

Wastewater Treatment Unit Program Evaluation Report



**Bio-Microbics, Inc.
MicroFAST® 0.5 with Ultraviolet
Light Disinfection for Fecal Coliform Reduction**

NSF International
789 N. Dixboro Rd.
Ann Arbor, MI 48105

**Analysis of Fecal Coliform Reduction
Bio-Microbics MicroFAST® 0.5 Treatment Unit**

Work completed under Contract No. 06/11A/2015/060

April 2007

EXECUTIVE SUMMARY

Testing of the Bio-Microbics MicroFAST® Model 0.5 for fecal coliform reduction was conducted following the provisions of NSF/ANSI Standard 40 for Residential Wastewater Treatment Systems (August 2005 Revision), which was developed by the NSF Joint Committee on Wastewater Technology. Bio-Microbics requested that sampling be completed to determine performance of their system for fecal coliform reduction according to the State of Washington's protocol for bacteriological reduction.

The performance evaluation was conducted at the NSF Wastewater Test Facility located in Waco, Texas wastewater diverted from the Waco municipal wastewater collection system, which serves predominantly residential development. Dosing to the treatment system, according to the NSF Standard 40 protocol, began on August 14, 2006. Sampling for fecal coliform for record began on September 4, 2006 and continued through March 2, 2007. Sampling started in the summer and continued into the winter, covering a range of operating temperatures.

A detailed data set of all fecal coliform data is available in Appendix B of this report. A summary of the performance of the Bio-Microbics MicroFAST® 0.5 with and without Ultra-violet Light disinfection (UV) is as follows:

- The geometric mean for influent fecal coliform over the course of the sampling period was 8.47×10^6 cfu/100 mL, with 30-day geometric means ranging from 3.75×10^6 to 1.98×10^7 cfu/100 mL.
- The overall geometric mean for the MicroFAST® 0.5 effluent was 3.98×10^4 cfu/100 mL, with 30-day effluent fecal coliform geometric means ranging from 2.42×10^4 to 6.62×10^4 cfu/100 mL.
- The overall geometric mean for the MicroFAST® 0.5 plus UV effluent was 56 cfu/100 mL, with 30-day geometric means ranging from 33 to 104 cfu/100 mL.
- Over the course of the evaluation, the average influent BOD₅ was 250 mg/L and the average influent total suspended solids were 310 mg/L.
- The effluent color ranged from 2 to 68 color units.
- Effluent turbidity ranged from a minimum of 0.25 NTU to a maximum of 4.2.
- The effluent temperature ranged from 12°C to 31°C.
- The effluent pH ranged from 6.8 to 7.0.
- The MicroFAST® 0.5 effluent flow rate, prior to the UV unit, was measured during fecal sample collection times and ranged from 0.69 to 0.76 gallons per minute.

This report includes all influent BOD₅ and TSS data collected during the 30 week testing period. During months three and five of the test, the monthly average influent wastewater characteristics were outside the ranges specified by the Standard. Month three had an average influent BOD of 360 mg/L and an influent TSS of 560 mg/L, while month five had an average influent TSS concentration of 390 mg/L. In order to correct for the excursion, data days were excluded to bring the average to 300 mg/L and 350 mg/L for BOD and TSS respectively. Nine days were excluded in month three to bring the averages to 290 mg/L for BOD and 340 mg/L for TSS. Month five had two days excluded from the calculations to result in a TSS average of 330 mg/L/

The fecal coliform data summarized in this report includes results generated from September 4, 2006 through March 2, 2007, including the 30-day geometric means of influent, MicroFAST® 0.5 effluent, and UV effluent (26 weeks).

Introduction

The ability of the BioMicrobics MicroFAST® 0.5 wastewater treatment system to reduce fecal coliform was evaluated at the NSF Wastewater Test Facility in Waco, Texas in accordance with the NSF/ANSI Standard 40 test protocol. Bio-Microbics requested that fecal coliform sampling and analyses be completed three times a week to evaluate the fecal coliform reduction performance of their MicroFAST® 0.5 treatment system plus UV.

