THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**DECENTRALIZED WASTEWATER TREATMENT – BIOLOGICAL, SAND FILTRATION, AND ULTRAVIOLET TREATMENT**
APPLICATION:	**DOMESTIC WASTEWATER TREATMENT FOR A RESIDENTIAL DEVELOPMENT**
TECHNOLOGY NAME:	**MODEL 6000 SEQUENCING BATCH REACTOR SYSTEM**
COMPANY:	**INTERNATIONAL WASTEWATER SYSTEMS**
ADDRESS:	**2020 Charlotte Street** **PHONE: (406) 582 1115** **BOZEMAN, MT 59718** **FAX: (406) 582 1116**
EMAIL:	claudes1985@yahoo.com

NSF International (NSF) operates the Water Quality Protection Center (WQPC) under the U.S. Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) Program. The WQPC evaluated the performance of a sequencing batch reactor biological treatment system, with media filtration and ultraviolet disinfection, for treatment of residential wastewater in a decentralized application. This verification statement provides a summary of the test results for the International Wastewater Systems Model 6000 Sequencing Batch Reactor (SBR) System. The Eagle Sewer District acted as the Testing Organization (TO) for the verification testing, which was performed near Boise, Idaho.

EPA created the ETV Program to facilitate deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups consisting of buyers, vendor organizations, and permitters; and the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and verifiable quality are generated, and that the results are defensible.

TECHNOLOGY DESCRIPTION

The following technology description is provided by the vendor and does not represent verified information.

The International Wastewater Systems' (IWS) Model 6000 SBR includes a 6,000 gallon (gal) equalization tank, a 6,000 gal modified SBR, a 3,000 gal holding tank, a coagulation injection system, a gravity sand filtration system, and an ultraviolet (UV) disinfection system. The IWS SBR is designed to provide treatment by optimizing the treatment conditions using a computer controlled and monitored system of pumps, floats, and probes to measure, monitor, and adjust the treatment parameters within the unit. The computer control system uses a programmable logic controller (PLC) and a software program, written by IWS, for the master control of the SBR and for communication outside the facility by modem and phone line installed with the unit.

Residential wastewater is discharged to an equalization tank and is pumped to the SBR for aerobic/anoxic biological treatment. In the treatment process, the wastewater/biological solids mixture (mixed liquor) is alternately mixed with, then deprived of, oxygen and is then periodically pumped to the clarification chamber, where quiescent conditions allow the solids to settle. A pump transfers the settled solids back to the aeration chamber and clarified effluent is pumped to the 3,000 gal holding tank. A portion of the mixed liquor is periodically wasted to a sludge holding tank to maintain optimal operating conditions in the treatment process.

A high-level switch in the effluent holding tank starts the coagulation-filtration system by injecting a coagulant, poly aluminum chloride (PAC) or aluminum sulfate (alum), ahead of a sand filter. The sand filter is a Centra-Flow dynamic sand bed filter that provides for continuous sand cleaning by using an airlift pump to extract the sand and solids from the filter, and lifting the mixture to a separation box. Cleaned sand is returned to the top of the filter and waste solids are piped to the equalization tank. A turbidity meter, used with an electronically actuated valve, monitors the effectiveness of the sand filter and reroutes the filtrate to the 3,000 gal holding tank for further treatment if the turbidity exceeds 5 Nephelometric Turbidity Unit(s) (NTU). Filtered water flows by gravity to the disinfection process.

The disinfection system consists of two UV disinfection units operating in parallel, with electronically actuated solenoid valves for each unit to prevent untreated water from reaching the post equalization tank. Each unit is designed to handle 20 gpm and achieve total coliform levels of <2.2 MPN/100 mL for water having suspended solids <10 mg/L and turbidity of <5 NTU.

IWS expects the system to require operator attention on a two to three visits per week basis, with additional time needed if special maintenance activities are required.

VERIFICATION TESTING DESCRIPTION

This verification was completed following the procedures described in the Verification Test Plan, which was prepared in accordance with the *Protocol for Verification of Wastewater Treatment Technologies,* dated April 2001.

Test Site

The verification test was performed at the Moon Lake Ranch Subdivision, located a few miles west of Boise, Idaho, which consists of 18 homes in an area not served by a centralized wastewater collection system. Each home has a holding tank and grinder pump system that is connected to a force main that delivers wastewater to the IWS Model 6000 SBR. The system, owned by the Moon Lake Ranch Homeowners Association, discharges treated effluent to a lake on the subdivision property and is permitted by the State of Idaho for surface water discharge.

