

**Arsenic Removal from Drinking Water by Adsorptive Media
U.S. EPA Demonstration Project at Desert Sands MDWCA, NM
Final Performance Evaluation Report**

by

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Sally Gutierrez, Director
National Risk Management Research Laboratory

ABSTRACT

This report documents the activities performed and the results obtained for the arsenic removal treatment technology demonstration project at the Desert Sands Mutual Domestic Water Consumers Association (MDWCA) facility in Anthony, NM. The objectives of the project were to evaluate 1) the effectiveness of Severn Trent Services' (STS) Arsenic Package Unit-300 (APU-300) SORB 33TM media in removing arsenic to meet the new arsenic maximum contaminant level (MCL) of 10 µg/L, 2) the reliability of the treatment system, 3) the simplicity of required system operation and maintenance (O&M) and operator skill levels, and 4) the cost-effectiveness of the technology. The project also characterized water in the distribution system and process residuals produced by the treatment system.

SORB 33TM media is an iron-based adsorptive media developed by Bayer AG and marketed by STS. Two media runs were conducted in the performance study, with the first utilizing the granular form of the media (-S) and the second utilizing the pelletized form (-P). According to the vendor, SORB 33TM-P is an improved version of the granular form (SORB 33TM-S) and has more robust physical integrity. The two forms of media have the same composition, but a different bulk density and media particle size distribution.

The APU-300 system consisted of two 63-in-diameter, 86-in-tall pressure vessels in parallel configuration. Each pressure vessel initially contained 80 ft³ of SORB 33TM-S media or 62 ft³ of SORB 33TM-P media. The adsorptive media were supported by a gravel underbed. Based on a design flowrate of 320 gal/min (gpm), empty bed contact times (EBCTs) for the system were 3.7 and 2.9 min, for the SORB 33TM-S and -P media, respectively. Hydraulic loading to each vessel based on the design flowrate was 7.4 gpm/ft².

The first media run operated from January 16, 2004 through July 14, 2005, treating approximately 52,645,000 gal of water based on totalizer readings from each vessel. The APU-300 system operated 6.2 hr/day with an average flowrate of 271 gpm. The second media run operated from July 29, 2005 through August 16, 2006, and treated approximately 46,553,000 gal of water based on totalizer readings from each vessel. The APU-300 system operated 7.8 hr/day with an average flowrate of 251 gpm. The EBCTs ranged from 3.1 to 7.5 min for the first media run, and from 2.5 to 6.2 min for the second.

Breakthrough of total arsenic at concentration above the 10 µg/L target MCL occurred at approximately 40,600 bed volumes (BV) during the first media run, representing approximately 62% of the vendor-estimated working capacity of 66,000 BV. During the second media run, breakthrough of arsenic occurred at approximately 49,500 BV, representing about 58% of the estimated working capacity of 85,200 BV.

During the study, total arsenic concentrations in source water ranged from 18.6 to 30.1 µg/L with As(III) comprising a significant portion of the total soluble arsenic with concentrations ranging from 17.6 to 25.2 µg/L. Prechlorination was effective in oxidizing As(III) to As(V), as evident by the low As(III) concentrations (i.e., averaged 2.0 µg/L) in water sampled immediately after prechlorination. Total and free chlorine residuals measured before and after the adsorption vessels were at the equivalent levels of 0.4 to 0.8 mg/L (as Cl₂) and 0.3 to 1.0 mg/L (as Cl₂), respectively, indicating little or no chlorine consumption by the SORB 33TM media. Concentrations of iron, manganese, silica, orthophosphate, and other ions in raw water were not high enough to impact arsenic removal by the media.

Backwash wastewater contained soluble arsenic concentrations ranging from 6.4 to 22.2 µg/L, and averaging 13.3 µg/L. The average soluble arsenic concentration was lower than that in raw water, indicating removal of some soluble arsenic by the media during backwash. Soluble iron and soluble

manganese concentrations ranged from <25 to 373 and 1.8 to 27.1 µg/L, respectively. As expected, total arsenic, iron, and manganese concentrations were considerably higher than soluble concentrations, indicating the presence of particulate metals in the backwash wastewater. Particulate As might be associated with either iron particles intercepted by the media beds during the service cycle or the media fines. Based on the total suspended solid (TSS) values, approximately 9.1 lb of suspended solid was produced in 10,000 gal of backwash wastewater from both vessels during each backwash event.

The spent media passed the Toxicity Characteristic Leaching Procedure (TCLP) test for all Resource Conservation and Recovery Act (RCRA) metals, with only barium showing detectable concentrations ranging from 0.61 to 0.76 mg/L. The average arsenic loading on the spent media as analyzed by inductively coupled plasma-mass spectrometry (ICP-MS) was 2.2 mg/g or 0.22% on SORB 33TM-S media and 1.6 mg/g or 0.16% on SORB 33TM-P media. These loadings compared well with the average adsorptive capacities, i.e., 2.1 and 1.7 mg/g, respectively, as calculated by dividing the area between the influent and effluent breakthrough curves by the amount of dry media in each vessel.

Distribution system water samples were collected to determine any impact of arsenic treatment on the lead and copper levels and water chemistry in the distribution system. Comparison of the distribution system sampling results before and after the operation of the APU-300 system showed a decrease in arsenic concentrations (from 22.4 to 28.2 µg/L to 1.8 to 19.0 µg/L) at all three sampling locations. However, the concentrations measured at the distribution system were higher than those in the system effluent. This likely was due to the blending with untreated water produced by a separate well in the distribution system. Neither lead nor copper concentrations at the sample sites appear to have been affected by the operation of the system.

The capital investment cost of \$153,000 included \$112,000 for equipment, \$23,000 for site engineering, and \$18,000 for installation. Using the system's rated capacity of 320 gpm, the capital cost was \$478/gpm of design capacity and the equipment-only cost was \$350/gpm of design capacity. These calculations did not include the cost of a building addition to house the treatment system. The unit annualized capital cost was \$0.09/1,000 gal, assuming the system operated 24 hours a day, 7 days a week, at the system design flowrate of 320 gpm for 20 years at 7% interest. The system operated only 7 hr/day on average, producing 40,395,000 gal of water per year. At this reduced usage rate, the unit annualized capital cost increased to \$0.37/1,000 gal.

The O&M cost of the APU-300 system was estimated at \$0.74/1,000 gal, which included media replacement and disposal, chemical supply, electricity consumption, and labor. Because the incremental costs for chemical supply and electricity were negligible, only media replacement and disposal and O&M labor would impact O&M costs.

The APU-300 system experienced excessive flow restriction, imbalanced flow, and/or elevated pressure differential across the adsorption vessels and the entire system during the first four months of system operation. After extensive on-site and off-site investigations and hydraulic testing, the system was retrofitted in May 2004 and, thus, able to operate according to the original design specifications.

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ABBREVIATIONS AND ACRONYMS

Δp	differential pressure
AAL	American Analytical Laboratories
Al	aluminum
AM	adsorptive media
APU	arsenic package unit
As	arsenic
bgs	below ground surface
BV	bed volume(s)
C/F	coagulation/filtration
Ca	calcium
Cl ₂	chlorine
CRF	capital recovery factor
Cu	copper
DO	dissolved oxygen
EBCT	empty bed contact time
EPA	U.S. Environmental Protection Agency
F	fluoride
Fe	iron
FRP	fiberglass reinforced plastic
GFH	granular ferric hydroxide
gpd	gallons per day
gpm	gallons per minute
HDPE	high-density polyethylene
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
IX	ion exchange
LCR	(EPA) Lead and Copper Rule
MCL	maximum contaminant level
MDL	method detection limit
MDWCA	Mutual Domestic Water Consumers Association
Mg	magnesium
mg/L	milligrams per liter
$\mu\text{g/L}$	micrograms per liter
Mn	manganese
Mo	molybdenum
mV	millivolts

Na	sodium
NA	not available
NaOCl	sodium hypochlorite
NMED	New Mexico Environmental Department
NTU	nephelometric turbidity unit
O&M	operation and maintenance
ORD	Office of Research and Development
ORP	oxidation-reduction potential
P&ID	pipng and instrumentation diagram
Pb	lead
PLC	programmable logic controller
psi	pounds per square inch
PO ₄	orthophosphate
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
Sb	antimony
SDWA	Safe Drinking Water Act
SiO ₂	silica
SM	system modification
SO ₄	sulfate
SOC	synthetic organic compound
STMGID	South Truckee Meadows General Improvement District
STS	Severn Trent Services
TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
V	vanadium
VOC	volatile organic compound
WRWC	White Rock Water Company

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1.0 INTRODUCTION

1.1 Background

The Safe Drinking Water Act (SDWA) mandates that U.S. Environmental Protection Agency (EPA) identify and regulate drinking water contaminants that may have adverse human health effects and that are known or anticipated to occur in public water supply systems. In 1975 under the SDWA, EPA established a maximum contaminant level (MCL) for arsenic at 0.05 mg/L. Amended in 1996, the SDWA required that EPA develop an arsenic research strategy and publish a proposal to revise the arsenic MCL by January 2000. On January 18, 2001, EPA finalized the arsenic MCL at 0.01 mg/L (EPA, 2001). In order to clarify the implementation of the original rule, EPA revised the rule text on March 25, 2003 to express the MCL as 0.010 mg/L (10 µg/L) (EPA, 2003). The final rule required all community and non-transient, non-community water systems to comply with the new standard by January 23, 2006.

In October 2001, EPA announced an initiative for additional research and development of cost-effective technologies to help small community water systems (<10,000 customers) meet the new arsenic standard, and to provide technical assistance to operators of small systems in order to reduce compliance costs. As part of this Arsenic Rule Implementation Research Program, EPA's Office of Research and Development (ORD) proposed a project to conduct a series of full-scale, on-site demonstrations of arsenic removal technologies, process modifications, and engineering approaches applicable to small systems. Shortly thereafter, an announcement was published in the *Federal Register* requesting water utilities interested in participating in Round 1 of this EPA-sponsored demonstration program to provide information on their water systems. In June 2002, EPA selected 17 out of 115 sites to host the demonstration studies, including the Desert Sands Mutual Domestic Water Consumers Association (MDWCA) water system in Anthony, NM.

In September 2002, EPA solicited proposals from engineering firms and vendors for cost-effective arsenic removal treatment technologies for the 17 host sites. EPA received 70 technical proposals for the 17 host sites, with each site receiving from one to six proposals. In April 2003, an independent technical panel reviewed the proposals and provided its recommendations to EPA on the technologies that it determined were acceptable for the demonstration at each site. Because of funding limitations and other technical reasons, only 12 of the 17 sites were selected for the demonstration project. Using the information provided by the review panel, EPA, in cooperation with the host sites and the drinking water programs of the respective states, selected one technical proposal for each site. Severn Trent Services (STS), using the Bayoxide E33 media developed by Bayer AG, was selected for the Desert Sands MDWCA facility in Anthony, NM. STS has given the E33 media the designation "SORB 33™".

1.2 Treatment Technologies for Arsenic Removal

The technologies selected for the 12 Round 1 EPA arsenic removal demonstration host sites include nine adsorptive media systems, one anion exchange system, one coagulation/filtration system, and one process modification with iron addition. Table 1-1 summarizes the locations, technologies, vendors, and key source water quality parameters of the 12 demonstration sites. An overview of the technology selection and system design (Wang et al., 2004) and the associated capital costs for each site (Chen et al., 2004) are provided on the EPA website at <http://www.epa.gov/ORD/NRMRL/arsenic/resource.htm>. As of September 2008, all 12 systems were operational, and the performance evaluation of 11 systems was completed.

Table 1-1. Summary of Round 1 Arsenic Removal Demonstration Sites

Demonstration Site	Technology (Media)	Vendor	Design Flowrate (gpm)	Source Water Quality		
				As (µg/L)	Fe (µg/L)	pH
WRWC, NH	AM (G2)	ADI	70 ^(a)	39	<25	7.7
Rollinsford, NH	AM (E33)	AdEdge	100	36 ^(b)	46	8.2
Queen Anne's County, MD	AM (E33)	STS	300	19 ^(b)	270 ^(c)	7.3
Brown City, MI	AM (E33)	STS	640	14 ^(b)	127 ^(c)	7.3
Climax, MN	C/F (Macrolite)	Kinetico	140	39 ^(b)	546 ^(c)	7.4
Lidgerwood, ND	SM	Kinetico	250	146 ^(b)	1,325 ^(c)	7.2
Desert Sands MDWCA, NM	AM (E33)	STS	320	23 ^(b)	39	7.7
Nambe Pueblo, NM	AM (E33)	AdEdge	145	33	<25	8.5
Rimrock, AZ	AM (E33)	AdEdge	90 ^(a)	50	170	7.2
Valley Vista, AZ	AM (AAFS50/ARM 200)	Kinetico	37	41	<25	7.8
Fruitland, ID	IX (A300E)	Kinetico	250	44	<25	7.4
STMGID, NV	AM (GFH/Kemiron)	Siemens	350	39	<25	7.4

AM = adsorptive media; C/F = coagulation/filtration; GFH = granular ferric hydroxide; IX = ion exchange; SM = system modification

MDWCA = Mutual Domestic Water Consumer's Association; STMGID = South Truckee Meadows General Improvement District; WRWC = White Rock Water Company; STS = Severn Trent Services

(a) Design flowrate reduced by 50% due to system reconfiguration from parallel to series operation.

(b) Arsenic exists mostly as As(III).

(c) Iron exists mostly as soluble Fe (II).

1.3 Project Objectives

The objective of the Round 1 arsenic demonstration program is to conduct full-scale arsenic treatment technology demonstration studies on the removal of arsenic from drinking water supplies. The specific objectives are to:

- Evaluate the performance of the arsenic removal technologies for use on small systems.
- Determine the required system operation and maintenance (O&M) and operator skill levels.
- Characterize process residuals produced by the technologies.
- Determine the capital and O&M cost of the technologies.

This report summarizes the performance of the STS system at the Desert Sands MDWCA facility from January 16, 2004 through August 17, 2006. The types of data collected included system operation, water quality (both across the treatment train and in the distribution system), residuals, and capital and O&M cost.

2.0 SUMMARY AND CONCLUSIONS

Based on the information collected during the 31 months of system operation, the following conclusions were made relating to the overall objectives of the treatment technology demonstration study.

Performance of the arsenic removal technology for use on small systems:

- Chlorine was effective in oxidizing As(III) to As(V), reducing soluble As(III) concentrations from 21.7 µg/L (on average) in raw water to 2.0 µg/L (on average).
- SORB33™ media was effective in removing arsenic, but its run length was shorter than projected by the vendor. For the run with the granular form of the SORB33™ media (-S), breakthrough of total arsenic at 10 µg/L occurred at 40,600 bed volumes (BV), representing 62% of the vendor estimated working capacity. For the run with the pelletized form of the media (-P), breakthrough of total arsenic occurred at 49,500 BV, representing 58% of the estimated working capacity.
- As much as 45% media loss was observed during the media run using the granular media (-S). Poor physical integrity of the media might have contributed to the media loss. Sieve analyses indicated disintegration of the granular media during the run. Media loss reduced to 12% during the second media run using the pelletized media (-P). Sieve analyses were not performed for the pelletized media.
- The throughput between consecutive backwash events decreased significantly during the media run using the granular media (-S), from over 2,885 BV after system retrofit to 630 BV at the end of the run. Media attrition of the granular media (-S) during backwash appeared to have caused more frequent backwash.
- Arsenic concentrations in the distribution system were reduced from the predemonstration levels of 22.4–28.2 µg/L to 1.8–19.0 µg/L after the system became operational. However, the reduced concentrations were still higher than those in the plant effluent, probably due to the blending of the treated water with untreated water produced by a separate well in the distribution system. Neither lead nor copper concentrations appear to have been affected by operation of the system.

Required system O&M and operator skill levels:

- The APU-300 system experienced excessive flow restriction, imbalanced flow, and/or elevated pressure differential across the adsorption vessels and the entire system during the first four months of system operation. After extensive onsite and off-site investigations and hydraulic testing, the system was retrofitted in May 2004. Since then the system was able to operate according to the original design specifications through the end of the demonstration study.
- The skill requirements to operate the treatment system were minimal with a typical daily demand on the operator of 15 to 20 min. Normal operation of the system did not appear to require additional skills beyond those necessary to operate the existing water supply equipment. A Level 3 state-certified operator was required for operation of the water system at MDWCA.

Characteristics of residuals produced by the technology:

- Each backwash event produced approximately 10,000 gal of wastewater. Backwash wastewater contained less soluble arsenic than raw water, indicating removal of arsenic by the media during backwashing.
- Approximately 2.2 and 1.6 mg of arsenic was loaded per gram of dry SORB33™-S and SORB33™-P media, respectively; equivalent to approximately 0.22 and 0.16%, respectively,

Capital and O&M cost of the technology:

- The unit annualized capital cost was \$0.09/1,000 gal if the system operated at 100% utilization rate. The system's actual unit annualized capital cost was \$0.37/1,000 gal, based on 7 hr/day of system operation and 40,395,000 gal/year of water production. The unit O&M cost was \$0.74/1,000 gal, based on media replacement and disposal, chemical supply, electricity consumption, and labor.

3.0 MATERIALS AND METHODS

3.1 General Project Approach

Following the predemonstration activities summarized in Table 3-1, the performance evaluation study of the STS treatment system began on January 16, 2004. Table 3-2 summarizes the types of data collected and/or considered as part of the technology evaluation process. The overall performance of the system was evaluated based on its ability to consistently remove arsenic to below the target MCL of 10 µg/L through the collection of water samples across the treatment train. The reliability of the system was evaluated by tracking the unscheduled system downtime and frequency and extent of repair and replacement. The unscheduled downtime and repair information were recorded by the plant operator on a Repair and Maintenance Log Sheet.

The O&M and operator skill requirements were evaluated based on a combination of quantitative data and qualitative considerations, including the need for any pre- and/or post-treatment, level of system automation, extent of preventative maintenance activities, frequency of chemical and/or media handling and inventory, and general knowledge needed for relevant chemical processes and related health and safety practices. The staffing requirements for the system operation were recorded on an Operator Labor Hour Log Sheet.

Table 3-1. Predemonstration Study Activities and Completion Dates

Activity	Date
Introductory Meeting Held	August 20, 2003
Request for Quotation Issued to Vendor Issued	August 26, 2003
Vendor Quotation to Battelle Submitted	September 17, 2003
Purchase Order Completed and Signed	October 3, 2003
Letter Report Issued	October 16, 2003
Concrete Pad Poured	October 30, 2003
Engineering Package to NMED Submitted	November 18, 2003
APU-300 Unit Shipped by STS	November 18, 2003
Draft Study Plan Issued	November 26, 2003
APU-300 Unit Delivered to Desert Sands MDWCA	December 1, 2003
System Installation Completed	December 11, 2003
Approval for Construction Granted by NMED	December 22, 2003
Building Construction Began	December 23, 2003
System Shakedown Completed	January 15, 2004
Performance Evaluation Began	January 16, 2004
Final Study Plan Issued	January 19, 2004
Building Construction Completed	January 23, 2004

NMED = New Mexico Environmental Department

The quantity of aqueous and solid residuals generated was estimated by tracking the amount of backwash water produced during each backwash cycle and the need to replace the media upon arsenic breakthrough. Backwash wastewater and spent media were sampled and analyzed for chemical characteristics.

Table 3-2. Evaluation Objectives and Supporting Data Collection Activities

Evaluation Objective	Data Collection
Performance	-Ability to consistently meet 10 µg/L of arsenic in treated water
Reliability	-Unscheduled system downtime -Frequency and extent of repairs including a description of problems, materials and supplies needed, and associated labor and cost
System O&M and Operator Skill Requirements	-Pre- and post-treatment requirements -Level of system automation for system operation and data collection -Staffing requirements including number of operators and laborers -Task analysis of preventative maintenance including number, frequency, and complexity of tasks -Chemical handling and inventory requirements -General knowledge needed for relevant chemical processes and health and safety practices
Residual Management	-Quantity and characteristics of aqueous and solid residuals generated by system operation
System Cost	-Capital cost for equipment, site engineering, and installation -O&M cost for media, chemical consumption, electricity usage, and labor

The cost of the system was evaluated based on the capital cost per gal/min (gpm) (or gal/day [gpd]) of design capacity and the O&M cost per 1,000 gal of water treated. This task required tracking of the capital cost for the equipment, engineering, and installation, as well as the O&M cost for media replacement and disposal, chemical supply, electricity usage, and labor.

3.2 System O&M and Cost Data Collection

The plant operator performed daily, weekly, and monthly system O&M and data collection following the instructions provided by STS and Battelle. On a daily basis, the plant operator recorded system operational data, such as pressure, flowrate, totalizer, and hour meter readings on a Daily System Operation Log Sheet; checked the sodium hypochlorite (NaOCl) drum level; and conducted visual inspections to ensure normal system operations. If any problems occurred, the plant operator contacted the Battelle Study Lead, who determined if STS was contacted for troubleshooting. The plant operator recorded all relevant information on the Repair and Maintenance Log Sheet. Weekly or bi-weekly, the plant operator measured water quality parameters, including temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and residual chlorine, and recorded the data on a Weekly Onsite Water Quality Parameters Log Sheet. Monthly, the plant operator inspected the system control panel to ensure that moisture had not penetrated into the panel (STS, 2004). A monthly backwash of the media was originally recommended by STS; however, since it had been retrofitted in May 2004, the system was backwashed automatically when triggered by an increase in differential pressure (Δp) across each adsorption vessel. Backwash data were recorded on a Backwash Log Sheet.

The capital cost for the arsenic removal system consisted of the cost for equipment, site engineering, and system installation. The O&M cost consisted of the cost for media replacement and spent media disposal, chemical and electricity consumption, replacement parts, and labor. The NaOCl and electricity consumption was tracked using the Daily System Operation Log Sheet. Labor for various activities, such as the routine system O&M, troubleshooting and repair, and demonstration-related work, were tracked using an Operator Labor Hour Log Sheet. The routine O&M included activities such as completing daily field logs, replenishing the NaOCl solution, ordering inventory, performing regular system inspection, and others as recommended by the vendor. The demonstration-related work, including activities such as

performing field measurements, collecting and shipping samples, and communicating with the Battelle Study Lead and the vendor, was recorded, but not used for the cost analysis.

3.3 Sample Collection Procedures and Schedules

To evaluate the system performance, samples were collected from the wellhead, treatment plant, and distribution system. Table 3-3 provides the sampling schedules and analytes measured during each sampling event. Figure 3-1 presents a flow diagram of the treatment system along with the analytes and schedules at each sampling location. Specific sampling requirements for analytical methods, sample volumes, containers, preservation, and holding times are presented in Table 4-1 of the EPA-endorsed Quality Assurance Project Plan (QAPP) (Battelle, 2003). The procedure for arsenic speciation is described in Appendix A of the QAPP.

3.3.1 Source Water. During the initial visit to the site, source water samples were collected and speciated using an arsenic speciation kit described in Section 3.4.1. The sample tap was flushed for several minutes before sampling; special care was taken to avoid agitation, which could cause unwanted oxidation. Analytes for the source water samples are listed in Table 3-3.

3.3.2 Treatment Plant Water. Treatment plant water samples were collected by the plant operator weekly, on a four-week cycle, for on- and off-site analyses. For the first week of each four-week cycle, water samples were collected at the wellhead (IN), after chlorination (AC), and from the combined effluent of Vessels A and B (TT) and analyzed for the monthly treatment plant analyte list shown in Table 3-3. For the second, third, and fourth week of each four-week cycle, water samples were collected at four locations across the treatment train, including IN, AC, after Vessel A (TA), and after Vessel B (TB) and analyzed for the weekly treatment plant analyte list shown in Table 3-3.

Over the course of the demonstration study, several changes were made to the sampling schedule as listed in Table 3-3 including:

- Sampling at IN, AC, TA, and TB was reduced from three times per month to once per month from April 30, 2004, to December 14, 2005, and then increased to twice per month from February 1, to August 2, 2006. No sampling was conducted from December 15, 2005, to January 31, 2006. Since February 1, 2006, the analysis for SiO₂, PO₄, alkalinity, and turbidity was discontinued, and only total As, Fe, and Mn were measured.
- Monthly speciation sampling at IN, AC, and TT was discontinued after January 4, 2006.
- On-site measurements of pH, temperature, DO, ORP, and Cl₂ (free and total) were reduced from weekly to monthly from March 2, 2005, to January 4, 2006, and discontinued thereafter.
- Total P replaced orthophosphate beginning on October 12, 2005 due to ease of analysis.