Dosing of the MicroFAST® 0.5 began on August 14, 2006. This report includes all the fecal coliform data generated during the performance evaluation, along with the data generated during the Standard 40 evaluation (see Appendix C). Per the requirements of Standard 40, the MicroFAST® 0.5 was dosed with raw wastewater at the design rated capacity of 500 gallons per day over the entire testing period. Wastewater was dosed at the following times:

6 a.m. to 9 a.m. - 35 percent of daily rated capacity (175 gallons)

11 a.m. to 2 p.m. - 25 percent of daily rated capacity (125 gallons)

5 p.m. to 8 p.m. - 40 percent of daily rated capacity (200 gallons)

The plant was subjected to the following loading sequence during the evaluation:

Design loading - 16 weeks

Stress loading - 7.5 weeks

Design loading - 2.5 weeks

During the design loading periods, flow proportioned 24-hour composite samples were collected of the influent five days per week. The influent samples were analyzed for carbonaceous five-day biochemical oxygen demand, and total suspended solids concentrations.

Stress testing is designed to evaluate how the plant performs under non-ideal conditions, including varied hydraulic loadings and electrical or system failure. The test sequences included (1) Wash Day stress, (2) Working Parent stress, (3) Power/Equipment Failure stress, and (4) Vacation stress.

During the stress test sequences, 24 hour composite samples are collected before and after each stress dosing pattern. The analyses and on-site determinations completed on the samples were the same as described for the design load testing. Each stress is followed by seven consecutive days of dosing at design rated capacity before beginning the next stress test. Sample collection is initiated twenty four hours after completion of wash day, working parent, and vacation stresses, and beginning 48 hours after completion of the power failure stress.

2.0 Process Description

The MicroFAST® 0.5 wastewater treatment bioreactor utilizes a proprietary attached and suspended growth process to achieve treatment. Since the media used in the plant is submerged, both attached and suspended biological growth occurs simultaneously. In both attached and suspended growth systems, microorganisms remove soluble contaminants from the wastewater, utilizing them as a source of energy for growth and production of new microorganisms.

In the suspended growth mode, organisms dispersed in the wastewater being treated come in contact with the organic matter in the wastewater, while in the fixed growth mode, the organisms form on a fixed media and the wastewater is circulated past them. As new organisms form in the fixed growth mode, the biological growth becomes thicker, resulting in anoxic conditions in the lower layers. As the bacterial mass builds, adhesion is weakened and the upper layers slough off, exposing a new surface on which aerobic growth continues. The accumulation of the biomass on the surface also provides for entrapment of organic solids, which are attacked by extracellular enzymes that solubilize the solids to make them available to the microorganisms as a food source. The conversion of the organic matter from soluble to biological solids allows for removal of the organic matter by settling of the solids in the treatment process.¹

The organisms primarily responsible for the degradation of the organic matter are aerobic bacteria. As such, the transfer of oxygen into the wastewater by an aeration system is critical to the treatment process. The aeration system also provides for the mixing of the wastewater and organisms to provide contact between the organic contaminants in the wastewater and the organisms that provide for removal of the contaminants. Interruption of the aeration system for a long period of time can have a serious impact on the process.

2.1 Description of Plant Evaluated

The MicroFAST® 0.5 tested in this evaluation has a rated capacity of 500 gallons per day (gpd). Specifications and drawings are included in Appendix A. The tank was constructed of concrete. The plant utilizes part of the tank for primary treatment, with the secondary treatment achieved in an aerobic zone inside an insert in the tank.

Wastewater enters the tank in the primary treatment zone, which extends from the inlet pipe to the forward bulkhead of the insert. A stream of partially treated water from the aeration zone is put outside the liner for denitrification. The quiescent condition in the primary zone allows the heavy solids in the wastewater to settle out. There are no skimmers or baffles in the primary zone, but floating materials remain in the zone because the inlet to the secondary zone is below the water surface.