Methods and Procedures

The system startup evaluation was made by shutting down one SBR and keeping the second unit on line while the out-of-service SBR was cleaned and prepared for startup. The startup time and conditions were documented. The verification test included sixteen sampling and analysis events over the one-year test period, and included monthly four-day sampling events, and one special four-day sampling event each season of the year. Sampling locations included the untreated wastewater, treated effluent from the SBR, and final effluent from the system after filtration

and UV disinfection. Flow-weighted composite and grab samples were collected during sampling events, depending on the requirements and holding time for each analysis. Grab samples were collected each sample day for pH, temperature, turbidity, and total coliform. The samples for total coliform were collected and placed directly into sterile bottles provided by the laboratory. Flow-weighted, 24-hr composite samples were collected each sampling day for total suspended solids (TSS), five-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and alkalinity. Four-day composite samples were collected for total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), nitrite plus nitrate (NO_2+NO_3-N), and total and soluble phosphorus (TP and SP, respectively) by taking an aliquot of each 24-hr composite sample and combining them to make the 96-hr composite. All of the 96-hr composites were prepared in the laboratory to ensure proper preservation and cooling was maintained.

When the sludge holding tank was nearly full, arrangements were made to have the sludge removed by a licensed hauler. The volume of sludge pumped from the tank was recorded each time the tank was emptied and a sample of the sludge was taken for analysis of percent solids and metals (As, Ba, Cd, Cr, Hg, Pb, Ni, Zn).

All analyses were completed in accordance with EPA approved methods or *Standard Methods for the Examination of Waster and Wastewater*, 20th Edition. An established quality assurance/quality control (QA/QC) program was used to monitor sampling and laboratory procedures. Details on all analytical methods and QA/QC procedures are provided in the full verification report.

PERFORMANCE VERIFICATION

Overview

Evaluation of the IWS Model 6000 SBR began in April 2004 when one SBR was taken off line and cleaned. The verification testing started July 1, 2004 and proceeded without interruption through June 30, 2005. All sixteen four-day sampling events were completed as scheduled, yielding 64 sets of analytical data for daily composite and grab sample parameters, and 16 sets of data for the 96-hr composite parameters.

One major change was made to the test system approximately two and one half months after the start of the verification test. The original system included two 6,000 gal SBR units, with no equalization or distribution tank ahead of the SBR units. One of the SBR units was converted to an equalization tank, while the second SBR unit continued to operate as an SBR. IWS made this same change to all of their systems to provide better flow control to the SBR unit and to reduce the potential for upsets in the SBR during very high inlet flow rates.

Startup

The SBR startup proceeded without difficulty. Startup and acclimation procedures were easy to follow and the SBR system established a viable biomass that would provide treatment of the wastewater within two to three weeks.

Verification Test Results

The average daily flow based on daily averages calculated for each month in the twelve-month verification period, was 2,277 gal and ranged from 1,827 to 3,690 gal. The peak single day flow of 6,026 gal occurred in November 2004 and the lowest single day flow of 259 gal occurred in October 2004.

Table 1 presents the results for BOD_5 and TSS. The SBR effluent achieved a mean reduction of 95% for BOD_5. The final treated effluent had a mean value of 4 mg/L giving a mean reduction of 98% for BOD_5. Most of the BOD_5 results in the final effluent were below the detection limit of either 3 or 4 mg/L.

The mean influent COD was 480 mg/L, with a range of 120 to 1,440 mg/L. The SBR effluent mean COD concentration was 49 mg/L, ranging from <20 to 240 mg/L, and the COD concentration in the treated effluent had a mean of 22 mg/L with a range of <20 to 45 mg/L. The mean value was very close to the detection limit for the COD test (20 mg/L), as most of the test results were below the detection limit.

Table 2 presents the results for TKN, NH_3-N, NO_2+NO_3-N) and total nitrogen (TN). TN was determined by adding the concentrations of the TKN (organic plus ammonia nitrogen), and NO_2+NO_3-N in the effluent. The SBR demonstrated a mean reduction of 83% in TN for the verification test period. The final treated effluent nitrogen concentrations were similar to the SBR effluent except for a somewhat lower mean concentration of TKN. The overall system removal efficiency for TN was 88%.