3.3.3 Backwash Wastewater. Grab samples were collected periodically from a tap on the backwash wastewater discharge line by the plant operator from May 2004 through November 2005. Filtered samples using 0.45- μ m filters were analyzed for soluble As, Fe, and Mn and non-filtered samples analyzed for pH, total dissolved solids (TDS), and turbidity. Since February 2006, composite samples were collected monthly using a procedure that allowed collection of more representative samples during backwash. Tubing, connected to the tap on the discharge line, directed a portion of backwash wastewater at approximately 1 gpm into a clean, 32-gal container over the duration of the backwash for each vessel. After the content in the container was thoroughly mixed, composite samples were collected and/or filtered on-site with 0.45- μ m disc filters. Filtered and non-filtered samples were analyzed for the analytes

Table 3-3. Sample Collection Schedule and Analyses

Sample Type	Sampling Locations ^(a)	No. of Samples	Frequency	Analytes	Collection Date(s)
Source Water	IN	1	Once (during initial site visit)	On-site: pH Off-site: As (total and soluble), As(III), As(V), Fe (total and soluble), Mn (total and soluble), Al (total and soluble), V (total and soluble), Mo (total and soluble), Sb (total and soluble), Na, Ca, Mg, Cl, F, SO ₄ , sulfide, SiO ₂ , PO ₄ , TOC, and alkalinity	08/20/03
Treatment Plant Water	IN, AC, TA, TB	4	3 time/month (01/28/04 – 04/07/04); monthly (04/30/04 – 12/14/05); No sampling (12/15/05 – 01/31/06); 2 time/month (02/01/06 – 08/02/06)	On-site ^(b) : pH, temperature, DO, ORP, Cl ₂ (free and total) Off-site ^(c) : As (total), Fe (total), and Mn (total), SiO ₂ , PO ₄ ^(d) alkalinity, and turbidity	01/28/04, 02/04/04, 02/11/04, 02/25/04, 03/03/04, 03/10/04, 03/24/04, 03/31/04, 04/07/04, 04/30/04, 05/26/04, 06/23/04, 07/21/04, 08/18/04, 09/15/04, 10/13/04, 11/03/04, 12/01/04, 01/05/05, 02/02/05, 03/02/05, 03/30/05, 04/27/05, 05/25/05, 06/07/05, 07/06/05, 08/17/05 ^(e) , 09/14/05 ^(e) , 10/12/05, 11/09/05, 12/14/05, 02/01/06, 02/15/06, 03/01/06, 03/15/06, 03/29/06, 04/12/06, 04/26/06, 05/10/06, 05/24/06, 06/07/06, 06/21/06, 07/05/06, 07/19/06, 08/02/06
	IN, AC, TT	3	Monthly (01/23/04 – 01/04/06)	On-site ^(b) : pH, temperature, DO, ORP, Cl ₂ (free and total) Off-site: As (total and soluble), As(III), As(V), Fe (total and soluble), Mn (total and soluble), Ca, Mg, F, NO ₃ , SO ₄ , sulfide, SiO ₂ , alkalinity, and turbidity	01/23/04, 02/18/04, 03/17/04, 04/14/04, 05/12/04, 06/09/04, 07/07/04, 08/04/04, 09/01/04, 09/29/04, 10/28/04, 11/17/04, 12/15/04, 01/20/05, 02/16/05, 03/16/05, 04/13/05, 05/11/05, 06/22/05, 08/03/05, 08/31/05, 09/28/05, 10/26/05, 11/30/05, 01/04/06
Backwash Wastewater	BW	2	Eighteen times	Before 02/01/06: pH, TDS, turbidity, soluble As, Fe, and Mn After 02/01/06: pH, TDS, and TSS, As (total and soluble), Fe (total and soluble), Mn (total and soluble)	05/23/04, 07/13/04, 09/30/04, 11/17/04, 12/06/04, 02/07/05, 06/14/05, 07/07/05, 09/15/05, 10/12/05, 11/09/05, 02/01/06, 03/15/06, 04/11/06, 05/10/06, 06/06/06, 07/18/06, 08/16/06

Table 3-3. Sample Collection Schedule and Analyses (Continued)

Sample Type	Sampling Locations ^(a)	No. of Samples	Frequency	Analytes	Collection Date(s)
Backwash Solids	BW	1 per vessel	Three times	Total Al, As, Ca, Cd, Cu, Fe, Mg, Mn, Ni, P, Pb, Si, and Zn	06/06/06, 07/18/06, 08/16/06
Distribution Water	One home (an LCR sampling location) and two non-residences within area served by Well No. 3, according to MDWCA model	5 (3 first draw and 2 flushed)	Monthly	pH, alkalinity, total As, Cu, Fe, Mn, and Pb	Baseline sampling ^(f) : 12/08/03, 12/11/03, 12/30/03 Monthly sampling: 02/11/04, 03/10/04, 04/07/04, 05/12/04, 06/23/04, 07/21/04, 08/18/04, 09/15/04, 10/13/04, 11/10/04, 12/08/04, 01/20/05, 02/16/05, 03/16/05, 04/13/05, 05/11/05, 06/22/05, 08/03/05, 09/14/05, 10/12/05, 11/09/05, 12/14/05
Spent Media	From spent media in vessels	2 to 3 per vessel	Two times (at end of media runs)	TCLP; total Al, As, Ca, Cd, Cu, Fe, Mg, Mn, Ni, P, Pb, Si, and Zn	07/27/05, 09/11/06 (Vessel B only)

- (a) Abbreviation corresponding to sample locations in Figure 3-1: IN = at wellhead, AC = after chlorination, TA = after Vessel A, TB = after Vessel B, TT = comined effluent, and BW = at backwash wastewater discharge line
- (b) Onsite chlorine residual measurements not performed at IN; measurements reduced to monthly from March 2, 2005 to January 4, 2006 and discontinued thereafter.
- (c) Since February 1, 2006, only total As, Fe, and Mn measured.
- (d) Total P replaced PO₄ since October 12, 2005.
- (e) Samples collected at IN, AC, and TT.
- (f) Three baseline sampling events performed before system startup.

performed for the grab samples plus total suspended solids (TSS) and total As, Fe, and Mn. TDS was discontinued after February 2006.

3.3.4 Residual Solids. Residual solids included backwash solids and spent media samples. Backwash solids/water mixtures were collected after solids settled in the 32-gal backwash containers and the supernatant carefully decanted. Due to low solids in the backwash wastewater, solids were collected from multiple backwash events during the last few months of system operation and combined for sufficient sample quantity. The samples were air-dried, acid-digested, and analyzed for Al, As, Ca, Cd, Cu, Fe, Mg, Mn, Ni, P, Pb, Si, and Zn. Insufficient sample existed for Toxicity Characteristic Leaching Procedure (TCLP) tests.

Two spent media samples were collected from each vessel during the first media changeout on July 27, 2005. Spent SORB 33TM-S media were removed from the top and bottom of each adsorption vessel using a 5-gal wet/dry shop vacuum that had been thoroughly cleaned and disinfected (Figure 3-2). Using a garden spade, the media from each layer was well-mixed in a clean 5-gal pail prior to being filled in an unpreserved 1-gal wide-mouth high-density polyethylene (HDPE) bottle. One aliquot of each sample was sent for TCLP tests. Another was air dried and acid digested for metal analysis. Three spent media samples were collected from Vessel B only during the second media changeout on September 11, 2006. Spent SORB 33TM-P media was removed from the top, middle, and bottom of the media bed using the method similar to that for the previous changeout. A portion of each sample was submitted for TCLP tests. Another portion of each sample was air dried and acid digested for metal analysis.

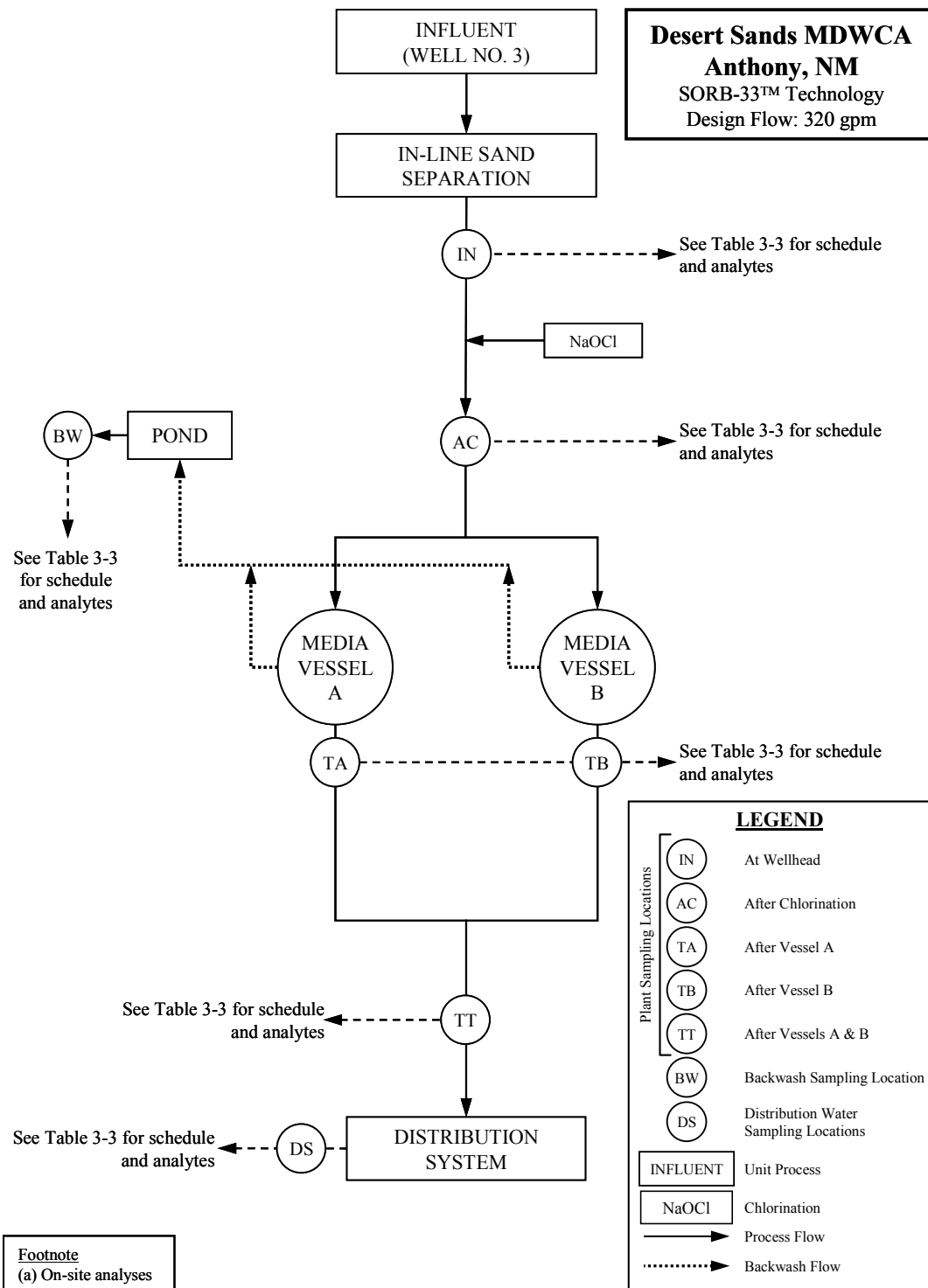


Figure 3-1. Process Flow Diagram and Sampling Locations



Figure 3-2. Apparatus Used for Spent Media Sampling

3.3.5 Distribution System Water. Water samples were collected from the distribution system to determine the impact of the arsenic treatment system on the water chemistry in the distribution system, specifically on lead, copper, and arsenic levels. In December 2003, prior to the startup of the treatment system, three baseline distribution system water samples were collected at three locations within the distribution system. Following system startup, distribution system sampling continued on a monthly basis at the same three locations until December 2005. Baseline and monthly distribution system samples were collected by the plant operator. Samples were collected at his home, which was included in the current Desert Sands MDWCA Lead and Copper Rule (LCR) sampling schedule, as well as two non-LCR sampling taps, with all three locations served by water produced from Well No. 3, as indicated by the Desert Sands MDWCA distribution system model.

The samples were collected at the LCR location following an instruction sheet developed according to the *Lead and Copper Rule Reporting Guidance for Public Water Systems* (EPA, 2002). Sampling at the two non-LCR locations was performed with the first sample taken at the first draw and the second sample taken after flushing the sample tap for several minutes. First draw samples were collected from cold-water faucets that had not been used for at least 6 hr to ensure that stagnant water was sampled. The sampler recorded the date and time of last water use before sampling and the date and time of sample collection for calculating the stagnation time. Analytes for the baseline samples coincided with the monthly distribution system water samples as described in Table 3-3. Arsenic speciation was not performed for the distribution water samples.

3.4 Sampling Logistics

All sampling logistics including arsenic speciation kits preparation, sample cooler preparation, and sampling shipping and handling are discussed as follows:

3.4.1 Preparation of Arsenic Speciation Kits. The arsenic field speciation method used an anion exchange resin column to separate the soluble arsenic species, As(V) and As(III) (Edwards et al., 1998). Resin columns were prepared in batches at Battelle laboratories according to the procedures detailed in Appendix A of the EPA-endorsed QAPP (Battelle, 2003).

3.4.2 Preparation of Sampling Coolers. For each sampling event, a cooler was prepared with the appropriate number and type of sample bottles, disc filters, and/or speciation kits. All sample bottles were new and contained appropriate preservatives. Each sample bottle was affixed with a pre-printed, colored-coded, waterproof label consisting of the sample identification (ID), date and time of sample collection, collector's name, site location, sample destination, analysis required, and preservative. The sample ID consisted of a two-letter code for the specific water facility, sampling date, a two-letter code for a specific sampling location, and a one-letter code designating the arsenic speciation bottle (if necessary). The sampling locations at the treatment plant were color-coded for easy identification. For example, red, orange, yellow, and green were used to designate sampling locations for IN, TA, TB, and TT, respectively. The labeled bottles for each sampling location were placed separately in a ziplock bag (each corresponding to a specific sample location) and packed in the cooler. On a monthly basis, the sample cooler also included bottles for the distribution system sampling.

In addition, all sampling- and shipping-related materials, such as disposable gloves, sampling instructions, chain-of-custody forms, prepaid/pre-addressed FedEx air bills, and bubble wrap, were placed in each cooler. The chain-of-custody forms and air bills were completed except for the operator's signature and the sample dates and times. After preparation, sample coolers were sent to the site via FedEx for the following week's sampling event.

3.4.3 Sample Shipping and Handling. After sample collection, samples for off-site analyses were packed carefully in the original coolers with wet ice and shipped to Battelle. Upon receipt, the sample custodian checked sample IDs against the chain-of-custody forms and verified that all samples indicated on the forms were included and intact. Discrepancies noted by the sample custodian were addressed with the plant operator by the Battelle Study Lead. The shipment and receipt of all coolers by Battelle were recorded on a cooler tracking log.

Samples for metal analyses were stored at Battelle's inductively coupled plasma-mass spectrometry (ICP-MS) laboratory. Samples for other water quality analyses were packed in separate coolers and picked up by couriers from American Analytical Laboratories (AAL) in Columbus, OH and TCCI Laboratories in New Lexington, OH, or shipped to DHL Analytical in Round Rock, TX. The chain-of-custody forms remained with the samples from the time of preparation through analysis and final disposition. All samples were archived by the appropriate laboratories for the respective duration of the required hold time and disposed of properly thereafter.

3.5 Analytical Procedures

The analytical procedures described in Section 4.0 of the EPA-endorsed QAPP (Battelle, 2003) were followed by Battelle ICP-MS, AAL, DHL, and TCCI Laboratories. Laboratory quality assurance/quality control (QA/QC) of all methods followed the prescribed guidelines. Data quality in terms of precision, accuracy, method detection limit (MDL), and completeness met the criteria established in the QAPP (i.e., 20% relative percent difference [RPD], 80 to 120% percent recovery and 80% completeness). The quality assurance (QA) data associated with each analyte will be presented and evaluated in a QA/QC Summary Report to be prepared under separate cover upon completion of the Arsenic Demonstration Project.

Field measurements of pH, temperature, DO, and ORP were conducted by the plant operator using a WTW Multi 340i handheld meter, which was calibrated for pH and DO prior to use following the

procedures provided in the user's manual. The ORP probe also was checked for accuracy by measuring the ORP of the standard solution and comparing it to the expected value. The plant operator collected a water sample in a clean, plastic beaker and placed the WTW probe in the beaker until a stable value was obtained. The plant operator also performed free and total chlorine measurements using Hach chlorine test kits following the user's manual.

4.0 RESULTS AND DISCUSSION

4.1 Facility Description

Desert Sands MDWCA has been in operation as a non-profit association under the New Mexico Sanitary Projects Act since December 1978. At the time of this demonstration study, the governing board consisted of five members, and the staff members consisted of an office manager (Secretary of the Association), a full-time operator, a part-time customer service clerk, and a part-time contracted operator intern. Desert Sands MDWCA served its customers through an existing supply, storage, and distribution network covering an area of approximately four square miles of unincorporated area in Southern Dona Ana County. The water treatment facility was located approximately 2 miles north of Anthony, NM and serves an area generally situated between Interstate 10 on the east, NM 478 on the west, O'Hara Road on the south, and Ernesto Road on the north.

According to the *40 Year Water Plan* (Desert Sands MDWCA, 2002a) prepared for the water utility in 2002, Desert Sands MDWCA served 1,886 community members. It was projected that population in the Desert Sands MDWCA service area would increase by approximately 5,600 over a 40-yr planning period, assuming a median growth rate of 3.5%. The water production and use have fluctuated over the past several years with the peak production occurring in 1998 at 63,500,000 gal. In 2002, total water production and use were approximately 56,100,000 and 51,400,000 gal, respectively. Water loss percentages ranged from 6.3 to 14.1% during 1998 through 2002, with the lowest and highest loss occurring in 2002 and 1998, respectively.

4.1.1 Pre-existing System. The pre-existing system consisted of two production wells (Wells No. 2 and 3) with a combined capacity of 420 gpm, one 99,000-gal and one 240,000-gal storage tank, and approximately 30 miles of distribution piping. Figure 4-1 presents a map of the Desert Sands MDWCA delivery service area.

Prior to the installation of the STS arsenic removal system, the treatment plant consisted of Well No. 3 (located about 20 ft from the pump house), a pump house, and a drainage pond. Well No. 3 was screened from 690 to 740 ft below ground surface (bgs) with the static groundwater table at 45 ± 1 ft bgs. The well water was filtered through an in-line sand separator (shown along with Well No. 3 on Figure 4-2) and then fed into the pump house (see piping in the pump house on Figure 4-3). A pressure of 75 pounds per square inch (psi) was maintained through the system. The maximum daily production was approximately 259,000 gpd and the average daily production was 158,000 gpd.

Before entering the distribution system, 0.4 to 0.5 mg/L (as Cl_2) of NaOCl was added to the water using a peristaltic pump (Figure 4-4) for a target chlorine residual level of 0.3 mg/L (as Cl_2). The two storage tanks are filled with excess water from the distribution system.

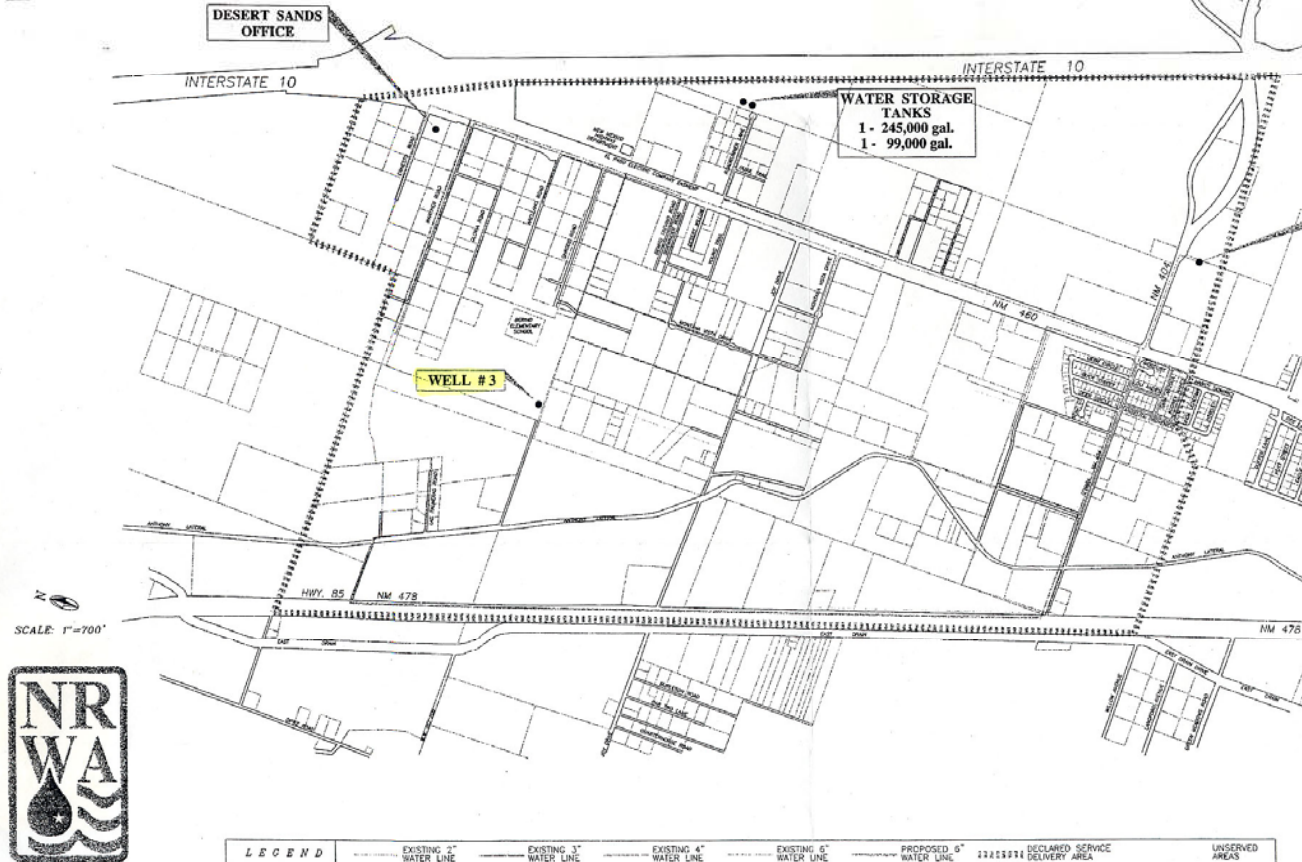
4.1.2 Source Water Quality. Source water samples were collected from Well No. 3 on August 20, 2003 and subsequently analyzed for the analytes shown in Table 3-3. The results of the source water analyses, along with those provided by the facility to EPA for the demonstration site selection and those independently collected and analyzed by EPA, are presented in Table 4-1.

Total arsenic concentrations in source water ranged from 17.0 to 22.7 $\mu\text{g/L}$. Based on the August 20, 2003 speciation sampling results, arsenic was present primarily as soluble As(III) (i.e., 96.9% at 21.6 $\mu\text{g/L}$), with only a small amount existing as soluble As(V) (i.e., 0.7 $\mu\text{g/L}$) and particulate As (i.e., 0.4 $\mu\text{g/L}$). Because As(V) adsorbs better with the SORB 33TM media, it was desirable to oxidize As(III) to As(V) before adsorption.

DESERT SANDS MUTUAL DOMESTIC WATER CONSUMERS ASSOCIATION DOÑA ANA COUNTY, NEW MEXICO



PROJECT LOCATION



PROJECT COST ESTIMATES

PHASE I COST ESTIMATES	
• NEW WELL	\$ 600,000
• WATER RIGHTS ACQUISITION	\$ 600,000
• DISTRIBUTION LINES	\$ 600,000
• EQUIPMENT	\$ 600,000
TOTAL PROJECT COST:	\$ 2,400,000

PHASE II COST ESTIMATES	
• WATER STORAGE	\$ 600,000
• WATER RIGHTS ACQUISITION	\$ 600,000
• DISTRIBUTION LINES	\$ 600,000
TOTAL PROJECT COST:	\$ 1,800,000

Figure 4-1. Map of Desert Sands MDWCA Service Area



Figure 4-2. Well No. 3 (Left) and In-Line Sand Separator (Center) Adjacent to Pump House (Right) at Desert Sands MDWCA Site



Figure 4-3. Piping Inside Pump House at Desert Sands MDWCA Site



Figure 4-4. Sodium hypochlorite (NaOCl) Injection System at Desert Sands MDWCA Site

pH values of source water ranged from 7.6 to 7.7, which was within the range recommended by STS. Therefore, pH adjustment was not recommended.