A honeycomb type media block is completely submerged in the tank insert and provides the fixed surface to support most of the biomass in the secondary aerobic zone. Aeration and circulation of the wastewater through the media is achieved by release of air in a draft tube near the bottom of the media block. The release of air causes the wastewater to rise through the tube to a deflector baffle that directs the water out over the media. The continuous circulation of the water establishes velocities in the media that assist in sloughing of excess biomass from the media. Sloughing biomass passes down through the media and settles to the bottom of the tank below the insert. Treated water passes out of the aerobic zone and the treatment plant through a pipe connected to a vertical channel cut in the media.

3.0 Evaluation Methods

3.1 Sampling Methods

All influent BOD₅ and TSS samples during the evaluation were 24-hour composite samples, collected by automatic samplers programmed to sample in coordination with the charge of influent wastewater to the system. Grab samples for fecal coliform were collected three days per week, alternately during one of the three dosing periods defined under Section 8.2.2.1 of NSF/ANSI Standard 40 (August 2005 revision). Samples were collected at approximately the same time from the influent and effluent of the MicroFAST® 0.5 model.

3.2 Analytical Methods

Fecal coliform samples collected during the evaluation were analyzed by IG Micromed using Method 9222D of *Standard Methods for the Evaluation of Water and Wastewater* (20th Edition).

4.0 Evaluation Results

The influent BOD₅ and TSS 30-day average concentrations met the requirements of Standard 40 throughout the test, with the exception of months three and five. During months three and five of the test, the monthly average influent wastewater characteristics were outside the ranges specified by the Standard. Month three had an average influent BOD of 360 mg/L and an influent TSS of 560 mg/L, while month five had an average influent TSS concentration of 390 mg/L. In order to correct for the excursion, data days were excluded to bring the average to 300 mg/L and 350 mg/L for BOD and TSS respectively. Nine days were excluded in month three to bring the averages to 290 mg/L for BOD and 340 mg/L for TSS. Month five had two days excluded from the calculations to result in a TSS average of 330 mg/L/

The overall averages of 180 mg/L and 210 mg/L, respectively, as shown in Table 1. Averages for months 1 through 6 represent the 26 weeks of testing

Table 1. 30-Day Influent Averages

Month	Influent 30-Day Average (mg/L)	
	BOD ₅	TSS
1	250	320
2	250	330
3	290	340
4	220	250
5	240	330
6	250	300

The influent fecal coliform concentrations were highly variable over the course of the test, ranging from a 30-day geometric mean minimum of 3.75×10^6 to a maximum of 1.98×10^7 cfu/100 mL. This variation is not surprising considering the inherent variability in grab sampling and the variability of the influent wastewater

Table 2. Fecal Coliform 30-day Geometric Mean Results

Month	Fecal Coliform Geometric Mean (cfu/100 mL)		
	Raw Influent	MicroFAST® 0.5 Effluent	UV Effluent
1	2.63×10^6	3.96×10^4	33
2	1.98×10^7	4.54×10^4	89
3	4.67×10^6	2.42×10^4	50
4	3.95×10^6	4.80×10^4	34
5	9.53×10^6	6.62×10^4	57
6	3.75×10^6	2.88×10^4	104

5.0 Summary of Fecal Coliform Testing

NSF conducted a six-month evaluation of the MicroFAST® 0.5 wastewater treatment system for fecal coliform reduction. The testing was conducted in accordance with NSF/ANSI Standard 40 protocol with dosing starting on August 14, 2006 and testing ending on March 2, 2007. The MicroFAST® 0.5 received an influent wastewater having overall average BOD₅ and TSS concentrations within the ranges set by Standard 40. The influent fecal coliform concentrations were within the $10^6 - 10^8$ range for the entire testing period. The 30-day geometric means for the treated system effluent ranged from 2.42×10^4 to 6.62×10^4 cfu/100 mL. The 30-day geometric means for the UV treated effluent ranged from 33 to 104 cfu/100 mL and the overall *geometric* mean was 56 cfu/100mL.