Table 1. BOD_5 and TSS Data Summary

	BOD_5 (mg/L)			TSS (mg/L)		
	Influent	SBR Effluent	Final Effluent	Influent	SBR Effluent	Final Effluent
Mean	230	12	4	170	26	6
Maximum	580	39	8	440	160	23
Minimum	86	<4	2	15	3	3
Std. Dev.	99	8.3	1.4	90	28	4

Note: Data are based on 64 samples.

Table 2. Nitrogen Data Summary

	TKN (mg/L)			NH_3-N (mg/L)		
	Influent	SBR Effluent	Final Effluent	Influent	SBR Effluent	Final Effluent
Mean	37.6	3.23	1.23	29.8	0.44	0.33
Maximum	50.2	6.40	3.54	40.0	2.99	2.53
Minimum	17.9	1.17	0.40	11.9	<0.04	<0.04
Std. Dev.	9.95	1.86	0.90	8.65	0.94	0.76

	NO_2+NO_3-N (mg/L)			TN (mg/L)		
	Influent	SBR Effluent	Final Effluent	Influent	SBR Effluent	Final Effluent
Mean	0.08	3.1	3.1	38	6.3	4.4
Maximum	0.232	9.9	8.8	50	15	9.8
Minimum	<0.02	0.50	0.6	18	2.0	1.0
Std. Dev.	0.06	2.4	2.2	9.9	3.3	2.3

Table 3 presents data for TP and SP. The SBR demonstrated a mean reduction of 56% of the TP and 59% of the SP present in the influent. The trends are very similar with SP representing approximately 65-75% of the TP concentration in both the influent and SBR effluent for the verification test period. The final treated effluent showed a small additional decrease in SP (mean of 1.1 mg/L versus 1.6 mg/L), while the TP concentration decreased from a mean of 2.4 mg/L to 1.3 mg/L. Overall the full treatment system achieved a 76% reduction in TP concentration and 72% reduction in SP concentration.

Table 3. Phosphorus Data

	Total Phosphorus (mg/L)			Soluble Phosphorus (mg/L)		
	Influent	SBR Effluent	Final Effluent	Influent	SBR Effluent	Final Effluent
Mean	5.4	2.4	1.3	3.9	1.6	1.1
Maximum	7.4	4.7	2.7	5.7	3.5	2.5
Minimum	2.9	0.37	0.08	1.5	0.12	<0.05
Std. Dev.	1.5	1.1	0.75	1.2	0.89	0.76

Note: The data in Tables 2 and 3 are based on 16 samples.

Total coliform results are presented in Table 4. The UV system reduced total coliform levels to below the detection limit on most sample days. Only one day exceeded 100 MPN/100 mL and two additional days exceeded 10 MPN/100 mL.

Table 4. Total Coliform Data Summary

	Total Coliform (MPN/ 100 mL)		
	Influent	**SBR Effluent**	**Final Effluent**
Geometric Mean	7.1×10^{6}	1.2×10^{5}	4
Maximum	1.6×10^{9}	5.0×10^{6}	120
Minimum	2.3×10^{5}	2.4×10^{3}	2

Note: Data are based on 63 samples of influent and SBR effluent, and 53 smaples of final effluent.

Verification Test Discussion

High influent volumes in November (several days above 4,000 gal and two days over 5,000 gal) resulted in high water alarms in the system. During this time, the filter was not meeting turbidity requirements, resulting in reject water from the filtration system going to the SBR in addition to the high influent volume. Five truckloads (15,500 gal) of raw wastewater from the equalization tank were hauled away to stabilize the system. In response, the process cycle time was also changed from four hours to six hours and the aeration cycle was lengthened from two 45-minute periods to two 90-minute periods. Following this change, the maximum daily flow during the test (6,026 gal) occurred three days later, followed by continued high flows for several more days, but the high flows did not significantly impact system performance.

SBR effluent BOD_5 exceeded 20 mg/L on eight of the 64 monitoring days, and exceeded 30 mg/L on three of those days. While there was no distinct pattern or cause identified for the days with higher BOD_5, the higher BOD_5 concentrations did tend to correspond with higher TSS concentrations. The highest BOD_5 concentration of 39 mg/L corresponded to the maximum TSS concentration of 160 mg/L. TSS varied considerably in the SBR effluent with eight of the 63 monitoring days exceeding 50 mg/L. Clarification of the biomass was generally successful, but poorer settling did at times challenge the coagulation/filtration system. The filtration system and the on-line turbidity monitor worked as designed, rejecting filtrate with higher turbidity and TSS. On days when TSS was elevated in the SBR effluent, the final effluent was typically 5 mg/L or less.