Iron levels in source water ranged from 38.9 to 73.0 $\mu\text{g/L}$; manganese levels ranged from 8.9 to 10.0 $\mu\text{g/L}$. At these levels, the vendor recommended not to pretreat iron and manganese prior to adsorption. Competing anions, such as orthophosphate and silica, were at levels sufficiently low (i.e., <0.065 to 0.1 mg/L and 34.6 to 35.1 mg/L, respectively) to not have a significant effect on arsenic adsorption by SORB 33TM media. Other analytes also were at levels low enough not to exert any impact on arsenic adsorption.

Although sulfide odor has been observed by the operator and by sampling personnel, sulfide was not detected at a detection limit of 0.05 mg/L. Additional samples were collected monthly during the demonstration study and analyzed for sulfide using a detection limit of 0.005 mg/L. The results are discussed in Section 4.4.1.

4.1.3 Distribution System. The Desert Sands MDWCA distribution system consists of a looped distribution line supplied by Wells No. 2 and No. 3. After chlorination, water from the two wells was pumped into the distribution system at two different locations, separated by approximately 2 miles. When the water production from the two wells exceeded the consumer demand, the excess flowed under pressure into the two storage tanks (i.e., Tank No. 2 at 75 ft tall by 15 ft in diameter, and Tank No. 3 at 86 ft tall by 22 ft in diameter) connected to the distribution system via 6- and 10-in-diameter polyvinyl chloride (PVC) pipe, respectively. The distribution system was constructed of PVC pipe, measuring approximately 30 miles in total length and varying from 2 to 10-in in diameter. The well pumps were activated by level sensors in the storage tanks, which signaled the pumps to turn on and off when the tank level reached a pre-set low and high level, respectively.

Table 4-1. Desert Sands MDWCA Well No. 3 Water Quality Data

Parameter	Unit	Utility Raw Water Data	EPA Raw Water Data	Battelle Raw Water Data
<i>Sample Date</i>		NA	09/24/02	08/20/03
pH	–	7.6	NA	7.7
Alkalinity (as CaCO ₃)	mg/L	240	185	188
Hardness (as CaCO ₃)	mg/L	152	NA	84
Chloride	mg/L	253	161	180
Fluoride	mg/L	NA	0.5	1.0
Sulfide	mg/L	NA	NA	<0.05
Sulfate	mg/L	158	180	190
Silica (as SiO ₂)	mg/L	NA	34.6	35.1
Orthophosphate (as P)	mg/L	<0.065	0.1	<0.10
TOC	mg/L	NA	NA	1.6
As (total)	µg/L	22.0	17.0	22.7
As (soluble)	µg/L	NA	NA	22.3
As (particulate)	µg/L	NA	NS	0.4
As(III)	µg/L	NA	NA	21.6
As (V)	µg/L	NA	NA	0.7
Fe (total)	µg/L	NA	73.0	38.9
Fe (soluble)	µg/L	NA	NA	<30
Al (total)	µg/L	NA	<25	27.2
Al (soluble)	µg/L	NA	NA	<10
Mn (total)	µg/L	NA	8.9	10.0
Mn (soluble)	µg/L	NA	NA	9.0
V (total)	µg/L	NA	NA	0.5
V (soluble)	µg/L	NA	NA	0.5
Mo (total)	µg/L	NA	NA	11.6
Mo (soluble)	µg/L	NA	NA	11.9
Sb (total)	µg/L	NA	<25	<0.1
Sb (soluble)	µg/L	NA	NA	<0.1
Na	mg/L	266	225	189
Ca	mg/L	43.0	26.3	27.2
Mg	mg/L	11.0	3.4	3.9

NA = not available; TOC = total organic carbon

Water from Wells No. 2 and No. 3 blended within the distribution system and the storage tanks. Desert Sands MDWCA has completed a modeling effort to examine the portions of the system served by the individual wells. The results of this modeling study were used to select distribution system sampling locations from areas that appear to be served by Well No. 3.

Desert Sands MDWCA sampled water periodically from the distribution system for several analytes: once a month for bacteria; once every three years for inorganics (such as heavy metals, cyanide, and F), volatile organic compounds (VOCs), and synthetic organic compounds (SOCs); and once every four years for radionuclides. Under the LCR, samples have been collected from customer taps at 20 locations every three years, with samples most recently collected in 2000. The monitoring results in 2002 (except for the LCR results that were reported in 2000) are summarized in Table 4-2. Desert Sands MDWCA's

**Table 4-2. Desert Sands MDWCA Distribution
System Water Quality Data**

Parameter	Units	Detected Level (Range)
Arsenic	µg/L	19 (10.4 to 19.3)
Barium	µg/L	52 (34.1 to 55.2)
Cadmium	µg/L	0.2 (0 to 0.2)
Chromium	µg/L	6 (3.3 to 5.5)
Copper ^(a)	µg/L	93 (2.8 to 103.5)
Nickel	µg/L	1 (0.54 to 1.2)
Lead ^(a)	µg/L	6 (0 to 6.9)
Selenium	µg/L	2 (1.1 to 1.6)
Thallium	µg/L	0.12 (0 to 0.12)

(a) Lead and copper data reported based on result of 20 samples collected on August 29, 2000.

Consumer Confidence Report (2002b) also included results for the contaminants that were monitored every three years for inorganics, VOCs, and SOCs, or four years for radionuclides.

4.2 Treatment Process Description

STS' APU systems are designed for arsenic removal for small systems with flowrates greater than 100 gpm. They use Bayoxide[®] E33 (branded as SORB 33[™] by STS), an iron-based adsorptive media developed by Bayer AG, for the removal of arsenic from drinking water supplies. Table 4-3 presents vendor-provided physical and chemical properties of the media. The SORB 33[™] media were delivered in a dry crystalline form and listed by NSF International under Standard 61 for use in drinking water applications. The media exist in both granular and pelletized forms, which have similar physical and chemical properties, except that pellets are denser than granules (i.e., 35 vs. 28 lb/ft³). Both granular and pelletized forms of the media were used at the Desert Sands MDWCA facility, with the granule form used in Media Run 1 and pelletized form used in Media Run 2.

STS provided an APU-300 system for the Desert Sands MDWCA site. Since the inception of the performance evaluation study in January 2004, difficulties were encountered in APU-300 system operation, including excessive flow restriction, imbalanced flow, and elevated Δp across the adsorption vessels and entire system. The system was retrofitted in May 2004 and details are described in Section 4.4.1.

Figure 4-5 is a simplified piping and instrumentation diagram (P&ID) of the system after the system retrofit. As shown in Figure 4-5, The APU-300 system consisted of two adsorption vessels, electrically actuated valve tree, and associated piping and instrumentation. Electrically actuated butterfly valves diverted raw water downward through the two adsorption vessels operating in parallel. As water passed through the fixed-bed adsorbers, arsenic concentrations were reduced to below 10 µg/L. When reaching 10-µg/L arsenic breakthrough, the spent media were removed and disposed of after being subjected to the EPA TCLP test. The design features of the APU-300 system are summarized in Table 4-4.

Four key process components are discussed as follows:

- **Intake and In-Line Sand Separation.** Raw water supplied from Well No. 3 passed through the in-line sand separator before it was chlorinated and fed into the APU-300 system.

Table 4-3. Physical and Chemical Properties of SORB 33™ Media

<i>Physical Properties</i>		
Parameter	SORB 33™-S	SORB 33™-P
Matrix	Iron oxide composite	Iron oxide composite
Physical Form	Dry granular media	Dry pelletized media
Color	Amber	Amber
Bulk Density (lb/ft ³)	28.1	35.0
BET Surface Area (m ² /g)	142	-
Attrition (%)	0.3	0.3
Moisture Content (%)	<15% (by weight)	<15% (by weight)
Particle Size Distribution (U.S. Standard Mesh)	10 × 35	14 × 18
Crystal Size (Å)	70	70
Crystal Phase	α – FeOOH	α – FeOOH
<i>Chemical Analysis</i>		
Constituents	Weight %	
FeOOH	90.1	
CaO	0.27	
SiO ₂	0.06	
MgO	1.00	
Na ₂ O	0.12	
SO ₃	0.13	
Al ₂ O ₃	0.05	
MnO	0.23	
TiO ₂	0.11	
P ₂ O ₅	0.02	
Cl	0.01	

Source: STS

- Chlorination.** The existing chlorination system was used to chlorinate source water with NaOCl. NaOCl was fed with a peristaltic pump at a location downstream of the in-line sand separator and upstream of the APU-300 treatment system. The peristaltic pump was synchronized with the well pump so that it operated only when the well pump was on. NaOCl dosage was controlled at 0.4 to 0.5 mg/L (as Cl₂) for a target chlorine residual level of 0.3 mg/L (as Cl₂). Actual dosages were monitored directly by measuring solution consumption rates in the chemical day tank and indirectly by measuring total and free chlorine residual levels at the AC sampling location, installed on a common feed line to the adsorption vessels, and at the TA, TB, and/or TT locations after the adsorption vessels.
- Arsenic Adsorption.** The APU-300 system was a fixed-bed down-flow adsorption system consisting of two 63-in-diameter, 86-in-tall vertical pressure vessels. The vessels were fiberglass reinforced plastic (FRP) construction, rated for 75 psi working pressure, skid mounted, and piped to a valve rack mounted on a polyurethane coated, welded frame. Each vessel was loaded with approximately 80 ft³ of SORB 33™-S or 62 ft³ of SORB 33™-P media supported by a gravel underbed. Loading of different volumes of media in the adsorption vessels were caused by different densities of the granular and pelletized media since the media were sold by weight rather than by volume. Empty bed contact time (EBCT) for the system was 3.7 and 2.9 min for the SORB 33™-S and SORB 33™-P media beds, respectively, based on a design flowrate of 320 gpm. Hydraulic loading to each vessel was approximately 7.4 gpm/ft².

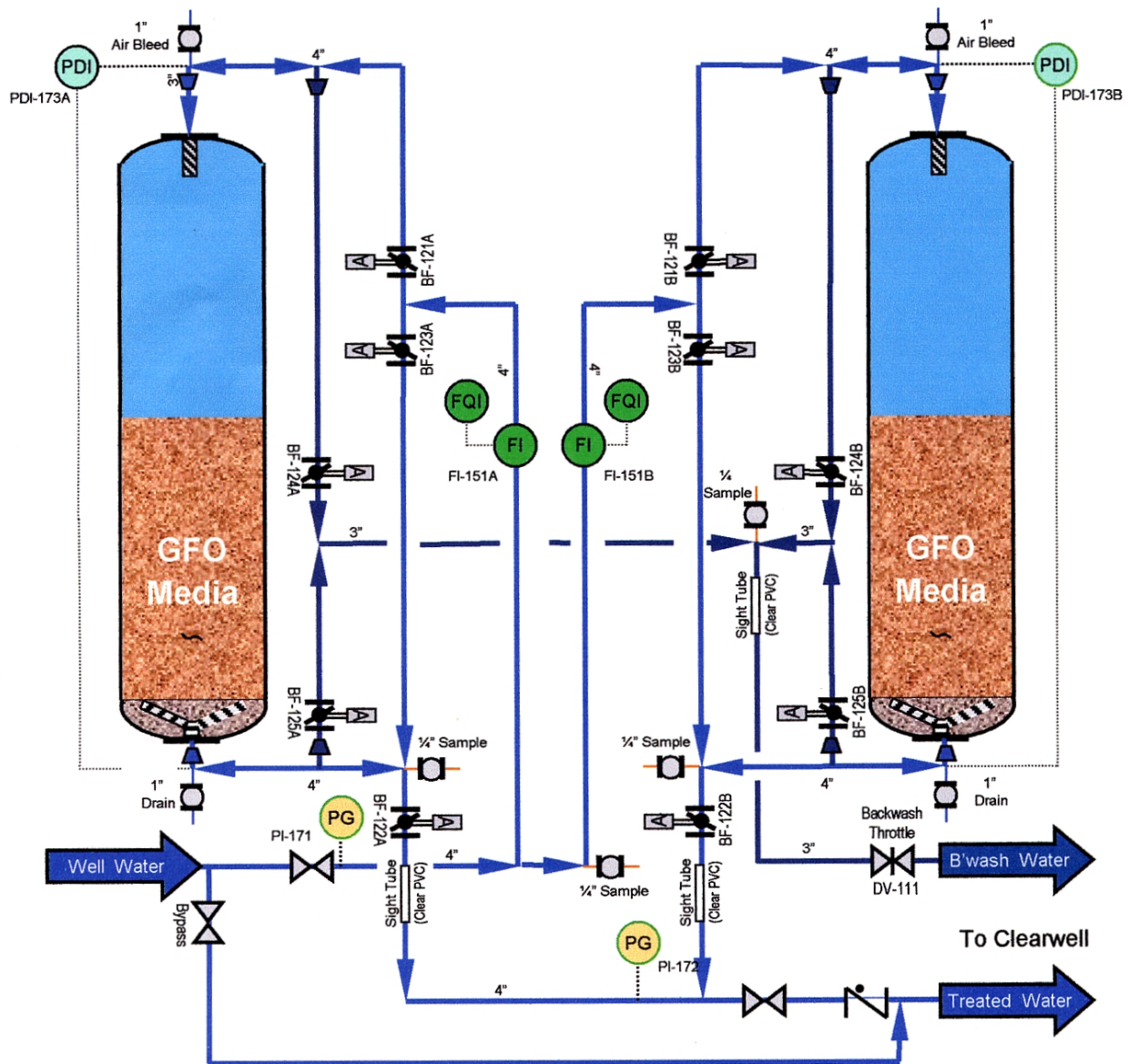


Figure 4-5. Schematic Diagram of STS APU-300 System after System Retrofit in May 2004

As illustrated in Figure 4-5, the two adsorption vessels were interconnected with schedule 80 PVC piping and 10 electrically actuated butterfly valves using a valve tree design (Figure 4-6). During normal operation, the feed valves (i.e., BF-121 A and B) and effluent valves (i.e., BF-122 A and B) were opened and the other six valves were closed to divert water downward through the two adsorption vessels. Flow through the two vessels was balanced by throttling the effluent valves, if needed. During backwash, the feed and effluent valves were closed and the backwash feed valves (i.e., BF-123 A and B) and backwash effluent valves (i.e., BF-124 A and B) were opened to divert water upward through the two adsorption vessels. During backwash rinse process, the feed valves (i.e., BF-121 A and B) and rinse valves (i.e., BF-125 A and B) were opened and the other six valves were closed to rinse the media with downward water flow.

Table 4-4. Design Specifications of APU-300 System

Parameter	Value	Remarks
Pretreatment		
Sand Separator	NA	Gravity separation
NaOCl Dosage (mg/L)	0.4–0.5	–
Adsorption Vessels and Media Beds		
Number of Adsorption Vessels	2	Parallel configuration
Vessel Size (in)	63 D × 86 H	21.6 ft ² cross-section
Type of Media	SORB 33 TM	Run 1: SORB 33 TM -S (granular) Run 2: SORB 33 TM -P (pelletized)
Media Volume (ft ³ /vessel)	80 (SORB 33 TM -S) 62 (SORB 33 TM -P)	–
Media Bed Depth (ft)	3.7 (SORB 33 TM -S) 2.9 (SORB 33 TM -P)	–
Service		
Design Flowrate (gpm/vessel)	160	320 gpm total
EBCT (min)	3.7 (SORB 33 TM -S) 2.9 (SORB 33 TM -P)	Based on design flowrate
Hydraulic Loading (gpm/ft ²)	7.4	Based on vessel cross sectional area of 21.6 ft ²
Average Use Rate (gpd)	345,600	Based on 320 gpm for 18 hr/day
Hydraulic Utilization (%)	75%	–
Estimated Working Capacity (BV)	66,000 85,200 ^(a)	Based on arsenic breakthrough at 10 µg/L
Estimated Breakthrough (1,000 gal)	79,000	Both vessels combined
Estimated Media Life (month)	7.6	Based on average use rate
Backwash		
Flowrate (gpm)	194 to 238	Recommended by STS
Hydraulic Loading (gpm/ft ²)	9 to 11	Recommended by STS
Frequency (time/month)	1	Manually or based on a Δp threshold
Duration (min/vessel)	20 to 25	–

(a) Estimated by assuming that SORB 33TM-S and -P media have similar adsorptive capacity.
NA = not applicable

Flow meters (+GF+SIGNET 8550 ProcessProTM Flow Transmitter) installed in the supply line of each adsorption vessel monitored instantaneous flowrates through the vessels. The flowmeters also tracked the volume of water treated in each vessel. Δp readings across each vessel were monitored by differential pressure gauges (WIKA Differential Pressure Gauge). The adsorption vessels were backwashed sequentially whenever the Δp across one vessel reached 10 psi. System controller (Figure 4-6) controlled the operation of the actuated valve tree for the adsorption, backwash, and forward fast rinse cycles.

- **Backwash.** STS recommended that the SORB 33TM media be backwashed monthly using raw water to loosen up the media bed, and remove particulates and media fines accumulating in the beds. The APU-300 system was designed and programmed with an automatic backwash feature that would place the vessels into backwash based on a set timer or when the Δp across a vessel had reached 10 psi. The backwash wastewater was directly discharged into a drainage pond adjacent to the treatment facility (Figure 4-7).



Figure 4-6. Treatment Process Components
 (*APU-300 System Valve Tree [top left and middle]; Backside of System Piping including Vessel Flow Meter Sensors [top right]; Sampling ports [middle]; and Control Panel [bottom]*)

4.3 System Installation

The installation of the APU-300 system, as originally designed with the use of a diaphragm valve, a Fleck valve controller along with a riser tube, and an orifice plate for each vessel, was completed in December 2003, with shakedown and startup activities continuing into January 2004. The system installation and building construction activities were carried out by the plant operator as a subcontractor to STS.

4.3.1 Permitting. Engineering plans for the system permit application were prepared by Bohannon Huston, an STS subcontractor located in Las Cruces, NM. The plans included diagrams and specifications of the APU-300 system, as well as drawings detailing the connections of the new unit to the



Figure 4-7. Backwash Wastewater Discharge into Pond

existing facility. After incorporating comments from Desert Sands MDWCA and Battelle, the plans were submitted by Desert Sands MDWCA to the New Mexico Environmental Department (NMED) Drinking Water Bureau for review and approval on November 18, 2003. The NMED issued a letter of approval on December 22, 2003, requiring that Desert Sands MDWCA flush and disinfect the system and associated plumbing, and retain negative results from bacteriological sampling prior to sending treated water to the distribution system.

4.3.2 Building Construction. Desert Sands MDWCA constructed an addition to its existing pump house at Well No. 3 to house the APU-300 system. The structure measures 15 ft × 15.5 ft at the base (232.5 ft²) with a total height of 12 ft, and consists of a concrete floor, a steel frame, insulated steel siding and roofing, and a walk-through door. The structure is just large enough to house the APU-300 system and the inlet and outlet plumbing. A photograph of the new structure, adjacent to the existing block pump house, is shown in Figure 4-8.

The building construction began on October 30, 2003, as the concrete pad was poured. After the system was placed on the pad, work on the frame and roof began on December 23, 2003 and was completed on January 5, 2004. Installation of the siding and insulation was completed by January 23, 2004.

4.3.3 System Installation, Shakedown, and Startup. The APU-300 system was delivered to the site on December 1, 2003. The plant operator, subcontracted to STS, performed the off-loading and installation of the system, including connections to the existing entry and distribution piping (Figure 4-9). Figure 4-10 shows the APU-300 system before the building enclosure was built around it. Figure 4-11 shows the media loading to the adsorption vessels. The system installation and media loading were completed and the system shakedown and startup commenced on December 11, 2003.

During system shakedown, it was observed that the system could produce no more than 40 gpm of flow in either the service or backwash mode, and that under-sized orifice plates had caused the unwanted flow restriction. The opening of the orifice plates had to be enlarged in an STS shop and repeatedly tested



Figure 4-8. Pump House (right) and System Enclosure



Figure 4-9. APU-300 System Being Connected to Distribution System

onsite from 0.5 to 1.5 in (on January 8, 2004) and then to 1.875 in (on January 15, 2004) in order to achieve the 150-gpm/vessel target flowrate in the service mode and 160 gpm/vessel in the backwash mode. Moreover, while operating at 320 gpm, the system experienced a pressure loss of 18 psi across the system, which was significantly higher than the STS specified value of less than 8 psi. The pressure loss across the adsorption vessels and the associated diaphragm valves, Fleck valve controllers, and orifice plates also was elevated, exceeding the maximum value of the Δp gauge readouts (i.e., 15 psi). Because of this elevated pressure loss (which was higher than the would-be set point of about 15 psi for triggering the automatic backwash), the pressure-actuated automatic backwash feature at the control panel had to be disabled to avoid the system operating in a constant backwash mode.



Figure 4-10. APU-300 System before Building Enclosure was Built



Figure 4-11. Media Loading to Adsorption Vessels

Under the conditions described above, the performance evaluation study officially began on January 16, 2004. Battelle provided operator training on data and sample collection and collected the first set of samples from the APU-300 system.

4.4 System Operation

Table 4-5 presents timelines of key activities/events that occurred during the system performance evaluations. These demonstration activities are described in more details in the following sections.

4.4.1 System Retrofit. In addition to the problems identified during shakedown and startup, several operational difficulties were encountered following commencement of the evaluation study, including one incident on February 3, 2004 when the flow through Vessel A decreased to 40 gpm and the system inlet pressure increased to 100 psi. At the request of Battelle, STS performed a series of hydraulic testing on three similar systems: one that was located at STS' Torrance, CA shop and ready to be shipped to the Queen Anne's County site in Maryland and two that were installed in Brown City, MI, and experiencing similar operational problems (i.e., restricted and imbalanced flow and elevated pressure losses).

Table 4-5. Demonstration Study Activities and Completion Dates

Activity/Event	Date
APU-300 System Performance Evaluation Began	January 16, 2004
Final Study Plan Issued	January 19, 2004
Building Construction Completed	January 23, 2004
STS Performed Aggressive Backwash on Both Vessels to Troubleshoot High Δp Issues	February 19, 2004
STS Collected Media Samples	February 26, 2004
STS Installed 3-in-diameter Bypass Line around Fleck Valve Controllers	March 8 to 9, 2004
System Retrofit with Valve Tree Plumbing Installed	May 16 to 24, 2004
STS onsite to troubleshoot and conduct a backwash	January 6, 2005
STS on Site to Perform Repairs and Re-program PLC	April 4 to 5, 2005
Media Changeout (switch from granular SORB 33™-S to pelletized SORB 33™-P)	July 27, 2005
STS Onsite for Troubleshooting and Media Sampling	October 27 to 28, 2005
APU-300 System Performance Evaluation Completed	August 17, 2006
APU-300 Property Transfer Completed	August 25, 2006

APU = arsenic package unit; PLC = programmable logic controller;
STS = Severn Trent Services

Before reaching a decision to perform hydraulic testing, STS suggested that the operational problems encountered might have been caused by:

- (1) Damaged media – media crushed by zero to 300 gpm flow swings after flow restrictors had been temporarily removed from the system to troubleshoot the flow restriction problem during the initial startup,
- (2) Insufficient backwash flowrates – due to the use of restrictor plates, and
- (3) Clogged top distributors and/or bottom laterals.

As part of its investigative work, STS performed more aggressive backwashes on both vessels and collected media samples for particle size distribution analyses on February 19 and 26, 2004, respectively. On March 8, 2004, STS installed a 3-in-diameter bypass line around the Fleck valve controller on each vessel with the intent to decrease the pressure loss and increase backwash flowrate. These efforts,

however, did not help resolve the problems, and the results of the particle size distribution analyses did not appear to support the speculation concerning media damage. These observations led STS to focus its investigative work on the design and construction of system plumbing.

Hydraulic testing on the two APU-300 systems at Brown City, MI, was conducted on March 19, 2004, with no media loaded in the vessels. While operating the system at 103 to 115 gpm/vessel (versus the design value of 160 gpm/vessel), a pressure loss of 7 to 8 psi was observed across each vessel, and 24 to 26 psi across the entire system. These results suggested that the system plumbing most likely was the source of high pressure losses, and that the media mostly likely was not responsible for the difficulties encountered at Desert Sands MDWCA. Replacement of the restrictive orifices from 1.25 to 1.875 in (as was used for the Desert Sands MDWCA system) did not solve the elevated pressure loss problems. Additional hydraulic testing was therefore conducted at Brown City, MI and STS' Torrance, CA facility in mid-April 2004. Table 4-6 summarizes the test results collected at Brown City, MI, Torrance, CA, and Anthony, NM.

Pressure profile data were collected across the systems at Brown City, MI and the Torrance, CA facility. As listed in Table 4-6 and shown in Figure 4-12, the major system components across each of the two parallel treatment trains included piping inlet, an automatic variable diaphragm valve (to control flow), a strainer, a programmable Fleck valve controller (to control flow from a service to backwash mode), an FRP vessel with a top diffuser and a bottom lateral, a restrictive orifice plate, and outlet piping. Pressure gauges were across the treatment train so that a complete pressure profile might be established. Δp readings as measured at Desert Sands MDWCA included those across the strainer, Fleck valve controller, and vessel, which was equipped with a top diffuser and a bottom lateral and loaded with 80 ft³ of media supported by 14 ft³ of under bedding.

