for a holiday and once because of plant process problems unrelated to the UV system.

During the testing, occasional instances of UV dose less than 100 mJ/cm^2 occurred, and these were attributed to occasional very sharp increases in flow. It could not be determined whether these flow spikes were truly changes in flow or were inaccuracies of the new plant flow meter. To address the situation, the target operational UV dose was raised to 104 mJ/cm^2 and the low dose alarm was set to 96 percent of this value (<100 mJ/cm^2) during the performance testing. The system was tested at high and varying flows, and it was expected that this correction would prevent the dose from going below the 100 mJ/cm^2 minimum requirement because of fluctuations in flow. As shown in **Table VI**, there was one day that the fecal coliform limit was not met. The County decided to require that the 30-day performance testing be re-started, and that the issues with the plant flow meter be resolved before re-starting the test.

During the initial performance test, it was noted that there were numerous hydraulic oil leaks in the automated cleaning system. Trojan believed the leaks were due to o-ring seals that were not suitable for this application. Trojan replaced all the seals in the system and subsequently found that each leak was actually attributed to broken seal connectors damaged during installation. All leaks were repaired shortly after the initial test was completed.

At the end of the initial performance test, Trojan informed the County that Trojan's validation report from February 2006, which was the basis of their design for the Falkenburg AWTP UV system, had been found to contain an error.

Table VI: INITIAL PERFORMANCE TESTING RESULTS

SAMPLE DATE	SCHEDULED SAMPLE TIME	FLOW (MGD)	UV DOSE (mJ/cm^2)	AEL FECAL COLIFORM (CFU/100mL) TROJAN BEFORE UV	AEL FECAL COLIFORM TROJAN (CFU/100mL) AFTER UV	AEL FECAL COLIFORM TROJAN (CFU/100mL) AFTER UV - Duplicate	HC FECAL COLIFORM (CFU/100 mL) POST UV
10/15/08	15:00	7.99	102.05	160	<1	<1	<1
10/16/08	15:00	6.50	107.33	170	<1	<1	<1
10/17/08	9:00	11.59	106.54	100	<1	<1	<1
10/18/08	10:00	11.84	104.38	6000	<1	<1	<1
10/19/08	11:00	10.32	103.98	2000	<1	<1	<1
10/20/08	12:00	8.34	106.30	4600	**6000 (Z)**	**6000 (Z)**	**NS (PLANT PROBLEMS)**
10/21/08	13:00	8.90	107.57	500	<1	<1	<1
10/22/08	14:00	9.17	104.71	1700	<1	<1	<1
10/23/08	15:00	8.71	106.29	300	<1	<1	<1
10/24/08	9:00	10.45	103.61	85	<1	<1	<1
10/25/08	10:00	11.82	101.47	600	**5**	**3**	<1
10/26/08	11:00	12.18	103.10	400	<1	<1	<1
10/27/08	12:00	8.30	105.24	1200	<1	<1	<1
10/28/08	13:00	7.40	146.27	1900	<1	<1	<1
10/29/08	14:00	8.23	108.44	300	<1	<1	<1
10/30/08	15:00	6.79	103.22	1500	<1	<1	<1
10/31/08	9:00	11.45	105.58	<1	<1	<1	<1
11/01/08	10:00	11.66	103.22	6000	<1	<1	<1
11/02/08	11:00	11.43	104.38	500	<1	<1	<1
11/03/08	12:00	7.74	102.39	400	<1	<1	<1
11/04/08	13:00	7.97	107.58	2500	<1	<1	<1
11/05/08	14:00	7.04	104.48	300	<1	<1	**1**
11/06/08	15:00	4.70	124.33	300	<1	<1	<1
11/07/08	9:00	12.94	101.54	9700	**100**	**120**	**1**
11/08/08	10:00	11.92	106.84	400	<1	<1	<1
11/09/08	11:00	13.07	105.40	600	<1	<1	<1
11/10/08	12:00	8.84	110.73	6000	<1	<1	<1
11/11/08	13:00	NS	NS	400	<1	<1	NS (holiday)
11/12/08	14:00	7.02	113.83	200	<1	<1	<1
11/13/08	15:00	6.73	107.81	200	<1	<1	<1