Operation and Maintenance Results

In December, a total of 10,500 gal of wastewater was removed from the equalization tank and trucked to the local municipal wastewater treatment plant. The high water condition was most likely due to a faulty low level UV intensity reading on the UV unit, based on system pumping records, UV readings, filter turbidity and effluent coliform data collected when UV readings were properly acquired by the PLC. Once the problem was resolved, the unit returned to normal operation and no additional high water alarms were encountered.

The Model 6000 SBR used an aluminum salt (alum or poly aluminum chloride) as a coagulant to treat the SBR effluent prior to filtration and used methanol as a supplemental carbon source for the denitrification process. These chemicals were added from 55 gal storage tanks by chemical metering pumps activated by the PLC during flow to the filter (aluminum) and during the anoxic cycle in the SBR (methanol). The chemical dose for aluminum was approximately 2.5 mg/L as Al. The average coagulant use, based on an average daily flow of 2,280 gal, was approximately 0.5 lbs/day as Al. This translates to approximately 1.1 pounds of PAC per 1,000 gal treated or 2.8 lbs of alum per 1,000 gal treated. The average methanol solution feed rate was 1.7 gal (2.8 lbs) per day, which translates to approximately 50 mg/L as carbon or 1.2 lbs of methanol per 1,000 gal treated.

The IWS Model 6000 SBR, while complex, is highly automated and PLC controlled so that operator intervention is not required on a daily basis. The operator can access the PLC via the Internet and the PLC can send various alarms to an operator when there is a potential problem. Based on the records maintained during the verification test, four to five hr/week are needed to handle routine operation and maintenance activities, with additional time needed for

mechanical problems or upset conditions. There were no major operational upsets in the SBR during the verification test, only adjustments in the SBR master cycle (aeration, anoxic, transfer, clarification). The most significant change was the November adjustment mentioned in the previous section.

There were no major mechanical component failures or major downtime periods during the verification test. When the process was changed in September to switch one SBR to an equalization tank, the switch was completed in two days, with flow to the one SBR maintained throughout the period. There was one structural failure during the test, when the baffle in the SBR between the aeration chamber and the clarifier chamber separated from the tank wall.

Quality Assurance/Quality Control

During testing, NSF completed a QA/QC audit of the Moon Lake Ranch site and Analytical Laboratories Inc. (ALI), the analytical laboratory. This audit included: (a) a technical systems audit to assure the testing was in compliance with the test plan, (b) a performance evaluation audit to assure that the measurement systems employed at the test site and by ALI were adequate to produce reliable data, and (c) a data quality audit of at least 10 percent of the test data to assure that the reported data represented the data generated during the testing. The audit determined that procedures being used in the field and the laboratory were in accordance with the established QAPP. EPA QA personnel also conducted a quality systems audit of NSF's QA Management Program.

Original Signed by Clyde R. Dempsey for Sally Gutierrez	*September 27, 2006*	*Original Signed by Robert Ferguson*	*October 2, 2006*
Sally Gutierrez	Date	Robert Ferguson	Date
Director		Vice President	
National Risk Management Research Laboratory		Water Programs	
Office of Research and Development		NSF International	
U.S. Environmental Protection Agency			

NOTICE: Verifications are based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. EPA and NSF make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements. Mention of corporate names, trade names, or commercial products does not constitute endorsement or recommendation for use of specific products. This report in no way constitutes an NSF Certification of the specific product mentioned herein.

Availability of Supporting Documents

Copies of *The Protocol for Verification of Wastewater Treatment Technologies,* dated April 2001, the Verification Test Plan, Verification Statement, and the Verification Report are available from the following sources:

1. ETV Water Quality Protection Center Manager (order hard copy)
   NSF International
   P.O. Box 130140
   Ann Arbor, Michigan 48113-0140
2. NSF web site: http://www.nsf.org/etv (electronic copy)
3. EPA web site: http://www.epa.gov/etv (electronic copy)

(NOTE: Appendices are not included in the Verification Report. Appendices are available from NSF upon request.)

EPA's Office of Wastewater Management has published a number of documents to assist purchasers, community planners and regulators in the proper selection, operation and management of onsite wastewater treatment systems. Two relevant documents and their sources are:

1. *Handbook for Management of Onsite and Clustered Decentralized Wastewater Treatment Systems* http://www.epa.gov/owm/onsite
2. *Onsite Wastewater Treatment Systems Manual* http://www.epa/gov/owm/mtb/decent/toolbox.htm