The results of the Brown City testing on April 6, 2004 showed that, after removing the restrictive orifice plate, strainer, and top diffuser, pressure losses were observed across the variable diaphragm valve (from 80 to 71 psi) and valve controller and bottom laterals (from 61 to 58 psi). These results were consistent with those observed during the April 8, 2004 testing at Torrance, CA, except for the 1-psi loss (from 44 to 43 psi) across the variable diaphragm valve. It was not clear what had caused the 11 psi loss across the variable diaphragm valve at Brown City; one possible explanation was that the valve was partially throttled during the testing. The pressure loss across the Fleck valve controller, strainer, top diffuser, and bottom laterals at Torrance, CA was 13 psi (from 43 to 30 psi), identical to that found at Brown City, MI. Furthermore, the pressure loss across the top diffuser and bottom lateral was 1 psi (from 34 to 33 psi), indicating little or no loss across these system components.

The test results at Brown City, MI and Torrance, CA were further confirmed during a separate test in Torrance, CA on April 14, 2004, which showed no loss across the variable diaphragm valve, 1 psi loss (from 54 to 53 psi) across top diffuser and bottom lateral, 13 psi loss (from 64 to 50 psi and less 1 psi across the top diffuser and bottom lateral) across the Fleck valve controller, and possibly 20 psi across the restrictive orifice plate (see the 20 psi increase at the inlet after restrictive orifice was restored to the system in Table 4-6). It was therefore evident that the main sources of the pressure loss originated from the Fleck valve controller and restrictive orifice plate.

Upon completion of the hydraulic testing, STS recommended four options to address the problems at Desert Sands MDWCA (and Brown City):

- (1) Replace the submersible pump by the host site,
- (2) Install a booster pump,
- (3) Run the existing submersible pump for longer periods each day, or
- (4) Retrofit the STS system.

Table 4-6. Results of Hydraulic Testing of STS APU-300 Systems

Site	Date	Vessel	Flowrate (gpm)	Pressure (psi)						ΔP (psi)		System Components								
				P1	P2	P3	P4	P5	P6	Vessel ^(a)	System	Variable Diaphragm Valve	Valve Controller	Strainer	Vessel					
															Top Diffuser	Media	Underbedding	Bottom Laterals	Restrictive Orifice	
<i>Before System Retrofitting</i>																				
Desert Sands MDWCA, NM	02/10/04	A	120	84					54	>15	30	✓	✓	✓	✓	✓	✓	✓	✓	
		B	180	84					54	>15	30	✓	✓	✓	✓	✓	✓	✓	✓	✓
Brown City, MI	03/19/04	A (unit 1)	115	82					58	7	24	✓	✓	✓	✓			✓	✓	
		B (unit 1)	113	82					58	8	24	✓	✓	✓	✓			✓	✓	
		A (unit 2)	105	84					58	8	26	✓	✓	✓	✓			✓	✓	
		B (unit 2)	113	84					58	8	26	✓	✓	✓	✓			✓	✓	
	04/06/04	A	160	80	71	61			58	58	13	22	✓	✓					✓	
		B	160	80	71				58	58	13	22	✓	✓					✓	
Torrance, CA	04/08/04	A	150	44	43	34	33	30	30	13	14	✓	✓	✓	✓				✓	
		B	150	44					30	13	14	✓	✓	✓	✓				✓	
	04/14/04	A	158	64	64	54	53	50		14	NA	✓	✓	✓	✓				✓	
<i>After System Retrofitting</i>																				
Torrance, CA	04/20/04	A	165	23		22	19		19	3	4								✓	
		B	165	52		51	50		50	1	2								✓	
		A	170	34		33	30		30	3	4								✓	
		B	155	34		34	33		30	1	4								✓	
Brown City, MI	04/29/04	A	190	62					58	0	4								✓	
		B	190	62					58	0	4								✓	
Desert Sands MDWCA, NM	05/24/04	A	140	66					60	3	6			✓	✓	✓	✓	✓	✓	
		B	135	66					60	3	6			✓	✓	✓	✓	✓	✓	

P1 = at system inlet
 P2 = after variable diaphragm valve and before entering strainer, valve controller, and vessel
 P3 = at top of vessel
 P4 = at bottom of vessel
 P5 = after vessel and valve controller and before entering restrictive orifice (if present)
 P6 = at system outlet

ΔP across vessel (including valve controller) = P2 – P5
 ΔP across vessel = P3 – P4 (after retrofitting)
 ΔP across system (treatment train) = P1 – P6
 (a) Including valve controller before system retrofitting

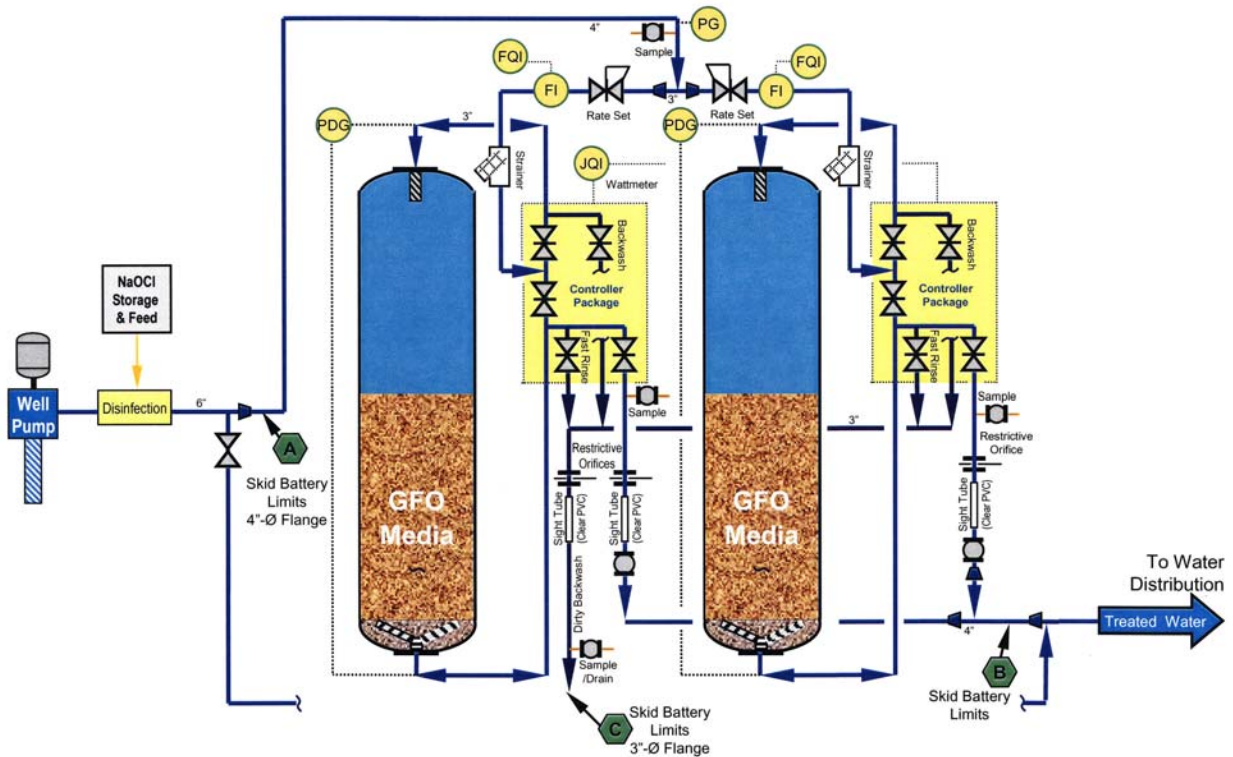


Figure 4-12. Schematic Diagram of STS APU-300 System before System Retrofit

After reviewing the pros and cons of each option, Battelle recommended and STS agreed to retrofit the APU-300 systems at both the Desert Sands MDWCA and Brown City sites. The changes included replacement of the 3-in-diameter pipe with 4-in-diameter pipe; removal of the diaphragm valves, restrictive orifice plates, and Fleck valve controllers; and installation of a nested network of fully-ported actuated butterfly valves and a new control panel. A schematic diagram of the new system design is presented in Figure 4-5.

The test results collected at Torrance, CA, Brown City, MI, and Desert Sands MDWCA, NM after the system retrofit are presented in Table 4-6. With the Torrance, CA and Brown City, MI systems operating at 155 to 190 gpm without media or underbedding loaded in the vessels, the pressure losses across the vessel (along with bottom laterals) and the system were 0 to 3 and 2 to 4 psi, respectively. The system was returned to service on May 24, 2004 with the modified pipe design, a new upper distributor, and new control panel in place. STS measured the freeboard as the new upper distributors were being installed, observing between 16.25 and 16.5-in in each vessel. Startup testing of the retrofitted unit showed a pressure loss across the media-filled vessels of 3 psi, and a total pressure loss across the system of 6 psi.

4.4.2 Operational Parameters. The operational parameters for the entire performance evaluation study are tabulated and attached as Appendix A. Key parameters are summarized in Table 4-7. The APU-300 system was evaluated with two forms of SORB 33™ media, with the first media run using the granular form and the second media run using the pelletized form. The first media run operated from January 16, 2004, through July 14, 2005. The second media run operated from July 29, 2005, through August 16, 2006. Relevant system operational parameters are discussed in detail below.

Table 4-7. Summary of APU-300 System Operation

Parameter	First Media Run (SORB 33™-S)					Second Media Run (SORB 33™-P)		
	01/16/04–05/16/04 (before Retrofit)		05/24/04–07/14/05 (after Retrofit)		01/16/04 – 07/14/05 (Combined)	07/29/05–08/16/06		
Cumulative Operating Time (hr)	493		2,745		3,238	3,004		
Average Daily Operating Time (hr)	4.3		6.6		6.2	7.8		
Component	Vessel A	Vessel B	Vessel A	Vessel B	System	Vessel A	Vessel B	System
Throughput (1,000 gal)	3,442	4,433	22,803	21,967	52,645	22,719	23,834	46,553
Bed Volumes of Water Treated (BV)	5,737	7,388	38,005	36,612	43,871	48,963	51,366	50,165
Average Flowrate (gpm) ^(a)	116	150	138	133	271	121	130	251
Range of Flowrate (gpm) ^(b)	110– 150 ^(b)	140– 180 ^(b)	90–190 ^(b)	80–175 ^(b)	205–300 ^(c)	75–170 ^(b)	75– 185 ^(b)	225–275 ^(c)
Average EBCT (min) ^(d)	5.2	4.0	4.3	4.5	NA	3.8	3.6	NA
Range of EBCT (min) ^(e)	4.0–5.4	3.3–4.3	3.1–6.6	3.4–7.5	NA	2.7–6.2	2.5–6.2	NA
Differential Pressure Across Vessel (psi)	>20	>20	2.5–15 ^(f)	2.5–15 ^(f)	NA	2.0–11	2.0–11	NA
System Pressure Loss (psi)	NA	NA	NA	NA	4–30 ^(f)	NA	NA	2–26
Number of Backwashes	6	6	60	63	NA	50	53	NA
Backwash Interval (day)	1–49	7–35	1–37	1–20	NA	1–18	1–26	NA

(a) Calculated based on cumulative throughput and corresponding operating time.

(b) Based on the instant flowrates measured at Vessels A and B.

(c) Calculated based on the daily operation time and daily throughput measured by the master flowmeter at the wellhead.

(d) Based on the average flowrate; and 80 ft³ and 62 ft³ of media per vessel during the first and second media runs, respectively.

(e) Based on the instant flowrates measured at Vessels A and B; and 80 ft³ and 62 ft³ of media per vessel during the first and second media runs, respectively

(f) For all measurements, except one outlier measured on July 11, 2005.

NA = not applicable

First Media Run. The first media run began on January 16, 2004. Difficulties were encountered during the initial four months of operation, and the system was retrofitted (Section 4.4.1) and returned to service on May 24, 2004. The first media run ended on July 14, 2005. The first media run operated for a total of 3,238 hr based on the well pump hour meter readings collected daily at the wellhead. This operational time represented a utilization rate of approximately 26%, or 6.2 hr/day. The low utilization rate was due primarily to relatively low water demand and the concurrent use of another well, Well No. 2, to supply water to the distribution system.

The first media run treated approximately 52,645,000 gal of water, with 49.9 and 50.1% of water flowing through Vessels A and B, respectively, based on totalizer readings from both vessels. This amount is 4% higher than that (50,712,000 gal) recorded from the master flow meter at the wellhead. Significant imbalance flow was observed between the two vessels before the system retrofit, with 43.7 and 56.3% flowing through Vessels A and B, respectively. The problems associated with the imbalanced flow were resolved after system retrofit, with 50.9 and 49.1% flowing through Vessels A and B, respectively, throughout the remainder of the first media run.

Figure 4-13 (left graph) presents instantaneous flowrates measured at Vessels A and B during the first media run. The imbalance flow before system retrofit was reflected in Figure 4-13, with flowrates through Vessel B significantly higher than those through Vessel A. This trend of constantly higher flow through Vessel B discontinued after system retrofit. The total flow through the APU-300 system remained relatively constant throughout the first media run at 266 and 271 gpm before and after retrofit, respectively (or 83.1 and 84.7% of the design value of 320 gpm). Because the imbalanced flow problem occurred before retrofit, EBCT values varied significantly between the two vessels, averaging at 5.2 min for Vessel A and 4.0 min for Vessel B. After retrofit, the difference in EBCT reduced significantly, with EBCT averaged 4.3 min for Vessel A and 4.5 min for Vessel B. The average EBCT was calculated based on total throughput and total operating hours.

Figure 4-14 (left graph) presents Δp readings measured across Vessels A and B during the first media run. Before system retrofit, the APU-300 system experienced elevated Δp across both vessels with readings that pegged the pressure gauges with graduations up to 20 psig. Δp readings across the entire system based on the difference between the pressure readings at the system inlet and outlet fluctuated from approximately 18 to more than 30 psig during this period. After system retrofit, Δp readings across each vessel reduced to as low as 2.5 to 6 psig from most measurements immediately after backwash. Similar to imbalanced flow problems, the problems associated with high Δp were solved with system retrofit.

Second Media Run. The second media run began on July 29, 2005 and ended on August 16, 2006, operating for a total of 3,004 hr based on well pump hour meter readings collected daily at the wellhead. The operational time represented a utilization rate of approximately 32.5%, or 7.8 hr/day.

The second media run treated approximately 46,553,000 gal of water, with 48.8 and 51.2% flowing through Vessels A and B, respectively, based on totalizer readings from both vessels. This amount was almost identical to that (i.e., 46,580,000 gal) recorded from the master flow meter at the wellhead. Figure 4-13 (right graph) presents instantaneous flowrates measured at Vessels A and B during the second media run. The two flowrate curves fluctuated slightly but essentially overlapped each other at 120 to 130 gpm throughout the run. The averaged total flow through the APU-300 system was 251 gpm, or 78.4% of the design value. The average EBCT was 3.8 min for Vessel A and 3.6 min for Vessel B, which is 31 to 24% higher than the design value of 2.9 min.

Figure 4-14 (right graph) presents Δp readings measured across Vessels A and B during the second media run. In most cases, Δp readings across each vessel immediately after backwash ranged from 2 to 5 psig, which were slightly lower than those measured during the first media run. The lower readings observed

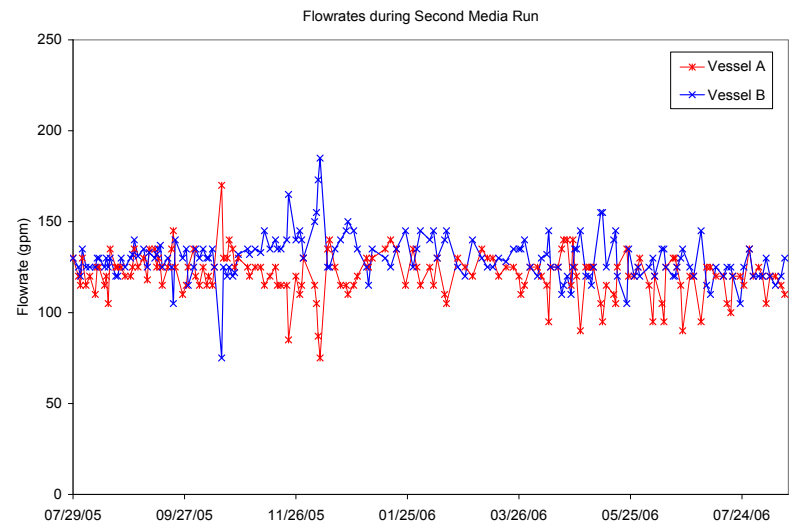
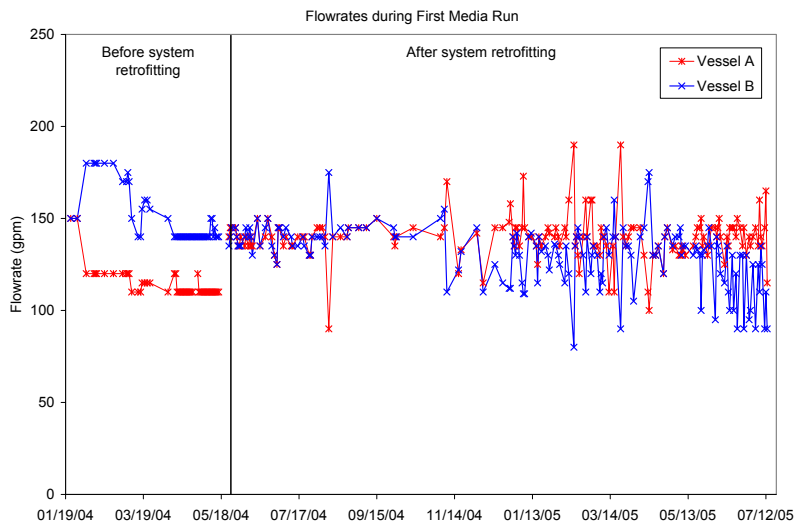


Figure 4-13. Flowrate Measurements for First (Left) and Second (Right) Media Runs

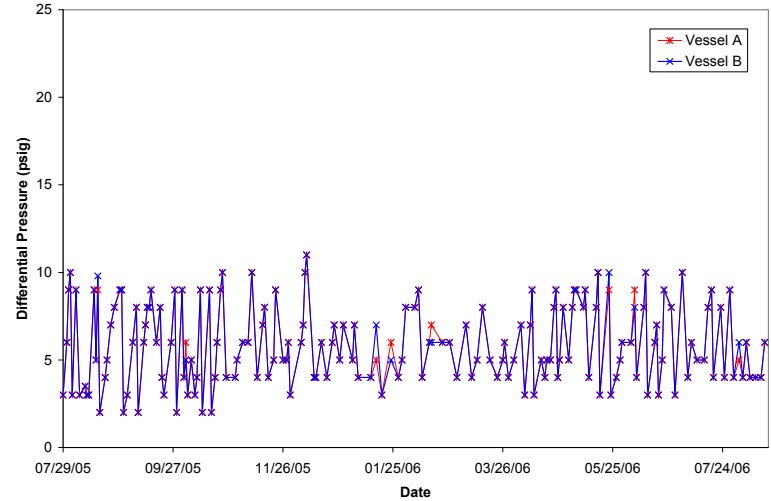
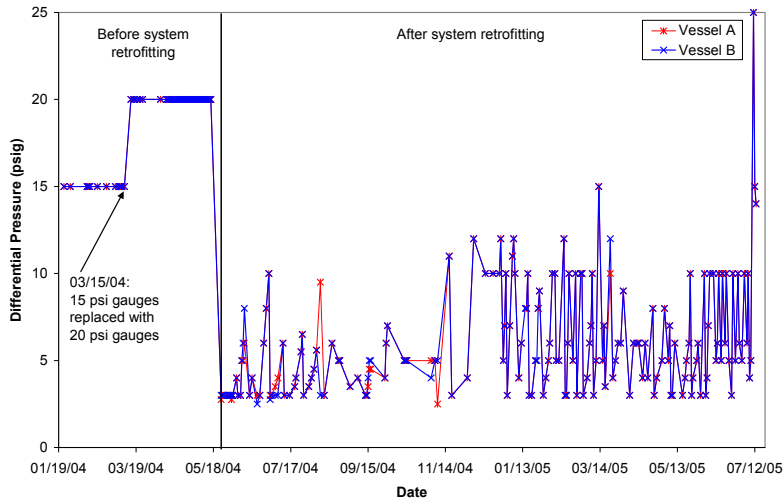


Figure 4-14. Differential Pressure across Vessels A and B during First (Left) and Second (Right) Media Runs

probably were due the somewhat larger media size and shorter bed depth associated with the use of pelletized media.

4.4.3 Media Loss and Breakdown. A significant amount of media were lost from the adsorption vessels during both media runs. The amount of loss was measured based on the freeboard measurements performed during media changout (Table 4-8). During the first media run, 42.1% and 45% of the granular media was lost from Vessels A and B, respectively. Apparently, the loss occurred throughout the run rather than during any specific period, according to the periodic freeboard measurements carried out on May 24, 2004, January 6, April 5, and July 25, 2005. Some of the other demonstration sites using SORB 33TM-S also experienced media loss, including about 50% during each of two media runs at Rollinsford, NH (Cumming et al., 2008) and at least 14 to 18% during the first 13 months of operation at Queen Anne’s County, MD (Chen et al., 2008). The media loss problem improved significantly after switching to the pelletized media, as evidenced by the 12% media loss (with a total throughput of 46,550,000 gal), which was one third of that lost in the first media run (with a total throughput of 52,650,000 gal). This was consistent with the vendor’s claim that the pelletized media was somewhat more robust than the granular media. Because the pelletized media were 25% denser, loading a similar weight of the pelletized media resulted in 25% less bed depth, thus yielding more freeboard in the vessels. The less media loss also could have been caused by less wash-away of media or media fines during backwash (assuming similar backwash flowrates) due to the presence of the 0.8-ft more freeboard in the adsorption vessels.



Table 4-8. Freeboard Measurements and Media Loss

First Media Run Granular			Second Media Run Pelletized		
Parameter	Vessel A	Vessel B	Parameter	Vessel A	Vessel B
Volume Loaded (ft ³)	80.0	80.0	Volume Loaded (ft ³)	62.0	62.0
Initial Freeboard (in) (May 24, 2004)	16.3	16.5	Initial Freeboard (in) (July 28, 2005)	24.0	24.0
Freeboard (in) (January 6, 2005)	25.3	24.0	Freeboard (in) (October 27, 2005)	24.0	23.5
Freeboard (in) (April 5, 2005)	32.0	30.5	Final Freeboard (in) (September 12, 2006)	NM	28.0
Final Freeboard (in) (July 25, 2005)	35.0	36.5	NA	NA	NA
Total Media Loss (in)	18.7	20.0	Total Media Loss (in)	NM	4.0
Total Media Loss (ft ³)	33.7	36.0	Total Media Loss (ft ³)	NM	7.2
Total Media Loss (%)	42.1	45.0	Total Media Loss (%)	NM	11.6

NA = not applicable; NM = not measured

Weak physical integrity might have contributed to media loss observed. Sieve analyses conducted by STS indicated that the granular media was breaking down as the run went by. As shown in Table 4-9, the samples collected from Vessel B at a depth of 16 in on July 2005 (or 18 months after system startup) had fewer large particles (i.e., 30% instead of 40% $\geq 1,180 \mu\text{m}$) and a larger amount of fines (i.e., 35% instead of 25% $\leq 550 \mu\text{m}$) when compared to the virgin granular media. The media breakdown might be linked to frequent or improper backwash (such as the use of excessive backwash loading rates), which is further discussed in Section 4.4.4.

Table 4-9. Particle Size Distribution of Granular Media before System Startup and during First Media Run

Sieve Size	January 2004 Virgin Media Collected before System Startup	July 2005 Used Media Collected from Vessel B ^(a)
		
U.S. Standard Mesh (µm)	(%)	(%)
+16 (>1,180)	40	30
+30 (>550)	75	65
-30 (<550)	25	35

(a) Collected at a depth of 16 in.

Note: Sieve analyses conducted by STS.

4.4.4 Backwash. STS recommended the SORB 33™ media be backwashed manually or automatically approximately once per month to loosen up the media bed. Automatic backwash could be initiated either by a timer or a Δp setting. However, due to faster than anticipated increase in Δp during system operation, backwash was conducted far more frequently than was originally anticipated. A brief description of the backwash events follows:

First Media Run. Due to the high Δp problems encountered, backwash was conducted only manually before system retrofit in mid-May 2004. During the first 17 weeks of operation leading to system retrofit, backwash was conducted seven times for Vessel A and eight times for Vessel B. After system retrofit, backwash took place either automatically based on a 10-psi Δp setting or manually when backwash wastewater sampling was required.