Table VII: RE-START PERFORMANCE TESTING RESULTS

SAMPLE DATE	SCHEDULED SAMPLE TIME	FLOW (MGD)	UV DOSE (MJ/cm2)	AEL FECAL COLIFORM (CFU/100mL) TROJAN BEFORE UV	AEL FECAL COLIFORM TROJAN (CFU/100mL) AFTER UV	AEL FECAL COLIFORM TROJAN (CFU/100ml) AFTER UV - Duplicate	HC FECAL COLIFORM (CFU\100 mL) POST UV
02/18/09	2:00	7.31	104.44	>60	<1	<1	<1
02/19/09	3:00	8.42	106.33	>60	<1	<1	<1
02/20/09	9:00	16.35	109.14	1,100	<1	<1	<1
02/21/09	10:00	12	104.1	>60	<1	<1	<1
02/22/09	11:00	12.01	105.83	>60	<1	<1	<1
02/23/09	12:00	8.11	104.19	400	<1	<1	<1
02/24/09	1:00	10.66	107.71	300	<1	<1	<1
02/25/09	2:00	11.72	105.86	1,200	<1	<1	<1
02/26/09	3:00	8.28	108.29	<1	<1	<1	<1
02/27/09	9:00	12.33	104.04	300	<1	<1	<1
02/28/09	10:00	13.20	108.00	NS[1]	NS	NS	<1
03/01/09	11:00	12.04	106.1	900	<1	<1	<1
03/02/09	12:00	10.90	106.52	400	<1	<1	<1
03/03/09	1:00	11.96	111.56	100	<1	<1	<1
03/04/09	2:00	11.97	105.22	200	<1	<1	<1
03/05/09	3:00	9.53	146.53	400	<1	<1	<1
03/06/09	9:00	9.99	142.48	2,000	<1	<1	<1
03/07/09	10:00	14.04	107.94	1,100	<1	<1	<1
03/08/09	11:00	11.20	139.78				<1
03/09/09	12:00	10.70	142.78				
03/10/09	1:00	7.97	144.19				
03/11/09	2:00						
03/12/09	3:00						
03/13/09	9:00						
03/14/09	10:00						
03/15/09	11:00						
03/16/09	12:00						
03/17/09	1:00						
03/18/09	2:00						
03/19/09	3:00						

1. The fecal results were disqualified due to a problem at the laboratory.

In January 2009, Trojan submitted a validation test report from 2008, which showed the UV dose provided by the installed system to be lower than 100 mJ/cm^2 at the design UVT of 65%. Trojan's 2008 validation test was acceptable to Hazen and Sawyer and FDEP for the purpose of temporarily re-programming the Falkenburg UV system. With the new dose control program, the UV system was able to provide the required UV dose of 100 mJ/cm^2 at the maximum day flow rate and at a UVT of 66.7% instead of 65%. It is estimated that the new dose control program will cause the system to consume 10-15% more power than was anticipated with the previous program. FDEP approved re-starting the performance test after Trojan re-programmed system controls based on the 2008 validation test. When Trojan obtains FDEP's full acceptance of this or another validation test for reuse applications, further changes to programming may be needed.

The performance test was re-started on February 18, 2009. Final performance test results will be complete in March 2009. **Table VII** provides the performance testing results recorded prior to submittal of this paper. As depicted in the results of the additional 30-day performance testing, there have been no occurrences of fecal coliform detection.

CONCLUSION

The Falkenburg AWTP expansion from a rated capacity of 9.0 mgd AADF to 12.0 mgd AADF was designed and bid to include conversion from gaseous chlorine disinfection to UV disinfection. The lowest responsible bid was based on the Trojan UV3000Plus LPHO system, and this system was installed. Trojan demonstrated the effectiveness of their quartz sleeve chemical/mechanical cleaning system with respect to its ability to maintain relative quartz sleeve transmittance or fouling factor greater than 0.95. The

Falkenburg AWTP performance testing results to date indicate that the conversion to UV disinfection is meeting the plant's permit limits for high level disinfection and public access reuse.

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