Appendix A

Plant Specifications and Drawings

SYSTEM SPECIFICATIONS

Bio-Microbics, Inc.
Model MicroFAST® 0.5

System Capacity

Design Flow	500gpd
System Hydraulic Capacity	
Pretreatment Chamber	500 gallons
Aeration Chamber	750 gallons
Hydraulic Retention Time (at Design Flow)	
Pretreatment Chamber	24 hours
Aeration Chamber	36 hours
Total Hydraulic Retention Time	60 hours

Aerator

Gast Regenerative Blower	Model R2103
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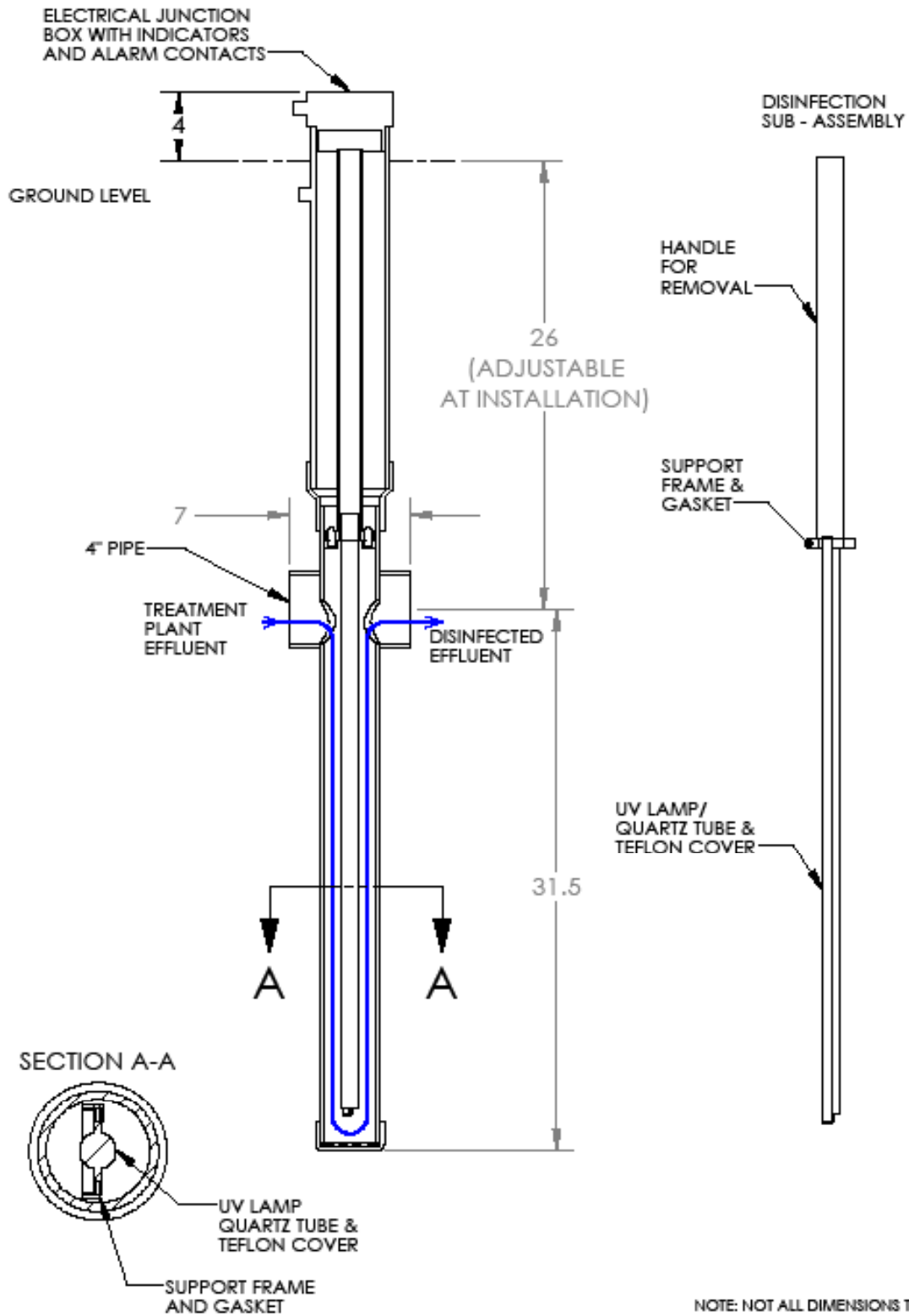
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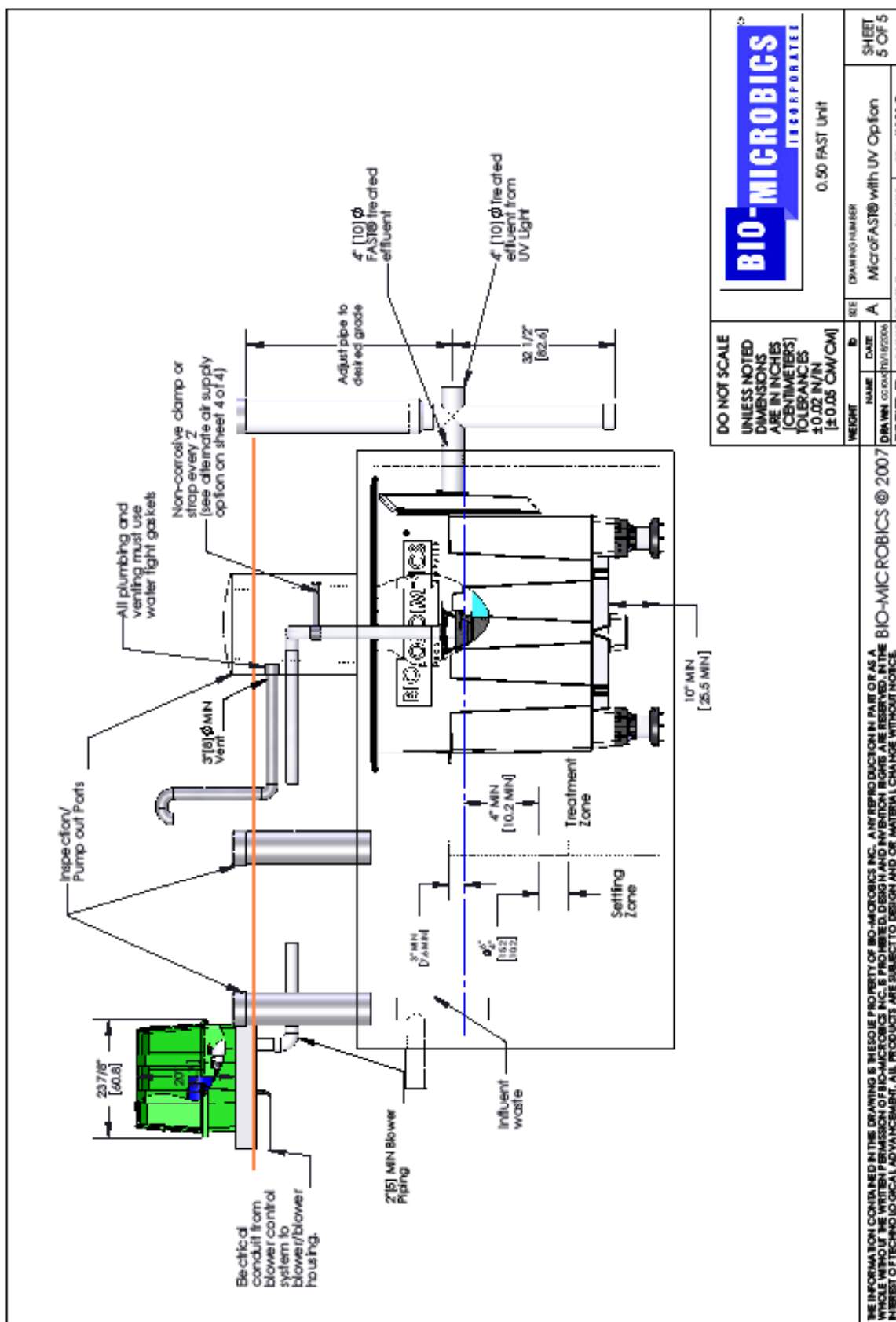
Material	Polypropylene
Standard Module Size	24" x 24" x 48"
Minimum Surface Area per Volume	27