Backwash was performed 59 times for Vessel A and 62 times for Vessel B during the remaining 14 months of the first media run. The throughput between two consecutive backwash events is presented in Figure 4-15 (top). After system retrofit, the throughput between backwash events for Vessels A and B decreased during the first four months from over 1,250,000 (2,090 BV) and 2,200,000 gal (3,680 BV), respectively, to around 500,000 gal (840 BV) in mid-September 2004. The throughput further reduced to and then leveled off at an average of around 375,000 gal (630 BV) for both Vessels A and B.

Second Media Run. Backwash was conducted 51 times for both Vessels A and B during the second media run, which lasted for about 12 months. Similar to the first media run, backwash was conducted either automatically based on a 10-psi Δp setting or manually when backwash wastewater sampling was needed. The throughput between two consecutive backwash events for the second media run is presented in Figure 4-15 (bottom). Throughput values between backwash events fluctuated widely between 1,300,000 and 150,000 gal and showed no noticeable trend of increasing or decreasing throughout the run. The averaged throughput between backwash events was 454,000 gal (760 BV) for Vessel A and 476,000 gal (800 BV) for Vessel B. These average throughput values were 1.2 to 1.6 times higher than that recorded in the first media run. The improved physical integrity of the pelletized media might have contributed to the higher throughput between backwash events observed during the second media run.

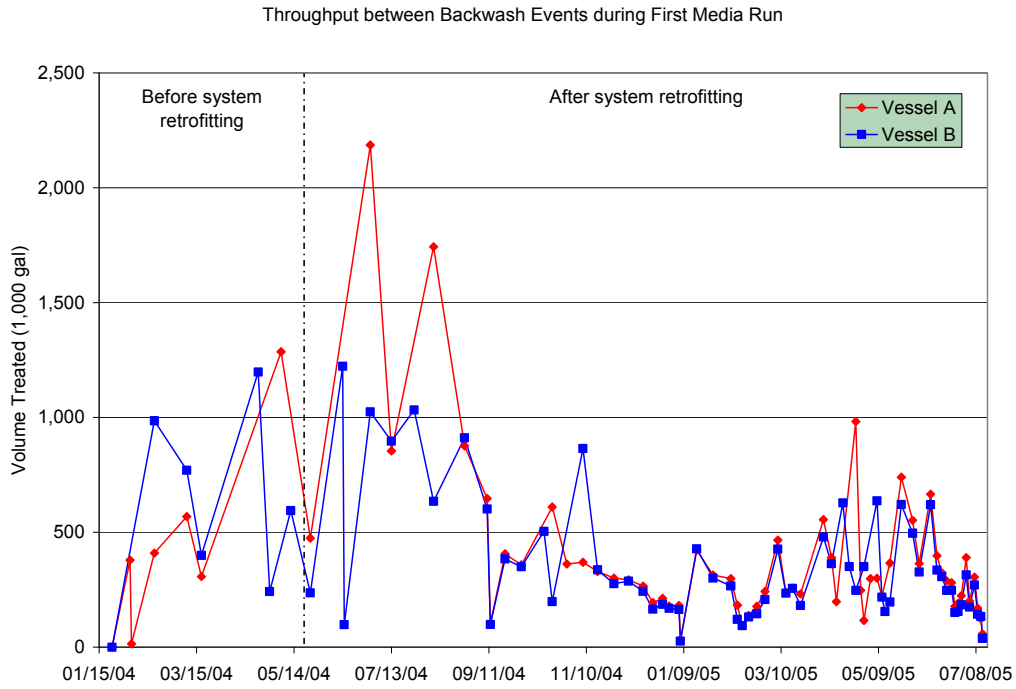


Figure 4-15. Throughput Between Backwash Events During First (Top) and Second (Bottom) Media Runs

The backwash was performed at flow rates typically ranging from 200 to 220 gpm. Each backwash event lasted typically for 20 min, followed by a four-min rinse, producing approximately 4000 to 5000 gal of water per vessel during each backwash event. Due to the cycles of water demand, automated backwash events typically took place overnight, when the operator was not present.

4.4.5 Media Changeout. During the performance evaluation study, one media changeout was performed by STS on July 27, 2005. Before spent media removal, the heights of the freeboard (i.e., from the flange at the top of the vessels to the media surface) were measured as recorded in Table 4-8. The spent SORB 33™-S media then was sampled and removed from each vessel as described in Section 3.3.4. A vacuum truck was used to remove the spent media and the gravel underbedding. Vacuum removal of the media was paused in each vessel to allow for the collection of spent media samples from the lower portion of the bed in each vessel. After the spent media and gravel were completely removed, the vessels were rinsed, new bottom laterals were installed, and the bottom flanges were reconnected. Each vessel was then half filled with chlorinated water. New gravel was added to each vessel, followed by virgin media, in the pelletized form. All gravel and media were added to the vessels through the 3-in diameter top flange. The vessels were then completely filled with chlorinated water with air bled from the top of each vessel, and the media was allowed to soak overnight. After the media were properly backwashed and freeboard measurements obtained, the system was returned to service.

Spent SORB 33™-P samples also were collected by Desert Sands MDWCA during media removal on September 11, 2006, although the media were not replaced at this time due to the completion of the demonstration study.

4.4.6 Residual Management. Residuals produced by the operation of the APU-300 system included backwash wastewater and spent media. Above ground piping for backwash wastewater from both vessels was combined before extending outside the building below the base of the wall. Backwash wastewater was discharged into an evaporation pond, where water either evaporated to the air or infiltrated into the ground (Figure 4-7). Particulates carried in the backwash wastewater remained in the pond.

4.4.7 System Operation Reliability and Simplicity. The overall system reliability and simplicity were examined both before and after system retrofit in May 2004. Aside from the excessive pressure losses and imbalanced flow prior to the system retrofit, the only other O&M issue encountered was the temporary failure of digital flow meters on the vessels on two separate occasions for one to two days at a time. After approximately two years of system operation after retrofit, two of the actuated valves (121-A and 123-A) began to stick and had to be replaced with Asahi Type 57 butterfly valves and Asahi Type 94 actuators in September 2006.

Unscheduled downtime during the first media run was caused by the need to address elevated pressure losses and imbalanced flows (Section 4.4.1). The system was shut down on February 19, 2004 for a system inspection, February 26, 2004 for media sampling, March 8, 2004 for the installation of a bypass line around the Fleck valve controller, and May 16 through 24, 2004 for system retrofit. Neither scheduled nor unscheduled downtime was required after system retrofit until the end of the performance evaluation study.

The simplicity of system operation and operator skill requirements are discussed according to pre- and post treatment requirements, levels of system automation, operator skill requirements, preventative maintenance activities, and frequency of chemical/media handling and inventory requirements.

Pre- and Post-Treatment Requirements. Pretreatment consisted of the injection of NaOCl upstream of the system for oxidation of As(III), Fe(II), and, perhaps, sulfide. The prechlorination system was already

in place to provide chlorine residuals in water before entering the distribution system. Vigilant oversight of the prechlorination system was necessary to ensure that the residual chlorine levels were maintained properly. Post-treatment was not required.

System Automation. For the most part, backwash was conducted automatically and triggered by a 10-psi Δp setting across each vessel. Backwash also was initiated manually when backwash wastewater sampling was required. Occasionally, only one vessel reached the trigger level and was backwashed, thus enabling it to receive more flow than the other and producing an imbalanced flow. When this occurred, the operator initiated a manual backwash on the second vessel, returning the system to a balanced flow. All other functions of the APU-300 system were automatic.

Operator Skill Requirements. Under normal operating conditions, the skill requirements to operate the APU-300 system were minimal. The daily demand on the operator was 15 min to allow the operator to visually inspect the system and record the operating parameters on the log sheets. The operation of the system did not appear to require additional skills beyond those necessary to operate the existing production equipment.

Based on the size of the population served and the treatment technology, the State of New Mexico requires Level 3 Certification for operation of the STS system at MDWCA facility. The State of New Mexico has five levels of certifications for operations of public water supply systems, based on the complexity of the treatment and distribution system, such as the size and type of the system, the capacity of the system in terms of size service area and number of users served, the type and character of the water to be treated, and the physical conditions affecting the treatment plants. The levels range from Level 1, the least complex, to Level 5, the most complex.

Preventative Maintenance Activities. Preventative maintenance tasks recommended by STS included monthly inspection of the control panel, quarterly checking and calibration of the flow meters, biannual inspection of the actuator housings, fuses, relays, and pressure gauges, and annual inspection of the butterfly valves. STS recommended checking the actuators at each backwash event to ensure that the valves were opening and closing in the proper sequence. Further, inspection of the adsorber laterals and replacement of the gravel underbedding were recommended concurrent with the media replacement. The operator inspected the valves and wiring monthly, which consumed approximately 15 min/month. The operator also compared the flow meter and totalizer data from the STS system to his existing meters on a consistent basis, which did not require any appreciable time expenditure.

Chemical/Media Handling and Inventory Requirements. Chemical use was not required beyond the prechlorination system already in place. At the water production rate observed during the performance evaluation study, Desert Sands MDWCA ordered one 53-gal drum of NaOCl per month. The plant operator switched the metering pump inlet tube from the empty drum to the new drum when necessary.

4.5 System Performance

The performance of the APU systems were evaluated based on analyses of water samples collected from the treatment plant, system backwash, and distribution system.

4.5.1 Treatment Plant Sampling. Water samples were collected at five locations through the treatment process: including at the inlet (IN), after prechlorination (AC), after Vessels A and B (TA and TB, respectively), and at the combined effluent (TT). The treatment plant water was sampled on 75 occasions (including five duplicate events) during the study, with field speciation performed 25 times (19 times during the first media run and six times during the second media run). Field-speciation samples at IN, AC, and TT were collected once every four weeks from system start-up through January 4, 2006.

Field speciation was discontinued from February 1 through the end of the performance evaluation sampling on August 2, 2006.

Table 4-10 provides a summary of analytical results for arsenic, iron, and manganese during the first media run from January 16, 2004, through July 14, 2005, and the second media run from July 29, 2005, through August 16, 2006. Table 4-11 summarizes the results of the other water quality parameters. The standard deviations for the measurements also are presented in Tables 4-10 and 4-11. Appendix B contains a complete set of analytical results during the operation of the first and second media runs. The analytical data were not significantly different throughout the demonstration study whether using SORB 33™-S for the first media run or SORB 33™-P for the second media run. The results of the water samples collected throughout the treatment plant are discussed below.

Arsenic. The key parameter for evaluating the effectiveness of the APU-300 system was the concentration of arsenic in the treated water. As shown in Tables 4-10 and 4-11 as well as Figures 4-16 through 4-18, the adsorptive behavior was very similar between the granular and pelletized media.

Figure 4-16 contains three bar charts showing the concentrations of total As, particulate As, and soluble As(III) and As(V) at the IN, AC, and TT sampling locations for each speciation sampling event. Total arsenic concentrations in raw water ranged from 19.9 to 30.1 µg/L and averaged 23.9 µg/L during the first media run; and it ranged from 18.6 to 25.9 µg/L and averaged 23.4 µg/L during the second media run (Table 4-10). Particulate arsenic concentrations averaged 1.2 and 1.1 µg/L during the first and second media runs, respectively. Soluble As(III) was the predominating species with its concentrations averaging 21.8 and 21.6 µg/L during the first and second media runs, respectively. The remainder of soluble arsenic was As(V) with concentrations averaging 1.4 and 0.9 µg/L, respectively. The arsenic concentrations measured during this study were consistent with those in raw water collected on August 20, 2003 (Table 4-1).

Prechlorination oxidized As(III) to As(V) and provided required chlorine residuals to the distribution system. Samples collected downstream of the chlorine addition point (AC) had average As(III) and As(V) concentrations of 1.9 and 21.4 µg/L, respectively, during the first media run; , and 2.1 and 20.2 µg/L, respectively, during the second media run. Two exceptions were noted on samples collected on June 9, 2004, and January 20, 2005, during which arsenic oxidation did not appear to occur. Onsite free and total chlorine measurements, however, indicated the presence of residual chlorine; therefore, sampling errors were suspected for these AC samples. Typically at the AC location, free chlorine was measured at 0.3 to 0.7 mg/L (as Cl₂) during the first media run and 0.6 to 1.0 mg/L during the second media run. Free chlorine residuals measured were very similar to total chlorine levels, which ranged from 0.4 to 0.8 mg/L during the first and second media runs (Table 4-11). The chlorine residuals measured at the TA, TB, and TT locations were similar to those at the AC location, indicating little or no chlorine consumption through the adsorption vessels.

The arsenic breakthrough curves for both media runs are shown in Figure 4-17. The plots clearly demonstrate the similarity in total arsenic concentrations at the IN and AC locations and significant decrease in total arsenic concentrations following adsorption vessels at the TA, TB, and TT locations. Arsenic concentrations at TA and TB were similar, despite the imbalanced flow observed.

As shown in the top of Figure 4-17, during the first media run, concentration spikes exceeding the 10-µg/L As target MCL were observed on December 1, 2004, at both TA and TB locations after treated 21,200 and 23,300 BV of water by Vessels A and B, respectively. These concentration spikes could not be related to any particular incidents after reviewing the field logs. An STS engineer came to the site on January 6, 2005, to perform a backwash. Total arsenic concentrations at the effluent locations went down

Table 4-10. Summary of Arsenic, Iron, and Manganese Analytical Results for First and Second Media Runs

Parameter (Figure, if any)	Sampling Location ^(a)	Number of Samples Media Run 1/ Media Run 2	Concentration (µg/L)			
			Minimum Media Run 1/ Media Run 2	Maximum Media Run 1/ Media Run 2	Average Media Run 1/ Media Run 2	Standard Deviation Media Run 1/ Media Run 2
As (total) (see Figure 4-17)	IN	49/26	19.9/18.6	30.1/25.9	23.9/23.4	2.5/1.7
	AC	49/26	19.6/21.1	30.1/31.5	24.2/23.8	2.6/2.1
	TA	30/18	NM	NM	NM	NM
	TB	29/18	NM	NM	NM	NM
	TT	19/8	NM	NM	NM	NM
As (soluble)	IN	19/6	21.2/19.7	26.8/24.4	23.2/22.2	1.5/1.6
	AC	19/6	20.3/21.0	27.2/23.7	23.2/22.4	1.7/0.9
	TT	19/6	NM	NM	NM	NM
As (particulate)	IN	19/6	0.1/0.1	4.7/3.3	1.2/1.1	1.5/1.4
	AC	19/6	0.1/0.1	5.1/9.6	1.4/2.5	1.9/3.7
	TT	19/6	NM	NM	NM	NM
As(III)	IN	19/6	17.6/19.1	25.2/23.1	21.8/21.6	1.6/1.4
	AC	17 ^(b) /6	0.5/0.9	4.6/3.8	1.9/2.1	1.1/1.0
	TT	19/6	NM	NM	NM	NM
As(V)	IN	19/6	0.1/0.1	6.7/2.1	1.4/0.9	1.9/0.7
	AC	17 ^(b) /6	18.4/18.1	23.6/22.0	21.4/20.2	1.2/1.5
	TT	19/6	NM	NM	NM	NM
Fe (total)	IN	49/25 ^(c)	<25/<25	154/290	59.9/98.6	28.8/72.4
	AC	49/26	<25/<25	112/112	50.8/53.5	24.9/23.4
	TA	30/18	<25/<25	48.1/<25	<25/<25	10.4/0.0
	TB	29/18	<25/<25	43.7/<25	<25/<25	8.7/0.0
	TT	19/8	<25/<25	<25/<25	<25/<25	0.0/0.0
Fe (soluble)	IN	19/6	<25/<25	57.1/39.2	27.5/<25	16.4/10.6
	AC	19/6	<25/<25	49.0/<25	<25/<25	9.0/2.8
	TT	19/6	<25/<25	<25/<25	<25/<25	0.0/0.0
Mn (total)	IN	49/26	7.0/6.9	24.8/15.7	9.5/9.7	2.7/1.9
	AC	49/26	7.1/7.4	22.0/14.2	9.7/9.9	2.8/1.9
	TA	30/18	<0.1/<0.1	5.0/1.0	0.6/0.4	1.3/0.3
	TB	29/18	<0.1/<0.1	1.4/0.8	0.3/0.5	0.3/0.2
	TT	19/8	<0.1/<0.1	0.8/0.6	0.3/0.3	0.2/0.2
Mn (soluble)	IN	19/6	6.3/8.7	10.5/10.3	8.8/9.4	1.1/0.7
	AC	19/6	4.7/6.6	9.2/8.3	6.6/7.4	1.3/0.6
	TT	19/6	<0.1/<0.1	0.5/0.5	0.2/0.3	0.2/0.2

(a) See Table 3-3.

(b) Data not included in calculations for 06/09/04 or 01/20/05 due to suspected sampling errors.

(c) One outlier (i.e., 1,151 µg/L on 07/19/06) not included in calculations.

NM = not meaningful for data related to breakthrough curves; see Figure 4-17 and Appendix B for results.

One-half of detection limit used for non-detect results for calculations.

Duplicate samples included for calculations.

Table 4-11. Summary of Water Quality Parameter Measurements

Parameter (Figure, if any)	Sampling Location ^(a)	Unit	Number of Samples Media Run 1/ Media Run 2	Concentration/Value			
				Minimum Media Run 1/ Media Run 2	Maximum Media Run 1/ Media Run 2	Average Media Run 1/ Media Run 2	Standard Deviation Media Run 1/ Media Run 2
Alkalinity (as CaCO ₃)	IN	mg/L	49/9	164/180	226/198	187/188	12/6
	AC	mg/L	49/9	170/180	216/198	186/192	9/7
	TA	mg/L	30/3	169/198	202/198	185/198	8/0
	TB	mg/L	30/3	169/194	198/198	185/197	8/2
	TT	mg/L	19/6	173/185	201/198	186/191	7/5
Fluoride	IN	mg/L	19/6	0.2/0.4	0.7/0.5	0.5/0.4	0.1/0.0
	AC	mg/L	19/6	0.2/0.4	0.8/0.5	0.5/0.4	0.1/0.0
	TT	mg/L	19/6	0.2/0.4	0.7/0.5	0.5/0.4	0.1/0.0
Sulfate	IN	mg/L	19/6	170/156	255/201	190/176	25/18
	AC	mg/L	19/6	160/157	255/200	186/176	26/17
	TT	mg/L	19/6	170/158	255/199	191/173	24/18
Orthophosphate (as PO ₄)	IN	mg/L	48/3	<0.05/<0.05	0.20/<0.05	<0.05/<0.05	0.0/0.0
	AC	mg/L	48/3	<0.05/<0.05	0.20/0.2	<0.05/<0.05	0.0/0.0
	TA	mg/L	29/0	<0.05/NA	<0.10/NA	<0.05/NA	0.0/NA
	TB	mg/L	29/0	<0.05/NA	<0.10/NA	<0.05/NA	0.0/NA
	TT	mg/L	18/3 ^(a)	<0.05/<0.05	0.20/<0.05	<0.05/<0.05	0.0/0.0
Total P (as PO ₄)	IN	mg/L	0/6	NA /<0.03	NA /<0.03	NA /<0.03	NA /0.0
	AC	mg/L	0/6	NA /<0.03	NA /<0.03	NA /<0.03	NA /0.0
	TA	mg/L	0/3	NA /<0.03	NA /<0.03	NA /<0.03	NA /0.0
	TB	mg/L	0/3	NA /<0.03	NA /<0.03	NA /<0.03	NA /0.0
	TT	mg/L	0/3	NA /<0.03	NA /<0.03	NA /<0.03	NA /0.0
Silica (as SiO ₂)	IN	mg/L	49/9	36.4/36.5	41.8/39.6	38.3/37.8	1.0/1.0
	AC	mg/L	49/9	36.4/36.2	41.7/39.6	38.2/37.8	1.1/1.1
	TA	mg/L	30/3	35.3/36.1	39.9/38.1	37.9/37.0	1.0/1.0
	TB	mg/L	30/3	36.2/35.6	40.0/38.1	38.0/36.9	1.1/1.3
	TT	mg/L	19/6	36.6/33.7	40.6/38.9	38.2/37.6	1.0/2.0
Sulfide	IN	µg/L	22/31 ^(b)	<5/<5	5.7/<5	<5/<5	0.0/0.0
TSS	IN	mg/L	0/4	NA /<1.0	NA /1.0	NA /<1.0	NA /0.3
	AC	mg/L	0/2	NA /<1.0	NA /<1.0	NA /<1.0	NA /0.0
	TT	mg/L	0/2	NA /<1.0	NA /<1.0	NA /<1.0	NA /0.0
Nitrate (as N)	IN	mg/L	17/6	<0.04/<0.04	<0.04/0.2	<0.04/0.1	0.0/0.1
	AC	mg/L	17/6	<0.04/<0.04	0.6/0.4	0.06/0.12	0.2/0.2
	TT	mg/L	17/6	<0.04/<0.04	0.1/1.0	<0.04/0.2	0.0/0.4
Turbidity	IN	NTU	48/9	0.2/0.2	3.5/1.5	0.7/0.7	0.7/0.4
	AC	NTU	48/9	0.1/0.1	2.4/1.4	0.5/0.4	0.4/0.4
	TA	NTU	29/3	<0.1/<0.1	2.7/0.6	0.3/0.2	0.5/0.3
	TB	NTU	29/3	<0.1/<0.1	0.8/0.8	0.2/0.3	0.2/0.4
	TT	NTU	19/6	<0.1/<0.1	0.7/0.2	0.2/0.1	0.2/0.1
pH	IN	S.U.	38/6	7.6/7.7	8.1/7.9	7.7/7.8	0.2/0.1
	AC	S.U.	38/6	7.6/7.7	8.0/7.9	7.7/7.8	0.1/0.1
	TA	S.U.	18/0	7.6/ NA	8.0/ NA	7.8/ NA	0.1/ NA
	TB	S.U.	18/0	7.6/ NA	7.9/ NA	7.8/ NA	0.1/ NA
	TT	S.U.	19/6	7.6/7.7	8.0/7.9	7.7/7.8	0.1/0.1

Table 4-11. Summary of Water Quality Parameter Measurements (Continued)

Parameter (Figure, if any)	Sampling Location ^(a)	Unit	Number of Samples Media Run 1/ Media Run 2	Concentration/Value			
				Minimum Media Run 1/ Media Run 2	Maximum Media Run 1/ Media Run 2	Average Media Run 1/ Media Run 2	Standard Deviation Media Run 1/ Media Run 2
Temperature	IN	°C	38/6	19.9/29.9	31.6/31.6	29.9/30.8	1.8/0.7
	AC	°C	38/6	28.8/30.8	31.6/31.8	30.4/31.2	0.7/0.5
	TA	°C	18/0	28.9/ NA	31.2/ NA	30.3/ NA	0.7/ NA
	TB	°C	18/0	29.0/ NA	31.1/ NA	30.3/ NA	0.6/ NA
	TT	°C	19/6	29.5/30.8	31.7/31.8	30.7/31.3	0.6/0.4
DO	IN	mg/L	38/6	0.1/0.1	1.9/0.3	0.9/0.2	0.5/0.1
	AC	mg/L	38/6	0.2/0.1	2.0/0.3	1.0/0.2	0.5/0.1
	TA	mg/L	18/0	0.4/ NA	2.0/ NA	1.2/ NA	0.4/ NA
	TB	mg/L	18/0	0.4/ NA	1.9/ NA	1.2/ NA	0.4/ NA
	TT	mg/L	19/6	0.2/0.2	2.3/0.2	0.9/0.2	0.6/0.0
ORP	IN	mV	26/6	20/14	101/52	57/32	22/17
	AC	mV	27/6	454/370	562/514	509/484	30/56
	TA	mV	11/0	471/ NA	566/ NA	521/ NA	29/ NA
	TB	mV	11/0	485/ NA	576/ NA	527/ NA	29/ NA
	TT	mV	16/6	392/410	561/576	511/511	39/54
Free Chlorine (as Cl ₂)	AC	mg/L	35/6	0.3/0.6	0.7/1.0	0.5/0.8	0.1/0.2
	TA	mg/L	17/0	0.3/ NA	0.6/ NA	0.5/ NA	0.1/ NA
	TB	mg/L	15/0	0.3/ NA	0.6/ NA	0.4/ NA	0.1/ NA
	TT	mg/L	19/6	0.3/0.3	0.7/0.7	0.5/0.5	0.1/0.1
Total Chlorine (as Cl ₂)	AC	mg/L	33/2	0.4/0.6	0.8/0.8	0.6/0.7	0.1/0.1
	TA	mg/L	15/0	0.5/ NA	0.7/ NA	0.5/ NA	0.1/ NA
	TB	mg/L	13/0	0.5/ NA	0.7/ NA	0.5/ NA	0.1/ NA
	TT	mg/L	18/1	0.4/0.6	0.8/0.6	0.6/0.6	0.1/NA
Total Hardness (as CaCO ₃)	IN	mg/L	19/6	68.9/81.4	102/90.0	86.6/84.7	8.6/3.1
	AC	mg/L	19/6	68.3/74.5	111/87.4	87.3/83.6	9.7/5.1
	TT	mg/L	19/6	68.4/75.2	110/88.1	86.3/84.0	11.3/4.7
Ca Hardness (as CaCO ₃)	IN	mg/L	19/6	53.1/68.2	83.7/75.5	70.7/70.6	7.8/2.6
	AC	mg/L	19/6	53.3/61.1	91.9/73.1	71.7/69.3	8.5/4.6
	TT	mg/L	19/6	53.3/61.4	86.5/74.2	70.4/69.6	9.3/4.4
Mg Hardness (as CaCO ₃)	IN	mg/L	19/6	13.2/13.2	20.0/15.0	15.9/14.1	1.6/0.7
	AC	mg/L	19/6	12.6/13.4	19.2/15.1	15.6/14.2	1.9/0.7
	TT	mg/L	19/6	12.4/13.8	23.5/15.1	15.9/14.3	2.4/0.5

(a) One outlier (i.e., 1.4 mg/L on 11/29/05) not included in calculations.