UV Disinfection System

Salcor 3G	120 Volts AC, 60Hz, Single Phase
	Lamp: 30 watts
	Radiant Intensity is 125 mW/cm ² @ 254 nm
	Nominal length of UV lamp: 31"
	Lamp Housing: 3" diameter x 35" long

SALCOR UV DISINFECTION UNIT





Appendix B
Fecal Coliform Results

Date	Raw Influent	MicroFAST® 0.5 Effluent	UV Effluent	Color	Turbidity (NTU)	Temperature (°C)	pH	Flow Rate (gpm)	DO
08/21/06	9,000,000	800,000	100	68.5	20.6	30	7	0.73	1.3
08/23/06	18,400,000	44,000	600	82.4	23.7	30	7	0.69	1.4
08/25/06	19,100,000	12,000	30	103	14.9	30	7	0.71	1.4
08/28/06	3,500,000	25,000	<10	234	12.4	30	6.9	0.71	1.3
08/30/06	18,000,000	106,000	<10	198	14.3	30	7	0.69	1.4
09/01/06	19,200,000	20,500	330	91.3	5.39	30	7	0.72	1.4
09/04/06	19,600,000	49,000	540	59.5	12.7	30	6.8	0.74	1.9
09/06/06	36,000,000	30,000	<10	55.9	3.53	30	6.8	0.73	1.7
09/08/06	28,000,000	94,000	670	83.7	4.41	30	6.8	0.71	1.8
09/11/06	41,000,000	6,000	950	54.9	3.04	30	6.8	0.71	1.7
09/13/06	4,250,000,000	86,000	<10	82	10.7	30	6.8	0.74	1.8
09/15/06	14,000,000	31,000	<10	75.2	8.75	30	6.8	0.7	1.8
09/18/06	8,400,000	36,000	<10	113	13.5	30	6.9	0.72	1.7
09/20/06	13,500,000	26,000	<10	61.7	7.84	30	6.9	0.71	1.8
09/22/06	3,000,000	51,000	<10	71.8	6.95	30	6.8	0.73	1.7
09/25/06	14,000,000	*	*	58.3	7.34	30	6.9	0.71	1.8
09/27/06	18,000,000	46,000	<10	71.8	7.57	30	6.9	0.7	1.6
09/29/06	28,300,000	59,000	50	68.5	7.33	30	6.9	0.73	1.7
10/02/06	13,400,000	52,000	<10	54.9	11.6	30	6.9	0.72	1.7
10/04/06	72,000,000	69,000	10	54.9	18.2	30	6.9	0.71	1.7
10/06/06	980,000	40,000	2,200	37.9	3.36	30	6.9	0.72	1.8
10/09/06	35,000,000	72,000	<10	58.3	26	31	6.8	0.71	1.7
10/11/06	28,000,000	148,000	30	95.6	36.9	31	6.8	0.72	1.6
10/13/06	76,000,000	24,700	7,800	88.8	22.5	31	6.8	0.72	1.8
10/16/06	20,500,000	70,000	220	41.3	59	31	6.9	0.72	1.7