(b) Includes 26 duplicate sampling events.

One-half of detection limit used for non-detect results for calculations.

Duplicate samples included for calculations.

to the levels around 5 µg/L at all effluent sampling locations thereafter, and increased gradually thereafter through the end of the first media run. The actual breakthrough of the first media run occurred at approximately 40,600 BV, representing about 62% of the vendor-estimated working capacity of 66,000 BV.

During the second media run (bottom of Figure 4-17), total arsenic concentrations at the effluent locations increased gradually. Breakthrough of arsenic above the 10 µg/L MCL occurred at approximately 49,500 BV, representing about 58 % of the estimated working capacity of 85,200 BV.

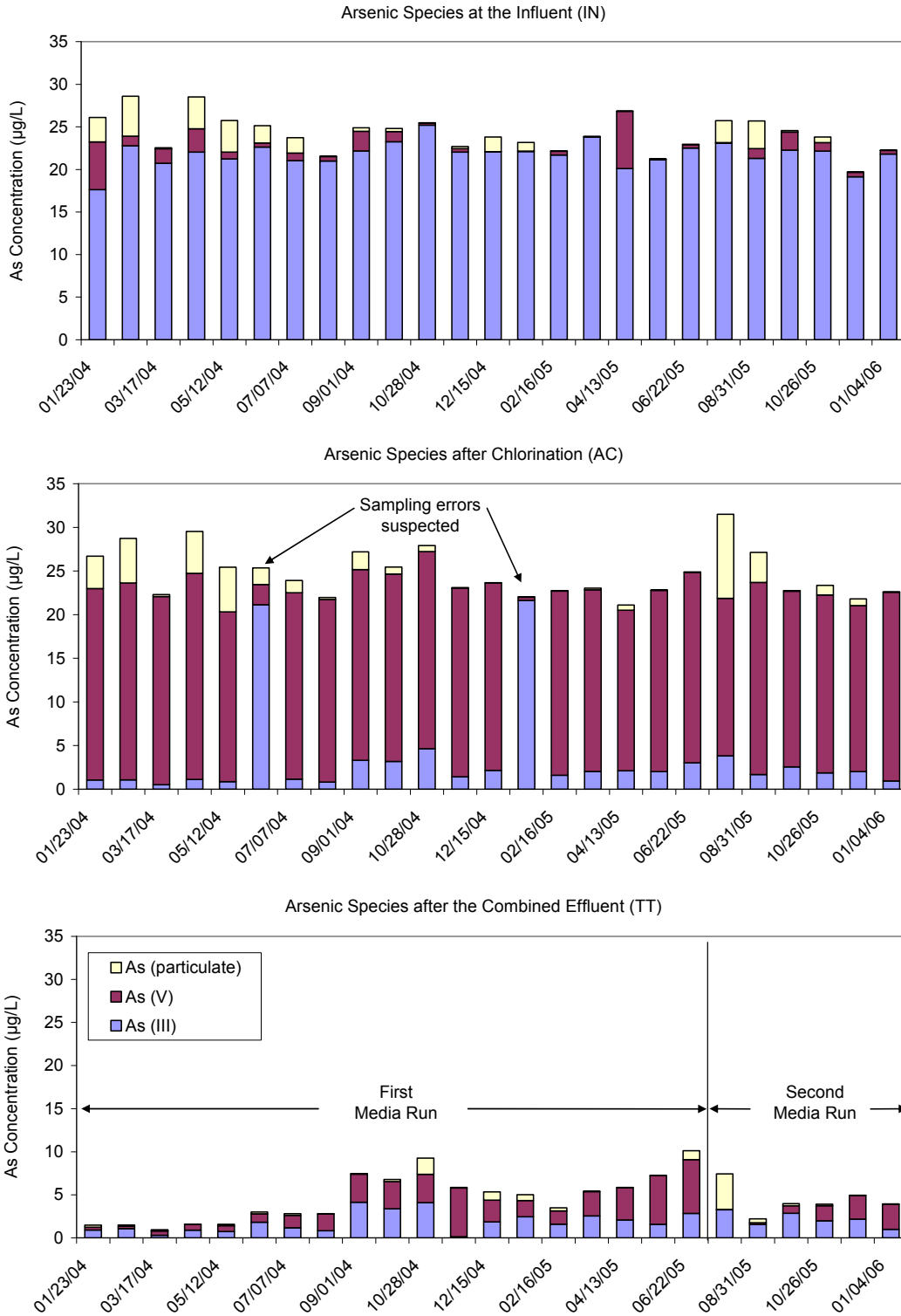


Figure 4-16. Concentrations of Arsenic Species at Wellhead, After Chlorination, and After Combined Effluent

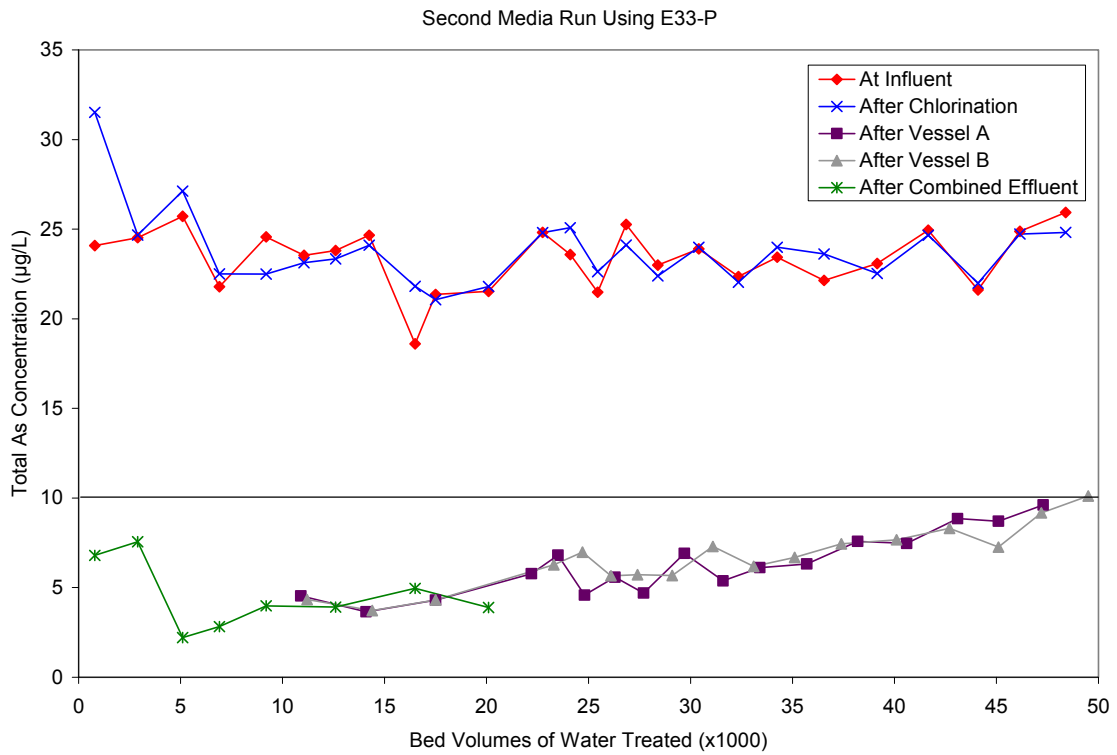
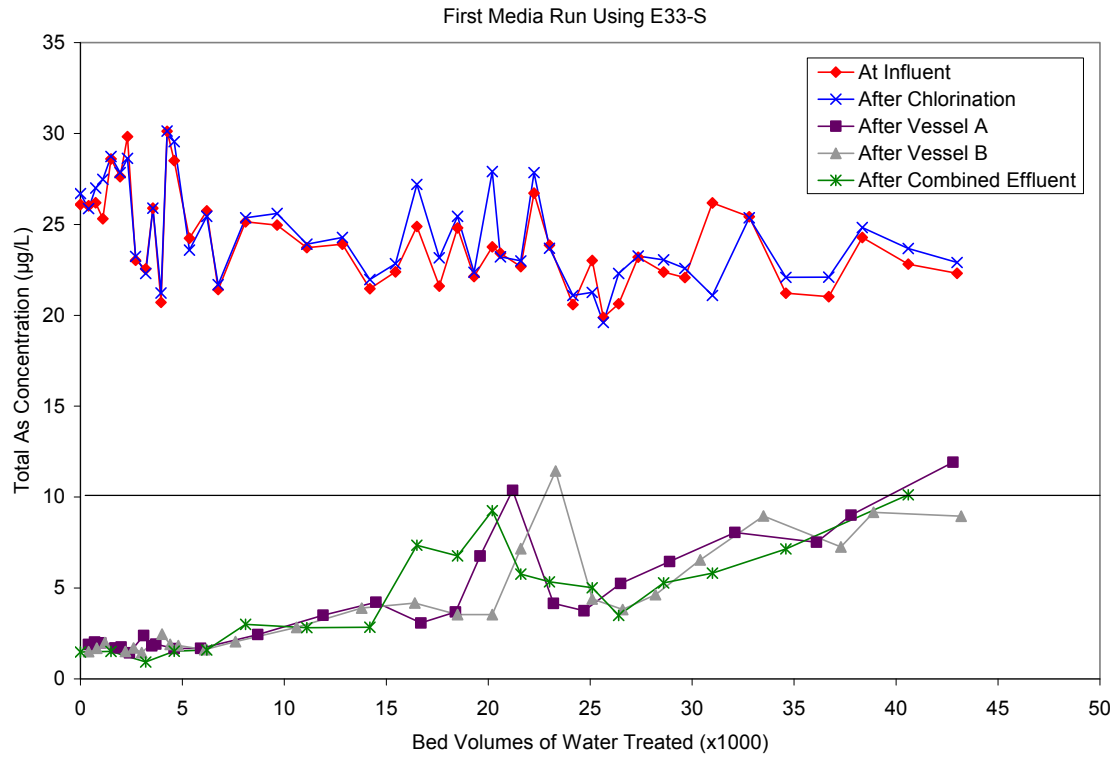


Figure 4-17. Total Arsenic Breakthrough Curves

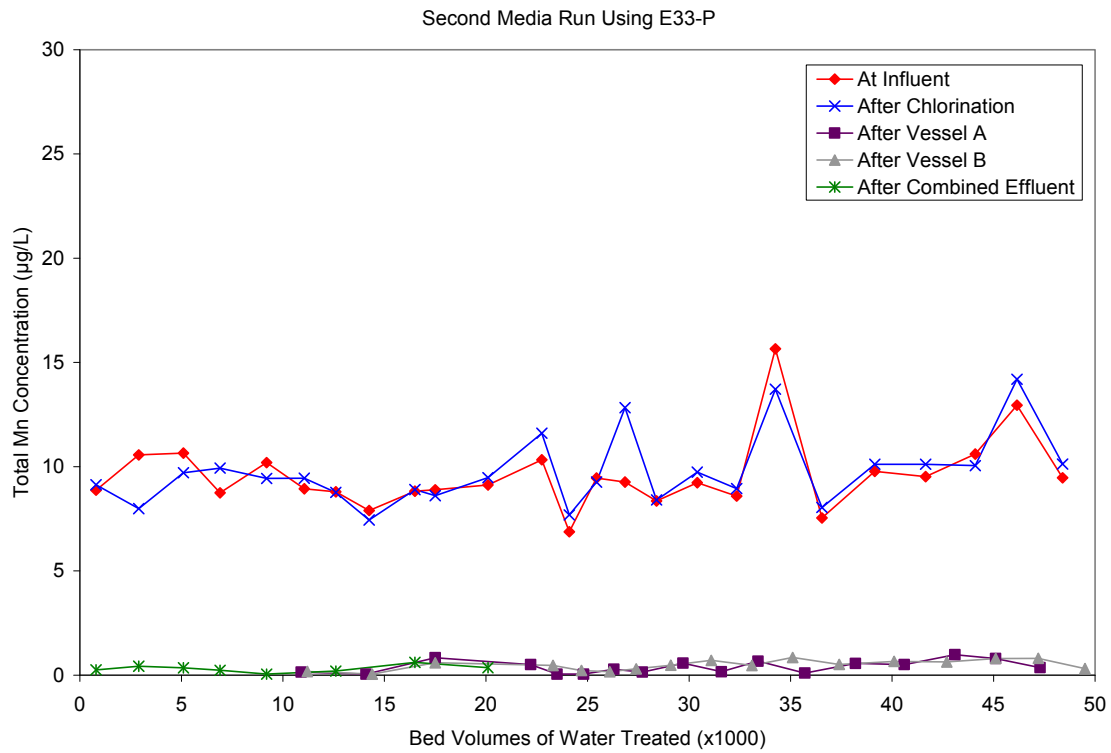
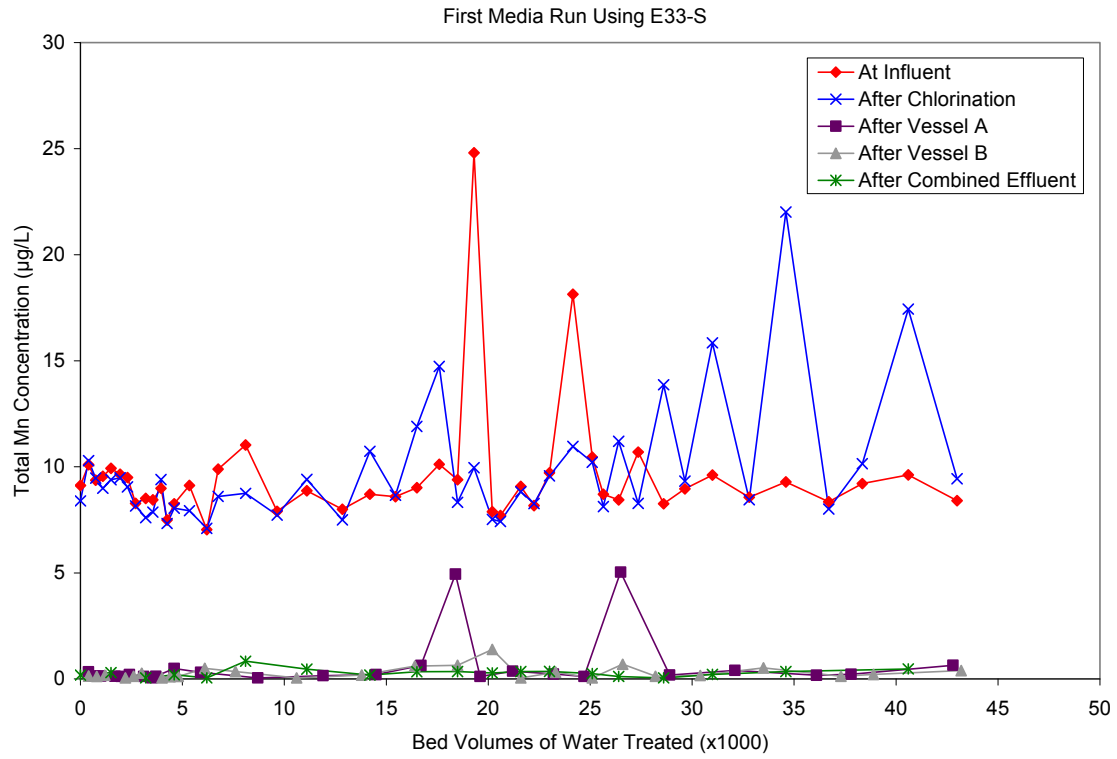


Figure 4-18. Total Manganese Concentrations Over Time

Iron. Total iron concentrations in raw water ranged from <25 to 154 µg/L and averaged 59.9 µg/L during the first media run, and from <25 to 290 µg/L and averaged 98.6 µg/L during the second media run (except for one outlier of 1,151 µg/L on July 19, 2006, as shown in Table 4-10). Total iron concentrations following prechlorination at the AC location ranged from <25 to 112 µg/L and averaged 50.8 µg/L during the first media run; and from <25 to 112 µg/L and averaged 53.5 µg/L during the second media run. Nearly all of the total iron concentrations at the TA, TB, and TT locations were <25 µg/L and with averaged concentrations <25 µg/L. Average dissolved iron concentrations were near and/or <25 µg/L at all locations. These data indicate that the majority of the total iron entering the treatment system was in particulate form, and that the iron particles were effectively captured by the media beds.

Manganese. Total Mn concentrations at the various sampling locations are plotted over time in Figure 4-18. Total manganese levels in raw water ranged from 7.0 to 24.8 µg/L and averaged 9.5 µg/L during the first media run, and ranged from 6.9 to 15.7 µg/L and averaged 9.7 µg/L during the second media run (Table 4-10). Soluble manganese levels in raw water and after the prechlorination process averaged 8.8 and 6.6 µg/L, respectively, in the first run; they averaged 9.4 and 7.4 µg/L, respectively, in the second media run. The data indicated that manganese existed primarily in the soluble form in raw water, and chlorination precipitated only <25% (on average) of soluble manganese before water entered the adsorption vessels. This observation was consistent with previous findings that free chlorine was relatively ineffective at oxidizing Mn(II) at pH values less than 8.5 (Knocke et al., 1987 and 1990).

As shown in Table 4-10, total Mn concentrations at the TA, TB, and TT locations were reduced to 0.3 to 0.6 µg/L during both media runs, indicating removal of Mn by the SORB 33™ media. Knocke et al. (1990) reported that the presence of free chlorine in the filter promoted Mn(II) removal on MnO_x-coated media, and that in the absence of free chlorine, Mn(II) removal was by adsorption only. In the absence of free chlorine, SORB 33™ media apparently had a limited adsorptive capacity for Mn(II). The presence of 0.3 to 1.0 mg/L (as Cl₂) of free chlorine (Table 4-11) apparently was enough to promote the removal of manganese by the SORB 33™ media presumably via a mechanism similar to that proposed by Knocke et al. (1990).

Other Water Quality Parameters. In addition to arsenic analyses, other water quality parameters were analyzed to provide insight to the chemical processes occurring within the treatment system. The complete water quality results are attached in Appendix B and summarized in Table 4-11.

Alkalinity (as CaCO₃) ranged from 164 to 226 mg/L during the first media run and from 180 to 198 mg/L during the second media run. Sulfate concentrations ranged from 170 to 255 mg/L during the first media run and from 156 to 201 mg/L during the second media run. Both alkalinity and sulfate concentrations remained relatively constant throughout the treatment train, indicating little or no effects by prechlorination or the adsorptive media. Historically, sulfide odor in raw water had been detected by the system operator. Sulfide analysis of raw water was conducted on 53 occasions (including 26 duplicate samples). Sulfide was only detected for two events: 5.2 µg/L (5.1 µg/L for duplicate) on March 3, 2004 and 5.7 µg/L (<5 µg/L for duplicate) on March 31, 2004.

Fluoride concentrations ranged from 0.2 to 0.8 mg/L in all samples throughout the study. Fluoride concentrations did not appear to be affected by the treatment. Orthophosphate (as PO₄) concentrations were below or near the method detection limit of 0.10 mg/L for all samples, with two exceptions (i.e., 0.20 mg/L at IN, AC, and TT on January 23, 2004, and 1.4 mg/L, most likely an outlier, at TT on November 17, 2004). Total P (as PO₄) concentrations measured during the second media run were under the method detection limit of 0.03 mg/L for all samples. Silica (as SiO₂) concentrations, ranging from 33.7 to 40.6 mg/L in vessel effluent, were similar to the levels in raw water only 19 days after system startup, indicating little or no adsorptive capacity for silica.

Onsite pH measurements throughout the study remained consistent across the treatment train at 7.6 to 8.1. DO levels ranged from 0.1 to 2.3 mg/L and were not affected by the prechlorination or the media. ORP readings were collected using a dedicated ORP probe since April 14, 2004. ORP readings at the IN location varied from 14 to 101 mV, indicating a reducing environment. After prechlorination, ORP readings at the AC location increased significantly, ranging from 370 to 562 mV. ORP readings at effluent locations (TA, TB, and TT) ranged from 392 to 576 mV. There did not appear to be a significant difference in ORP values between the AC and treated water samples (TA, TB, and TT), indicating little or no effect from the media.

Total hardness (as CaCO₃) ranged from 68.9 to 102 mg/L in raw water, consisting predominantly of calcium hardness (approximately 82%). Hardness was not affected by either prechlorination or the media.

Sodium hypochlorite was added upstream of the treatment system. In addition to the original purpose of disinfecting water, chlorine also oxidized As(III) to As(V) to increase the arsenic adsorptive capacity by the media. Free and total chlorine were monitored at the AC, TA, TB, and TT sampling locations. Free and total chlorine residuals at the AC location ranged from 0.3 to 1.0 mg/L and 0.4 to 0.8 mg/L, respectively. Chlorine residuals measured at the TA, TB, and TT locations were similar to those measured at the AC location, indicating little or no chlorine consumption through the APU-300 system.

4.5.2 Backwash Wastewater Sampling. Backwash wastewater was sampled periodically from the sample ports located in the backwash effluent discharge lines from each vessel. Backwash was performed using raw water (non-chlorinated). The unfiltered samples were analyzed for pH, turbidity, and TDS/TSS. Filtered samples using 0.45- μ m disc filters were analyzed for soluble arsenic, iron, and manganese. For the last seven backwash wastewater sampling events (taking place since February 1, 2006, through the end of the performance evaluation study), TSS and total As, Fe, and Mn concentrations also were measured. The analytical results are summarized in Table 4-12; results of the sample collected on May 23, 2004 were not included in the data analysis due to a sampling error that the operator filled bottles reserved for filtered samples with a portion of an unfiltered sample. Section 3.3.3 describes the sampling procedures and modifications.

pH values of backwash wastewater ranged from 7.5 to 8.1, similar to those of raw water. Soluble arsenic concentrations ranged from 6.4 to 25.7 μ g/L and averaged 13.3 μ g/L. This average concentration was lower than that in raw water (i.e., 22.7 μ g/L [on average]), indicating removal of some soluble arsenic by the media during backwash. Soluble iron concentrations ranged from <25 to 373 μ g/L and averaged 133 μ g/L; soluble manganese concentrations ranged from 1.8 to 27.1 μ g/L and averaged 10.5 μ g/L. Soluble Mn concentrations in backwash wastewater were slightly higher than those in raw water (averaged 9.6 μ g/L).