Date	Raw Influent	MicroFAST® 0.5 Effluent	UV Effluent	Color	Turbidity (NTU)	Temperature (°C)	pH	Flow Rate (gpm)	DO
10/18/06	44,000,000	89,000	335	71.8	22.1	31	6.9	0.71	1.7
10/20/06	14,400,000	85,000	300	78.6	14.4	31	6.8	0.7	1.6
10/23/06	24,000,000	24,000	270	25	14	30	6.8	0.73	1.6
10/25/06	14,400,000	60,000	10	25	8.48	30	6.9	0.71	1.6
10/27/06	16,800,000	54,000	80	25	14.2	30	6.9	0.73	1.5
10/30/06	9,400,000	2,900	10	25	6.5	30	6.9	0.73	1.6
11/01/06	19,000,000	40,000	10	25	7.56	30	6.9	0.71	1.6
11/03/06	17,000,000	45,000	<10	25	13.1	30	6.8	0.72	1.6
11/06/06	12,000,000	24,000	40	25	4.67	30	6.8	0.72	1.5
11/08/06	9,000,000	58,000	<10	25	9.44	30	6.9	0.71	1.5
11/10/06	5,000,000	33,000	10	25	6.33	30	6.8	0.72	1.5
11/13/06	8,250,000	2,250	<10	25	4.33	20	6.9	0.7	0.6
11/15/06	8,000,000	125,000	<10	25	1.79	19	6.8	0.7	0.5
11/17/06	1,360,000	5,600	30	25	2.54	22	6.9	0.76	1.3
11/20/06	5,750,000	11,000	80	25	3.4	21	6.9	0.72	1.9
11/22/06	10,200,000	46,000	380	25	5.89	21	6.9	0.73	1.9
11/24/06	7,850,000	23,000	420	25	5.55	21	6.9	0.72	1.9
11/27/06	1,040,000	12,000	270	28	1.83	22	6.8	0.71	1.9
11/29/06	740,000	33,000	210	25	5.6	22	6.8	0.72	1.8
12/01/06	1,700,000	64,000	160	25	7.88	22	6.8	0.73	1.9
12/04/06	500,000	29,000	130	25	6.95	23	6.9	0.72	1.8
12/06/06	1,060,000	25,000	870	25	11.7	23	6.9	0.73	1.7
12/08/06	11,800,000	58,000	10	25	5.62	23	6.9	0.72	1.7
12/11/06	6,530,000	25,300	<10	25	6.59	23	6.8	0.74	1.6
12/13/07	7,200,000	102,000	10	25	8.34	22	6.9	0.71	1.7

Date	Raw Influent	MicroFAST® 0.5 Effluent	UV Effluent	Color	Turbidity (NTU)	Temperature (°C)	pH	Flow Rate (gpm)	DO
12/15/07	12,200,000	135,000	20	25	4.67	22	6.9	0.69	1.8
12/18/07	8,400,000	34,000	20	50	35.1	23	6.9	0.72	1.8
12/20/07	5,540,000	55,200	100	50	8.88	23	6.9	0.7	1.8
12/22/07	5,800,000	51,700	20	25	18.1	23	6.8	0.71	1.7
12/25/07	13,400,000	76,000	20	50	19	23	6.9	0.7	1.6
12/27/07	100,000	13,000	<10	50	34.7	23	6.9	0.73	1.8
12/29/07	7,670,000	113,000	240	50	35.2	23	6.9	0.72	1.6
01/01/07	5,700,000	45,000	20	25	12.9	23	6.9	0.74	1.8
01/03/07	5,900,000	58,000	70	25	14	23	6.9	0.72	1.7
01/05/07	36,000,000	125,000	20	25	20.1	23	6.9	0.71	1.6
01/24/07	4,070,000	40,000	130	25	37.1	12	6.9	0.71	3.4
01/26/07	6,800,000	3,340	5,000	25	4.59	13	6.9	0.72	3.3
02/09/07	4,800,000	97,000	500	25	21.4	14	6.9	0.71	3.2
02/12/07	3,100,000	56,000	70	25	21.6	14	6.8	0.71	2.9
02/14/07	3,400,000	40,700	20	25	11.2	14	6.8	0.72	2.8
02/16/07	9,800,000	133,000	24,000	25	31.1	14	6.8	0.73	2.8
02/19/07	2,100,000	34,017	40	25	37	15	6.9	0.69	3
02/21/07	10,000,000	4,000	2,900	25	4.94	15	7	0.72	3
02/23/07	4,600,000	30,000	<20	50	36.4	15	6.9	0.71	2.9
02/26/07	1,300,000	11,500	20	25	68.4	18	6.9	0.76	2
02/28/07	3,200,000	9,400	<10	25	19.9	18	6.9	0.71	1.7
03/02/07	2,750,000	30,600	20	25	13	18	6.9	0.73	1.8
03/05/07	600,000	12,000	80	25	26.2	19	6.9	0.71	1.7
03/07/07	800,000	11,400	25	25	25.6	18	6.9	0.72	1.7
03/09/07	4,050,000	44,000	4180	25	23.8	18	6.9	0.73	1.7

* 092506 - Data unreported due to laboratory error