As expected, total arsenic, iron, and manganese concentrations were significantly higher than soluble concentrations, indicating the presence of particulates in backwash wastewater. Particulate As might be associated with either iron particles intercepted by the media beds during the service cycle or the media fines. Assuming the average backwash flowrate was 200 gpm and the backwash duration was 25 min per vessel (Table 4-4), the total amount of backwash wastewater generated during each backwash event would be 10,000 gal. Assuming that 109 mg/L of TSS (i.e., the average of TSS values measured on May 10, June 6, July 18, and August 16, 2006) was produced in 10,000 gal of backwash wastewater from the vessels, approximately 9.1 lb of solids would be discharged during each backwash event. Based on the average total metal (or, more correctly, digested metal) data collected during the last seven backwash events (i.e., 53.3 μ g/L of particulate arsenic, 14,635 μ g/L of particulate iron, and 851 μ g/L of particulate manganese), the solids discharged would be composed of 0.005, 1.2, and 0.07 lb of arsenic, iron, and

Table 4-12. Backwash Wastewater Sampling Results

Sampling Event		Vessel A											Vessel B										
		pH	Turbidity	TDS	TSS	Total As	Soluble As	Particulate As	Total Fe	Soluble Fe	Total Mn	Soluble Mn	pH	Turbidity	TDS	TSS	Total As	Soluble As	Particulate As	Total Fe	Soluble Fe	Total Mn	Soluble Mn
No.	Date	S.U.	NTU	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	S.U.	NTU	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1	05/23/04 ^(a)	7.5	180	NS	203	NS	3.5	NS	NS	825	NS	89.0	7.9	99	NS	202	NS	5.6	NS	NS	2,166	NS	131
2	07/13/04	7.9	220	766	NS	NS	12.1	NS	NS	69.8	NS	7.6	7.9	160	756	NS	NS	9.6	NS	NS	83.0	NS	8.2
3	09/30/04	8.0	0.2 ^(b)	886	NS	NS	9.4	NS	NS	160	NS	13.0	8.1	0.1 ^(b)	780	NS	NS	11.3	NS	NS	176	NS	13.5
4	11/17/04	7.8	260	772	NS	NS	9.0	NS	NS	136	NS	7.6	7.9	200	794	NS	NS	12.2	NS	NS	152	NS	10.2
5	12/06/04	7.6	240	730	NS	NS	8.0	NS	NS	25.0	NS	2.1	7.7	180	710	NS	NS	6.4	NS	NS	38.0	NS	2.6
6	02/07/05	7.6	220	706	NS	NS	9.0	NS	NS	140	NS	7.3	7.9	330	742	NS	NS	10.2	NS	NS	175	NS	8.8
7	06/14/05	7.8	119 ^(b)	780	NS	NS	25.7	NS	NS	70.0	NS	6.3	7.9	111 ^(b)	772	NS	NS	22.2	NS	NS	53.0	NS	4.8
8	07/07/05	7.8	70 ^(b)	852	NS	NS	19.6	NS	NS	50.0	NS	6.9	7.9	85 ^(b)	872	NS	NS	21.2	NS	NS	57.4	NS	7.3
9	09/15/05	7.6	240	852	NS	NS	7.9	NS	NS	111	NS	11.1	7.7	170	798	NS	NS	9.7	NS	NS	106	NS	9.7
10	10/12/05	8.0	220	794	NS	NS	9.7	NS	NS	26.7	NS	3.6	8.0	280	786	NS	NS	10.3	NS	NS	35.9	NS	4.1
11	11/09/05	7.9	300	770	NS	NS	10.4	NS	NS	<25	NS	2.7	7.9	110	766	NS	NS	11.3	NS	NS	<25	NS	1.8
12	02/01/06 ^(c)	8.0	NS	974	924	143	10.9	132	28,818	199	1,620	15.4	8.1	NS	782	408	103	16.0	86.5	32,793	163	1,267	12.5
13	03/15/06	8.1	NS	802	2,180	40.4	13.1	27.3	5,463	255	453	17.7	8.1	NS	812	1,850	40.7	13.1	27.6	10,106	373	468	27.1
14	04/11/06	7.9	NS	806	1,080	72.0	16.1	56.0	30,841	62.4	1,224	6.8	8.0	NS	762	792	80.0	13.2	66.8	18,599	47.7	1,035	5.3
15	05/10/06	8.0	NS	768	100	48.8	15.9	32.9	6,915	194	443	19.2	8.0	NS	758	70	45.2	14.5	30.7	4,317	227	383	19.9
16	06/06/06	7.9	NS	784	154	49.3	13.6	35.7	12,758	197	793	16.1	7.9	NS	744	122	50.6	13.6	37.0	11,049	196	707	16.2
17	07/18/06	8.0	NS	760	132	111	19.8	90.9	16,632	325	1,381	21.7	7.9	NS	938	152	80.0	15.2	64.8	13,999	307	1,110	19.7
18	08/16/06	7.9	NS	742	127	60.0	17.5	42.6	13,187	164	910	12.0	7.9	NS	786	17	33.7	15.6	18.1	2,229	113	266	9.2

- (a) Operator filled sample bottle with a portion of unfiltered water.
 (b) Sample analyzed outside of hold time.
 (c) Sampling protocol hereafter revised to include TSS and total As, Fe, and Mn analyses.
 NS = not sampled

manganese, respectively (Table 4-12). These amounts, after being converted to the weights of corresponding metal oxides, apparently were lower than those estimated based on TSS. Challenges associated with sampling and sample digestion were believed to have contributed to the discrepancies observed.

Table 4-13 presents the total metal results of backwash solid samples. Backwash solid samples were collected three times on June 6, July 18, and August 16, 2006, from both Vessels A and B. The samples collected were combined to obtain sufficient sample quantitative for total metal analysis and the results are presented in Table 4-13. Iron levels in the solids averaged 329 mg/g (or 33%). Arsenic levels averaged 1.4 mg/g (or 0.14%).

The total throughput between the backwash events conducted on June 6, July 18, and August 16, 2006 for both Vessels A and B was 3,584,000 gal (Figure 4-15). Assuming the average total Fe in source water was 98.6 µg/L and all Fe in source water was collected by the media beds and discharged as backwash solids during backwash events, then there would be approximately 1,338 g of solid Fe was discharged as a part of TSS in the three backwash events. The average TSS values measured on June 6, July 18, and August 16, 2006 was 117.3 mg/L (Table 4-12). Assuming 30,000 gal of backwash wastewater were produced in the three backwash events from both vessels, approximately 13,320 g solids would be discharged during the three backwash events. Therefore, the iron level in backwash solids can be calculated as approximately 10%, which is less than one third of that calculated based on backwash solids metal analysis, indicating the backwash solids contained significant amount of media fine.

Table 4-13. Backwash Solids Total Metal Analysis

Analyte (µg/g)	Mg	Al	Si	P	Ca	Mn	Fe	Ni	Cu	Zn	As	Cd	Pb
Vessel A	3,477	5,855	772	376	30,224	6,801	310,337	74.5	63.2	129	1,331	<0.5	13.5
Vessel B	2,460	4,071	711	310	17,525	3,455	347,988	88.0	38.4	90.1	1,496	<0.5	3.6

Note: Solids collected from three backwash events (on June 6, July 18, and August 16, 2006) and combined for sufficient sample quantity.
Average compositions calculated from triplicate analyses.

4.5.3 Spent Media Sampling. Spent media samples were collected for metals and TCLP analysis (Section 3.3.4) at the end of the first media run on July 27, 2005, and the end of the second media run on September 11, 2006. The results from TCLP analysis (Table 4-14) indicated that the media was non-hazardous and could be disposed of in a sanitary landfill. Only barium was detected at 0.61 to 0.64 mg/L on the spent SORB 33™-S media; and at 0.76 mg/L on the spent SORB 33™-P media. All other Resources Conservation and Recovery Act (RCRA) metals were at concentrations less than the respective method detection limits.

The ICP-MS results of spent media are shown in Table 4-15. The spent media contained mostly iron at 595 mg/g (as Fe) or 946 mg/g (as FeOOH) on the granular media, and at 457 mg/g (as Fe) or 727 mg/g (as FeOOH) on the pelletized media. The FeOOH content of the spent granular media was higher than the 90.1% (by weight) specified by the Bayer AG for the virgin media (Table 4-3), perhaps indicating some iron attachment on the spent media during treatment. The FeOOH content of the spent pelletized media, however, was significantly lower than the 90.1% specified by the Bayer AG for the virgin granular media. STS indicated that the chemical contents are the same for both the granular and pelletized media. It is not clear what caused the low iron content on the spent pelletized media. Challenges associated with

Table 4-14. TCLP Results of Spent Media

Parameter	Method	SORB 33™-S		SORB 33™-P
		Vessel A	Vessel B	Vessel B
Arsenic (mg/L)	EPA 200.7	<0.12	<0.12	<0.10
Barium (mg/L)	EPA 200.7	0.64	0.61	0.76
Cadmium (mg/L)	EPA 200.7	<0.018	<0.018	<0.010
Chromium (mg/L)	EPA 200.7	<0.043	<0.043	<0.010
Lead (mg/L)	EPA 200.7	<0.040	<0.040	<0.050
Mercury (mg/L)	EPA 245.1	<0.00036	<0.00036	<0.0020
Selenium (mg/L)	EPA 200.7	<0.15	<0.15	<0.10
Silver (mg/L)	EPA 200.7	<0.048	<0.048	<0.010

sampling and sample digestion were believed to have contributed to the discrepancies observed. The spent granular media also contained higher concentrations of Al, Mn, Cu, Zn and As and lower concentrations of P compared to the spent pelletized media.

The average arsenic loadings on the spent granular and pelletized media were 2.2 and 1.6 mg/g of dry media based on the analytical results shown on Table 4-15. The adsorptive capacity also was calculated by dividing the arsenic mass represented by the area between the influent (AC) and effluent (TT) curves, as shown in Figure 4-17 by the amount of dry media in each vessel. Assuming no media loss, the dry weight of the granular media, i.e., 1,913 lb/vessel, was calculated based on a wet weight of 2,250 lb (i.e., 80 ft³ of media at 28.1 lb/ft³) and a maximum moisture content of 15% (Table 4-3). Similarly, the dry weight of the pelletized media was calculated as 1,845 lb/vessel. Using this approach, the theoretical arsenic loadings on the media were calculated as 2.1 and 1.7 mg/g of dry media for the granular and pelletized media, respectively; of which 105 and 94% were recovered via ICP-MS analysis. The adsorptive capacities and percentages of recovery for both media are summarized in Table 4-16.

4.5.4 Distribution System Water Sampling. Distribution system samples were collected to investigate if the water treated by the arsenic removal system would impact the lead, copper, and arsenic levels and other water chemistry in the distribution system. Prior to the installation/operation of the treatment system, baseline distribution water samples were collected on December 8, 11, and 30, 2003. Following the installation of the treatment system, distribution water sampling continued on a monthly basis at the same three locations. The sampling at the distribution system discontinued after December 14, 2005. The samples were analyzed for pH, alkalinity, arsenic, iron, manganese, lead, and copper. First draw samples were collected at the three sampling locations according to the procedure noted in Section 3.3.5. In addition, flushed samples also were collected at the DS2 and DS3 locations, which were non-residences.

The main difference observed between the baseline samples and samples collected after the treatment system startup was a decrease in arsenic concentrations at each of the sampling locations. Arsenic concentrations were reduced from the range of 22.4 to 28.2 µg/L to 1.8 to 19.0 µg/L. Although the arsenic concentrations measured during system operation were lower than the baseline values, they were still higher than the APU-300 system effluent results. This phenomenon was due probably to the blending of water produced by Well No. 3 in the distribution system with untreated water from Well No. 2. A sample collected from Well No. 2 on June 2, 2004 contained 14.9 µg/L of total arsenic.

Measured pH values ranged from 7.1 to 8.2, and alkalinity levels ranged from 176 to 268 mg/L (as CaCO₃). Iron concentrations in the first draw samples ranged from <25 to 97.7 µg/L, except for two samples at DS2 (i.e., 783 and 931 µg/L), with the majority of the samples <25 µg/L. Iron concentrations

Table 4-15. Spent Media Total Metal Analysis

Analyte (µg/g)	Mg	Al	Si	P	Ca	Fe	Mn	Ni	Cu	Zn	As	Cd	Pb
<i>Media Run 1: SORB 33™-S Samples Collected on 07/27/05</i>													
Vessel A - Top	1,915	576	1,146	267	2,551	602,316	3,001	126	37.9	39.2	2,192	<0.2	1.0
Vessel A - Bottom	1,928	596	979	277	2,581	579,891	2,720	125	31.7	34.3	2,037	<0.2	0.9
Vessel B - Top	1,924	744	1,180	297	2,578	596,164	3,011	116	39.6	42.7	2,289	<0.2	1.0
Vessel B - Bottom	1,922	627	1,254	297	2,735	603,437	3,019	118	38.2	38.9	2,315	<0.2	0.9
<i>Media Run 2: SORB 33™-P Samples Collected on 09/11/06</i>													
Vessel B - Top	1,948	457	618	530	2,690	457,691	2,770	126	23.0	<50	1,767	<0.5	1.0
Vessel B - Middle	1,814	322	878	510	2,529	466,760	2,358	125	15.4	<50	1,488	<0.5	0.9
Vessel B - Bottom	1,878	356	1,212	522	2,489	447,598	2,280	122	14.7	<50	1,483	<0.5	0.9

Note: Average compositions calculated from triplicate analyses.

Table 4-16. Summary of SORB 33™ Media Adsorptive Capacities

Period	Media Run 1 (01/16/04–07/14/05)		Media Run 2 (07/29/05–08/16/06) ^(a)	
	Breakthrough Curve (Figure 4-17)	Spent Media (Table 4-15)	Breakthrough Curve (Figure 4-17)	Spent Media (Table 4-15)
Unit	mg As/g dry SORB 33™-S		mg As/g dry SORB 33™-P	
Average	2.1 ^(b)	2.2	1.7 ^(b)	1.6 ^(c)
Recovery	105%		94%	

(a) Treatment system off from 08/17/06 until media removal on 09/11/06.

(b) Assumed and corrected for 15% moisture content of media.

(c) Based on spent media from Vessel B only. Vessel A emptied prior to sampling.

in the flushed samples from DS2 and DS3 ranged from <25 to 55 µg/L. In general, iron concentrations in the distribution system samples decreased since the system began operating. Manganese concentrations in the distribution system samples ranged from <0.1 to 94.1 µg/L, but the only results greater than 7.7 µg/L were first draw samples at DS2. Manganese levels appear slightly lower since the system began to operate.

Lead levels ranged from 0.2 to 71.7 µg/L, with eight of the 119 samples exceeding the action level of 15 µg/L. Five of the action level exceedances for lead were from first draw samples at DS2, with the remaining three exceedances in first draw samples from DS3. Copper concentrations ranged from <0.1 to 393 µg/L, with no samples exceeding the 1,300 µg/L action level. Neither lead nor copper concentrations in the distribution system appeared to have been affected by the operation of the arsenic treatment unit. The results of the distribution system sampling are summarized in Table 4-17.

4.6 System Cost

The cost of the system was evaluated based on the capital cost per gpm (or gpd) of design capacity and the O&M cost per 1,000 gal of water treated. This task required tracking capital cost for the equipment, site engineering, and installation and the O&M cost for media replacement and disposal, replacement parts, chemical supply, electricity consumption, and labor. The building cost was not included in the capital cost because it was outside of the scope of this demonstration project and was funded separately by Desert Sands MDWCA.

4.6.1 Capital Cost. The capital investment for the equipment, site engineering, and installation was \$153,000 (see Table 4-18). The equipment cost was \$112,000 (or 73% of the total capital investment), which included \$72,200 for the APU-300 skid-mounted unit, \$24,000 for the SORB 33™ media (i.e., \$5.34/lb to fill two vessels), and vendor's labor and travel for the system shakedown and startup.

The engineering cost included preparation of the system layout and footprint, design of the piping connections up to the distribution tie-in points, design of the electrical connections, and assemblage and submission of the engineering plans for the permit application (Section 4.3.1). The engineering cost was \$23,000, which was 15% of the total capital investment.

The installation cost included equipment and labor to unload and install the APU-300 system, perform the piping tie-ins and electrical work, and load and backwash the media (Section 4.3.3). The installation was performed by STS and the Desert Sands MDWCA plant operator subcontracted to STS. A variety of elevated pressure and flow restriction issues caused the actual system startup date to be delayed, eventually prompting STS to redesign the system's piping, valving, and instruments and controls. The costs for the system retrofitting were not included in this cost analysis. The installation costs were \$18,000, or 12% of the total capital investment.

The capital cost of \$153,000 was normalized to \$478/gpm (\$0.33/gpd) of design capacity using the system's rated capacity of 320 gpm (or 460,800 gpd). The capital cost also was converted to an annualized cost of \$14,442/yr using a capital recovery factor (CRF) of 0.09439 based on a 7% interest rate and a 20-yr return period. Assuming that the system operated 24 hr/day, 7 day/wk at the design flowrate of 320 gpm to produce 168,192,000 gal/yr, the unit capital cost would be \$0.09/1,000 gal. During the first media run, the system operated an average of only 7 hr/day (average of the first and second media run, Table 4-7), producing 40,395,000 gal of water in one year, so the unit capital cost increased to \$0.37/1,000 gal at this reduced rate of usage.

Table 4-17. Distribution System Sampling Results

Sampling Event		DS1									DS2									DS3																	
		LCR									Non-Residence ^(a)									Non-Residence ^(a)																	
		1st Draw			1st Draw						Flushed						1st Draw					Flushed															
		Stagnation Time	pH	Alkalinity	As	Fe	Mn	Pb	Cu	pH	Alkalinity	As	Fe	Mn	Pb	Cu	pH	Alkalinity	As	Fe	Mn	Pb	Cu	pH	Alkalinity	As	Fe	Mn	Pb	Cu							
No.	Date	hr	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L								
BL1	12/08/03	8.0	7.1	200	23.3	48.1	5.0	0.9	9.1	7.7	187	26.3	36.5	6.4	22.5	99.5	Not sampled.									7.8	181	26.3	74.1	7.5	8.2	33.6	Not sampled.				
BL2	12/11/03	8.5	7.8	178	26.0	40.1	4.0	0.6	7.1	7.8	196	28.2	931	94.1	16.8	206	Not sampled.									7.9	200	23.7	40.4	7.7	1.0	10.1	Not sampled.				
BL3	12/30/03	7.7	7.7	197	22.4	<25	2.0	1.1	17.0	Not sampled.						7.8	201	23.4	<25	2.3	1.2	8.6	Not sampled.					7.8	207	23.6	<25	2.1	1.1	9.1			
1	02/11/04	8.5	7.6	207	10.4	49.2	1.9	0.4	14.1	7.8	182	7.4	783	34.1	60.2	393	7.8	186	2.5	55.2	0.6	2.9	25.7	7.7	198	5.3	47.3	1.7	8.7	30.0	7.7	215	6.7	48.3	2.3	1.0	17.0
2	03/10/04	7.8	7.8	230	8.1	<25	1.9	0.7	12.5	7.8	235	8.8	97.7	10.8	71.7	159	7.8	230	8.3	<25	2.7	1.5	9.3	7.9	197	2.4	22.5	5.6	41.3	315	8.0	185	1.8	<25	0.1	6.2	14.5
3	04/07/04	8.5	7.7	249	9.3	<25	3.5	0.2	7.5	7.8	257	10.2	26.6	23.8	15.9	105	7.8	265	9.5	<25	1.3	0.8	6.6	8.0	168	2.8	<25	4.1	3.3	42.5	7.9	180	2.5	<25	0.1	0.9	10.8
4	05/12/04	8.1	7.8	223	9.5	<25	1.7	1.7	156	7.8	237	7.2	<25	1.8	1.7	15.5	7.8	241	7.6	<25	2.2	2.3	11.4	7.8	229	5.1	<25	1.9	3.4	19.6	7.8	233	5.6	<25	1.0	2.1	11.0
5	06/23/04	8.1	8.0	183	1.8	<25	1.0	2.0	33.7	7.9	195	3.1	<25	1.4	6.0	84.7	7.9	195	4.3	<25	1.2	9.3	1.6	8.0	195	2.5	<25	0.6	22.9	121	7.9	175	4.5	<25	1.2	3.8	19.2
6	07/21/04	8.1	7.7	188	4.9	<25	0.2	0.2	4.1	7.7	203	6.0	<25	1.6	1.3	9.4	7.7	207	6.9	<25	1.8	1.2	7.8	7.7	200	6.4	<25	1.0	1.6	8.5	7.7	200	7.2	<25	1.0	1.6	8.5
7	08/18/04	8.1	7.5	180	5.7	29.0	0.3	1.7	23.7	7.5	219	8.8	60.0	2.0	1.9	9.5	7.6	219	9.4	26.4	2.0	1.4	6.4	7.7	188	6.0	<25	0.7	2.9	11.8	7.7	188	6.2	<25	0.6	1.8	7.5
8	09/15/04	8.1	7.8	226	8.0	<25	1.5	0.3	10.2	7.8	222	10.2	<25	1.5	1.5	13.0	7.7	214	10.4	<25	1.5	0.8	9.2	8.0	190	5.5	<25	0.2	1.7	15.6	8.1	186	5.4	<25	<0.1	1.8	17.9
9	10/13/04	8.1	7.7	207	6.9	<25	4.2	0.3	6.8	7.8	191	7.0	<25	1.8	1.6	20.2	7.8	199	7.1	<25	1.9	1.2	11.3	7.9	191	3.7	<25	<0.1	18.0	200	8.0	175	3.5	<25	3.2	1.7	16.9
10	11/10/04	8.1	7.9	201	4.8	<25	0.5	1.3	65.1	7.9	185	4.2	<25	0.5	0.9	8.8	8.0	185	4.8	<25	1.0	0.9	11.7	8.0	185	3.6	<25	0.2	1.4	12.2	8.0	185	3.6	<25	0.2	0.8	8.4
11	12/08/04	8.8	8.0	211	12.3	<25	1.8	0.2	5.5	8.0	231	16.6	<25	2.5	0.8	12.1	8.0	223	19.0	<25	2.2	0.4	6.6	7.9	244	18.1	<25	2.1	1.0	17.8	7.9	244	16.5	<25	2.4	0.7	13.7
12	01/20/05	7.5	7.5	211	7.5	<25	1.2	0.2	8.7	7.7	189	5.3	<25	0.2	0.7	9.7	7.4	181	4.7	<25	0.1	0.6	8.0	7.7	215	6.3	<25	1.7	1.1	16.0	7.5	185	5.0	<25	0.4	0.6	9.4
13	02/16/05	7.8	7.9	201	6.8	<25	0.8	0.3	12.1	7.7	245	10.4	<25	3.0	0.9	18.2	7.7	250	10.7	<25	2.6	0.4	10.0	7.7	268	10.3	<25	3.1	0.9	15.3	7.7	245	10.3	<25	2.8	0.8	13.1
14	03/16/05	8.0	7.9	201	6.6	<25	0.0	0.1	5.0	7.9	187	6.2	<25	<0.1	0.6	8.2	8.1	192	6.4	<25	<0.1	0.6	7.8	7.8	187	6.5	<25	<0.1	0.6	7.9	8.0	196	6.9	<25	<0.1	0.5	7.3
15	04/13/05	7.4	8.1	220	7.0	<25	0.5	0.2	5.4	8.2	211	6.3	<25	0.2	0.9	11.0	8.2	211	6.2	<25	0.1	0.9	10.0	8.2	207	6.7	61.9	0.4	1.0	10.0	8.2	211	6.4	<25	0.1	0.9	11.4
16	05/11/05	8.0	7.3	185	7.4	<25	0.5	0.4	4.4	7.4	185	7.3	<25	<0.1	1.4	11.2	7.6	198	8.4	30.0	<0.1	1.3	9.8	7.5	198	7.7	<25	<0.1	1.0	9.7	7.6	198	8.1	32.5	0.1	1.1	9.5
17	06/22/05	7.5	7.6	189	10.8	<25	1.7	0.3	5.1	7.7	198	11.5	<25	1.2	5.6	52.1	7.7	198	11.5	<25	1.3	0.8	6.7	7.7	198	9.8	<25	1.3	1.8	13.4	7.7	198	11.3	<25	1.4	0.8	7.0
18	08/03/05	8.1	7.5	176	7.6	<25	0.6	0.3	3.3	7.6	220	9.5	<25	1.4	1.9	11.8	7.6	211	9.8	<25	1.2	0.9	5.5	7.7	189	3.7	<25	0.2	1.4	8.8	7.7	189	3.7	<25	0.2	1.1	7.5
19	09/14/05	8.2	7.6	220	5.2	<25	1.8	0.5	4.9	7.5	220	6.5	<25	2.0	1.1	8.9	7.6	207	6.2	<25	1.8	0.6	6.1	7.7	176	3.0	<25	0.1	1.3	8.0	7.7	198	3.6	<25	<0.1	1.0	7.5
20	10/12/05	9.0	7.8	194	4.6	<25	0.5	0.3	<0.1	7.9	189	4.6	<25	<0.1	2.3	12.2	7.9	194	4.7	<25	0.1	0.2	<0.1	7.9	189	4.6	<25	<0.1	2.5	13.8	7.9	198	4.0	<25	<0.1	0.2	<0.1
21	11/09/05	8.2	7.7	176	4.7	<25	<0.1	0.4	3.6	7.7	185	4.8	<25	<0.1	0.9	10.1	7.7	176	4.9	<25	<0.1	0.5	2.9	7.7	176	4.8	<25	<0.1	0.7	4.5	7.7	198	4.9	<25	<0.1	0.5	4.2
22	12/14/05	7.8	7.9	198	7.3	<25	0.7	0.4	57.9	8.1	211	8.5	<25	1.5	1.1	28.1	8.0	211	8.8	<25	1.5	0.8	12.8	8.0	207	7.0	<25	0.3	0.3	14.7	8.0	202	6.9	<25	0.4	0.2	8.7

(a) Stagnation time not available for non-residences.

Note: Alkalinity measured in mg/L as CaCO₃. Action levels: 15 µg/L Pb and 1.3 mg/L Cu. BL = baseline sampling; NA = data not available.

Desert Sands MDWCA constructed an addition to its existing pump house at Well No. 3 to house the APU-300 system (Section 4.3.2). The structure was built by the Desert Sands MDWCA plant operator with the exception of the electrical tie-in. The total cost for the building construction was \$3,700, including \$2,700 for materials and \$1,000 for approximately 80 hr of labor.

Table 4-18. Capital Investment for APU-300 System

Description	Cost	% of Capital Investment Cost
<i>Equipment</i>		
APU-300 Skid-Mounted System	\$72,200	–
SORB 33™ Media	\$24,000	2,250 lb for SORB 33™-S; 2,170 lb for SORB 33™-P
Misc. Equipment and Materials	\$2,500	–
Vendor Labor	\$9,500	–
Vendor Travel	\$3,800	–
Equipment Total	\$112,000	73%
<i>Engineering</i>		
Subcontractor	\$16,300	–
Vendor Labor	\$6,700	–
Engineering Total	\$23,000	15%
<i>Installation</i>		
Subcontractor	\$9,000	–
Vendor Labor	\$5,600	–
Vendor Travel	\$3,400	–
Installation Total	\$18,000	12%
Total Capital Investment	\$153,000	100%

4.6.2 O&M Cost. The O&M cost was \$0.74/1,000 gal for media replacement and disposal, replacement parts, chemical supply, electricity, and labor, as summarized in Table 4-19. The media replacement and disposal cost was calculated based upon the throughput to arsenic breakthrough at the end of the second media run for actual costs incurred (i.e., \$30,900 to rebed both vessels). This media changeout cost included costs for media, freight, labor, travel expenses, and a media profiling and disposal fee. Upon arsenic breakthrough at 46,553,000 gal during the second media run, the media replacement cost was \$0.66/1,000 gal (Figure 4-19).

Because the system was under warranty during the first year of operation, no expenses were incurred for repairs to the system during this time. However, after two years of operation, two actuated valves (121-A and 123-A) began sticking and required replacement. A local company, Parmeter Power and Control, was contracted to perform the replacement for \$3,036. This cost included \$2,625 for the two valves and \$411 for labor and travel costs. The new valves were installed on September 8, 2006.

The only chemical cost was the use NaOCl for prechlorination, which was in place prior to the installation of the APU-300 system to provide chlorine residual prior to distribution. The APU-300 system did not change the use rate of the NaOCl solution, so the chemical cost was negligible.

Electricity consumption also was negligible, particularly since the system retrofit in May 2004. After retrofitting, the electric meter stopped registering power consumption. The operator assumed that the meter was faulty, and replaced it with a new and factory-tested meter, which also did not register any power consumption. It was then determined that the APU-300 system did not consume enough electricity

to register regular increases on the meter (i.e., less than 1 kWh/week after retrofit compared to 3-4 kWh/week before retrofit).

The routine, non-demonstration related labor activities consumed only 15 min/day (Section 4.4.7). Based on this time commitment and a labor rate of \$18.20/hr, the labor cost was \$0.05/1,000 gal of water treated.

Table 4-19. O&M Costs for APU-300 System

Cost Category	Value	Remarks
<i>Media Replacement and Disposal</i>		
Media Cost (\$/ft ³)	\$202	–
Media Volume (ft ³)	124	SORB 33-P media
Media Replacement Cost (\$)	\$25,080	–
Labor Cost (\$)	\$4,130	–
Media Disposal Fee (\$)	\$1,690	Waste profile included
Subtotal (\$)	\$30,900	–
Media Replacement and Disposal Cost (\$/1,000 gal)	\$0.66	Second media run throughput = 46,553,000 gal, see Figure 4-19
<i>Equipment Replacement</i>		
Replacement Valves' Cost (\$)	\$2,625	Two actuated valves
Labor and Travel Cost (\$)	\$411	–
Equipment Replacement Cost (\$/1,000 gal)	\$0.03	Total system throughput = 99,200,000 gal
<i>Electricity</i>		
Electric Utility Charge (\$/kWh)	\$0.14	Rate provided by DSMDWCA
Usage (kWh)	126	–
Total Electricity Cost (\$)	\$17.64	Total system throughput = 99,200,000 gal
Electricity Cost (\$/1,000 gal)	\$0.00	\$0.01/1,000 gal prior to retrofit
<i>Labor</i>		
Average Weekly Labor (hr)	1.75	15 min/day
Total Labor (hr)	270	Total system throughput = 99,200,000 gal
Labor Cost (\$/1,000 gal)	\$0.05	Labor rate = \$18.20/hr
Total O&M Cost (\$/1,000 gal)	\$0.74	See Figure 4-19

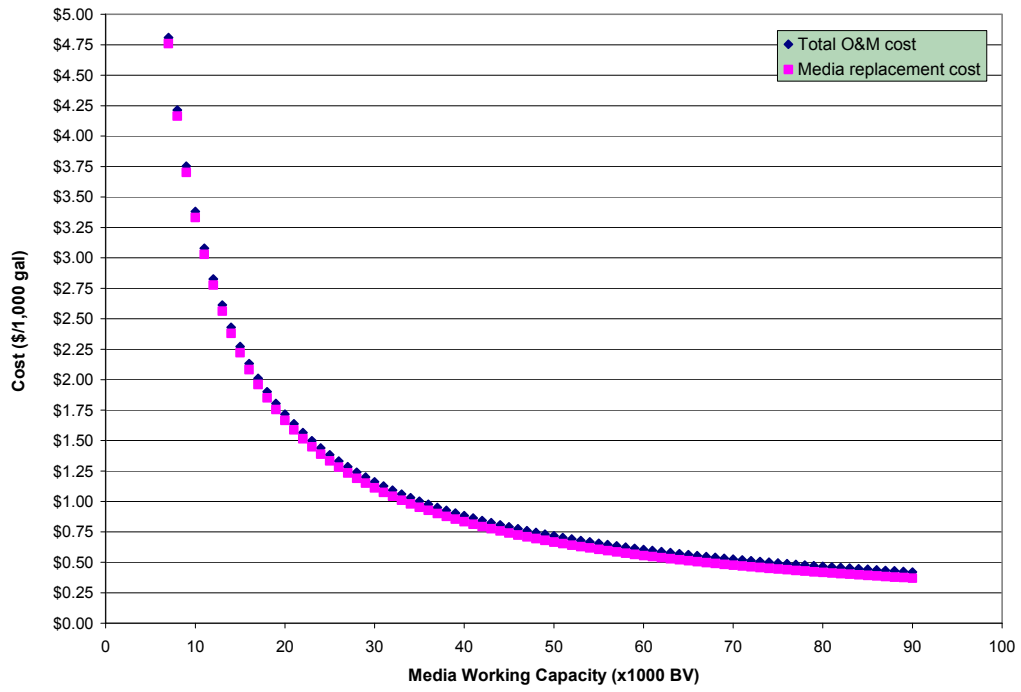


Figure 4-19. Media Replacement and O&M Cost for APU-300 System

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APPENDIX A

OPERATIONAL DATA

Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System Operation Log Sheet

Week No.	Date	Pump House					Instrument Panel								
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
1	01/23/04	0.0	0.0	234,081	221	216	NA	NA	NA	>15	>15	76	56	20	
	01/24/04	4.9	4.9	234,153	266	259	88	88	73	off	off	52	52	NA	
	01/25/04	8.1	13.0	234,282	335	327	137	225	188	off	off	56	56	NA	
2	01/26/04	5.0	18.0	234,359	375	367	80	305	254	off	off	58	58	NA	
	01/27/04	2.0	20.0	234,403	399	391	48	353	294	off	off	54	54	NA	
	01/28/04	5.0	25.0	234,476	438	428	76	429	358	>15	>15	78	60	18	
	01/29/04	4.0	29.0	234,540	471	461	66	495	413	off	off	54	54	NA	
	01/30/04	4.0	33.0	234,597	501	491	60	555	463	off	off	60	60	NA	
	01/31/04	3.0	36.0	234,658	538	526	72	627	523	off	off	60	60	NA	
	02/01/04	4.0	40.0	234,713	568	558	62	689	574	off	off	60	60	NA	
3	02/02/04	4.0	44.0	234,771	584	603	61	750	625	off	off	55	55	NA	
	02/03/04	5.6	49.6	234,845	600	663	76	826	688	off	off	60	60	NA	
	02/04/04	1.3	50.9	234,866	615	681	33	859	716	24	24	80	56	24	
	02/05/04	8.0	58.9	234,989	620	757	81	940	783	off	off	52	52	NA	
4	02/09/04	11.5	70.4	235,167	753	868	244	1,184	987	off	off	NM	NM	NA	
	02/10/04	0.4	70.8	235,174	756	872	7	1,191	993	>15	>15	84	54	30	
	02/11/04	5.7	76.5	235,225	799	926	97	1,288	1073	>15	>15	84	56	28	
	02/12/04	4.7	81.2	235,333	830	969	74	1,362	1135	>15	>15	86	56	30	
	02/13/04	4.9	86.1	235,408	863	1,015	79	1,441	1201	off	off	56	56	NA	
5	02/16/04	14.1	100.2	235,623	956	1,111	189	1,630	1358	off	off	54	54	NA	
	02/17/04	5.2	105.4	235,701	990	1,158	81	1,711	1426	off	off	50	50	NA	
	02/18/04	5.0	110.4	235,777	1,025	1,207	84	1,795	1496	>15	>15	82	56	26	
	02/19/04	7.5	117.9	235,891	1,074	1,277	119	1,914	1595	off	off	54	54	NA	
	02/20/04	5.5	123.4	235,976	1,112	1,328	89	2,003	1669	off	off	50	50	NA	
6	02/23/04	11.4	134.8	236,151	1,192	1,436	188	2,191	1826	off	off	50	50	NA	
	02/24/04	4.3	139.1	236,216	1,221	1,476	69	2,260	1883	off	off	50	50	NA	
	02/25/04	4.3	143.4	236,282	1,250	1,516	69	2,329	1941	>15	>15	82	56	26	
	02/26/04	3.9	147.3	236,342	1,279	1,555	68	2,397	1998	off	off	52	52	NA	
	02/27/04	2.9	150.2	236,387	1,298	1,582	46	2,443	2036	off	off	50	50	NA	
	02/28/04	4.0	154.2	236,448	1,327	1,623	70	2,513	2094	off	off	50	50	NA	
7	02/29/04	4.2	158.4	236,511	1,356	1,660	66	2,579	2149	off	off	50	50	NA	
	03/01/04	4.1	162.5	236,575	1,384	1,698	66	2,645	2204	off	off	50	50	NA	
	03/02/04	4.6	167.1	236,644	1,415	1,740	73	2,718	2265	off	off	52	52	NA	
	03/03/04	4.0	171.1	236,715	1,446	1,782	73	2,791	2326	>15	>15	82	58	24	
	03/04/04	4.6	175.7	236,775	1,475	1,820	67	2,858	2382	off	off	54	54	NA	
	03/05/04	6.9	182.6	236,801	1,480	1,836	21	2,879	2399	off	off	59	54	5	
	03/06/04	5.0	187.6	236,876	1,521	1,883	88	2,967	2473	>15	>15	82	60	22	
	03/07/04	5.9	193.5	236,966	1,563	1,936	95	3,062	2552	>15	>15	84	60	24	
8	03/08/04	1.7	195.2	236,994	1,563	1,936	0	3,062	2552	>15	>15	82	56	26	
	03/09/04	2.8	198.0	237,035	1,594	1,977	72	3,134	2612	off	off	off	off	NA	
	03/10/04	5.0	203.0	237,112	1,631	2,022	82	3,216	2680	>15	>15	80	56	24	
	03/11/04	5.8	208.8	237,201	1,671	2,083	101	3,317	2764	off	off	off	off	NA	
	03/12/04	3.3	212.1	237,253	1,694	2,105	45	3,362	2802	off	off	off	off	NA	
	03/13/04	3.4	215.5	237,305	1,717	2,137	55	3,417	2848	off	off	off	off	NA	
	03/14/04	6.2	221.7	237,377	1,749	2,180	75	3,492	2910	off	off	off	off	NA	
9	03/15/04	3.0	224.7	237,455	1,784	2,227	82	3,574	2978	>20	>20	80	60	20	
	03/16/04	7.6	232.3	237,564	1,839	2,299	127	3,701	3084	off	off	off	off	NA	
	03/17/04	6.9	239.2	237,671	1,889	2,360	111	3,812	3177	>20	>20	82	60	22	
	03/18/04	1.9	241.1	237,698	1,902	2,377	30	3,842	3202	>20	>20	off	off	NA	
	03/19/04	8.4	249.5	237,799	1,949	2,434	104	3,946	3288	off	off	off	off	NA	
	03/20/04	2.2	251.7	237,864	1,979	2,472	68	4,014	3345	>20	>20	84	62	22	
	03/21/04	3.3	255.0	237,924	2,003	2,502	54	4,068	3390	off	off	54	off	NA	
10	03/22/04	3.2	258.2	237,963	2,025	2,531	51	4,119	3433	>20	>20	84	62	22	
	03/23/04	4.0	262.2	238,025	2,053	2,567	64	4,183	3486	off	off	off	off	NA	
	03/24/04	5.1	267.3	238,103	2,088	2,613	81	4,264	3553	>20	>20	84	off	NA	
	03/25/04	5.8	273.1	238,199	2,138	2,676	113	4,377	3648	off	off	off	off	NA	
	03/26/04	4.3	277.4	238,258	2,166	2,710	62	4,439	3699	off	off	off	off	NA	
	03/27/04	3.6	281.0	238,315	2,192	2,743	59	4,498	3748	off	off	off	off	NA	
03/28/04	3.5	284.5	238,369	2,217	2,775	57	4,555	3796	off	off	off	off	NA		

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House					Instrument Panel								
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
11	03/29/04	4.3	288.8	238,434	2,246	2,813	67	4,622	3852	off	off	NM	60	NA	
	03/30/04	3.5	292.3	238,494	2,273	2,848	62	4,684	3903	off	off	NM	60	NA	
	03/31/04	4.3	296.6	238,554	2,301	2,884	64	4,748	3957	off	off	NM	58	NA	
	04/01/04	4.8	301.4	238,628	2,341	2,934	90	4,838	4032	off	off	NM	60	NA	
	04/02/04	2.9	304.3	238,674	2,363	2,960	48	4,886	4072	off	off	NM	58	NA	
	04/03/04	3.0	307.3	238,719	2,384	2,987	48	4,934	4112	off	off	NM	58	NA	
	04/04/04	NA	NA	238,772	2,408	3,018	55	4,989	4158	off	off	NM	60	NA	
12	04/05/04	6.3	313.6	238,816	2,428	3,043	45	5,034	4195	off	off	NM	60	NA	
	04/06/04	2.9	316.5	238,868	2,449	3,071	49	5,083	4236	off	off	NM	60	NA	
	04/07/04	2.0	318.5	238,893	2,464	3,090	34	5,117	4264	>20	>20	60	82	22	
	04/08/04	3.9	322.4	238,952	2,497	3,130	73	5,190	4325	off	off	NM	62	NA	
	04/09/04	2.8	325.2	238,995	2,517	3,155	45	5,235	4363	off	off	NM	58	NA	
	04/10/04	3.5	328.7	239,049	2,542	3,186	56	5,291	4409	off	off	NM	60	NA	
	04/11/04	2.9	331.6	239,093	2,562	3,212	46	5,337	4448	off	off	NM	60	NA	
13	04/12/04	3.2	334.8	239,135	2,582	3,237	45	5,382	4485	>20	>20	82	60	22	
	04/13/04	2.9	337.7	239,188	2,606	3,268	55	5,437	4531	>20	>20	82	60	22	
	04/14/04	3.2	340.9	239,235	2,627	3,296	49	5,486	4572	>20	>20	84	60	24	
	04/15/04	4.3	345.2	239,301	2,664	3,341	82	5,568	4640	>20	>20	84	60	24	
	04/16/04	3.4	348.6	239,353	2,688	3,372	55	5,623	4686	>20	>20	82	60	22	
	04/17/04	4.0	352.6	239,413	2,715	3,407	62	5,685	4738	>20	>20	84	60	24	
	04/18/04	3.4	356.0	239,465	2,739	3,438	55	5,740	4783	>20	>20	84	60	24	
14	04/19/04	4.0	360.0	239,525	2,767	3,473	63	5,803	4836	>20	>20	84	60	24	
	04/20/04	3.6	363.6	239,580	2,791	3,505	56	5,859	4883	>20	>20	84	60	24	
	04/21/04	4.1	367.7	239,634	2,816	3,537	57	5,916	4930	>20	>20	82	58	24	
	04/22/04	2.9	370.6	239,687	2,846	3,575	68	5,984	4987	>20	>20	82	60	22	
	04/23/04	3.3	373.9	239,737	2,870	3,604	53	6,037	5031	>20	>20	80	60	20	
	04/24/04	3.8	377.7	239,795	2,896	3,638	60	6,097	5081	>20	>20	80	60	20	
	04/25/04	4.4	382.1	239,860	2,926	3,676	68	6,165	5138	>20	>20	80	60	20	
15	04/26/04	3.8	385.9	239,919	2,953	3,711	62	6,227	5189	>20	>20	82	60	22	
	04/27/04	4.0	389.9	239,980	2,955	3,746	37	6,264	5220	>20	>20	82	60	22	
	04/28/04	4.0	393.9	240,023	2,955	3,779	33	6,297	5248	>20	>20	82	60	22	
	04/29/04	3.1	397.0	240,101	2,955	3,817	38	6,335	5279	>20	>20	82	60	22	
	04/30/04	3.8	400.8	240,147	2,983	3,850	61	6,396	5330	>20	>20	82	60	22	
	05/01/04	5.4	406.2	240,230	3,022	3,895	84	6,480	5400	>20	>20	82	60	22	
	05/02/04	5.1	411.3	240,291	3,030	3,953	66	6,546	5455	>20	>20	82	60	22	
16	05/03/04	2.8	414.1	240,360	3,077	3,968	62	6,608	5507	>20	>20	82	60	22	
	05/04/04	3.9	418.0	240,400	3,104	4,002	61	6,669	5558	>20	>20	82	60	22	
	05/05/04	4.5	422.5	240,478	3,136	4,042	72	6,741	5618	>20	>20	80	60	20	
	05/06/04	6.6	429.1	240,577	3,188	4,107	117	6,858	5715	>20	>20	80	60	20	
	05/07/04	5.7	434.8	240,664	3,229	4,157	91	6,949	5791	>20	>20	82	60	22	
	05/08/04	6.2	441.0	240,759	3,274	4,210	98	7,047	5873	>20	>20	80	60	20	
	05/09/04	6.0	447.0	240,849	3,315	4,262	93	7,140	5950	>20	>20	80	60	20	
17	05/10/04	5.7	452.7	240,936	3,356	4,312	91	7,231	6026	>20	>20	82	60	22	
	05/11/04	7.5	460.2	241,034	3,402	4,368	102	7,333	6111	>20	>20	80	58	22	
	05/12/04	4.0	464.2	241,110	3,436	4,412	78	7,411	6176	>20	>20	80	60	20	
	05/13/04	6.9	471.1	241,215	3,493	4,478	123	7,534	6278	>20	>20	80	60	20	
	05/14/04	3.3	474.4	241,266	3,517	4,507	53	7,587	6323	>20	>20	80	60	20	
	05/15/04	5.7	480.1	241,353	3,557	4,557	90	7,677	6398	>20	>20	80	60	20	
	05/16/04	12.9	493.0	241,554	3,663	4,649	198	7,875	6563	>20	>20	80	60	20	
18	05/17/04	<i>System was turned off for repairing</i>													
	05/18/04														
	05/19/04														
	05/20/04														
	05/21/04														
	05/22/04														
05/23/04															
19	05/24/04	4.6	497.6	241,646	3,663	4,649	0	7,875	6563	2.8	3.0	66	60	6	
	05/25/04	7.0	504.6	241,746	3,705	4,752	145	8,020	6683	3.0	3.0	68	62	6	
	05/26/04	6.2	510.8	241,846	3,759	4,779	81	8,101	6751	3.0	3.0	64	58	6	
	05/27/04	5.8	516.6	241,940	3,809	4,820	91	8,192	6827	off	off	52	52	NA	
	05/28/04	3.8	520.4	242,002	3,842	4,852	65	8,257	6881	off	off	52	52	NA	
	05/29/04	8.9	529.3	242,146	3,919	4,929	154	8,411	7009	3.0	3.0	56	50	6	
	05/30/04	6.4	535.7	242,248	3,972	4,983	107	8,518	7098	3.0	3.0	62	56	6	
20	05/31/04	6.5	542.2	242,353	4,029	5,040	114	8,632	7193	3.0	3.0	66	60	6	
	06/01/04	8.8	551.0	242,498	4,104	5,116	151	8,783	7319	2.8	3.0	68	62	6	
	06/02/04	7.8	558.8	242,617	4,166	5,179	125	8,908	7423	3.0	3.0	60	54	6	
	06/03/04	6.9	565.7	242,725	4,223	5,231	109	9,017	7514	off	off	off	52	NA	
	06/04/04	5.3	571.0	242,810	4,266	5,283	95	9,112	7593	off	off	off	50	NA	
	06/05/04	6.8	577.8	242,917	4,321	5,341	113	9,225	7688	4.0	4.0	60	52	8	
06/06/04	6.4	584.2	243,018	4,373	5,396	107	9,332	7777	3.0	3.0	56	50	6		

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House					Instrument Panel								
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
21	06/07/04	9.2	593.4	243,164	4,446	5,476	153	9,485	7904	off	off	off	58	NA	
	06/08/04	6.7	600.1	243,270	4,499	5,534	111	9,596	7997	3.0	3.0	56	50	6	
	06/09/04	10.4	610.5	243,432	4,580	5,621	168	9,764	8137	5.0	5.0	62	52	10	
	06/10/04	9.2	619.7	243,576	4,652	5,700	151	9,915	8263	5.0	6.0	67	56	11	
	06/11/04	4.4	624.1	243,645	4,680	5,739	67	9,982	8318	6.0	8.0	64	58	6	
	06/12/04	9.5	633.6	243,795	4,761	5,821	163	10,145	8454	off	off	off	52	NA	
	06/13/04	6.1	639.7	243,891	4,808	5,872	98	10,243	8536	off	off	off	58	NA	
22	06/14/04	10.3	650.0	244,054	4,837	5,970	127	10,370	8642	off	off	off	58	NA	
	06/15/04	9.2	659.2	244,203	4,910	6,054	157	10,527	8773	3.0	3.0	66	60	6	
	06/16/04	7.5	666.7	244,321	4,972	6,116	124	10,651	8876	off	off	off	62	NA	
	06/17/04	9.7	676.4	244,477	5,055	6,197	164	10,815	9013	4.0	4.0	70	62	8	
	06/18/04	8.1	684.5	244,606	5,123	6,263	134	10,949	9124	off	off	off	58	NA	
	06/19/04	8.9	693.4	244,747	5,198	6,337	149	11,098	9248	off	off	off	60	NA	
	06/20/04	6.0	699.4	244,843	5,248	6,387	100	11,198	9332	off	off	off	52	NA	
23	06/21/04	15.0	714.4	245,019	5,349	6,479	193	11,391	9493	3.0	2.5	60	56	4	
	06/22/04	9.1	723.5	245,164	5,415	6,555	142	11,533	9611	off	off	off	off	NA	
	06/23/04	5.5	729.0	245,251	5,461	6,600	91	11,624	9687	3.0	3.0	58	52	6	
	06/24/04	9.8	738.8	245,407	5,542	6,683	164	11,788	9823	off	off	off	58	NA	
	06/25/04	5.8	744.6	245,509	5,589	6,732	96	11,884	9903	off	off	off	60	NA	
	06/26/04	6.4	751.0	245,602	5,643	6,786	108	11,992	9993	6.0	6.0	72	60	12	
	06/27/04	6.0	757.0	245,706	5,697	6,841	109	12,101	10084	off	off	off	58	NA	
24	06/28/04	6.4	763.4	245,794	5,742	6,887	91	12,192	10160	8.0	8.0	76	60	16	
	06/29/04	7.3	770.7	245,911	5,803	6,948	122	12,314	10262	off	off	off	62	NA	
	06/30/04	5.5	776.2	245,999	5,849	6,994	92	12,406	10338	10.0	10.0	80	60	20	
	07/01/04	6.8	783.0	246,109	5,907	7,051	115	12,521	10434	3.0	2.8	62	56	6	
	07/02/04	5.9	788.9	246,205	5,958	7,101	101	12,622	10518	3.0	3.0	58	52	6	
	07/03/04	10.2	799.1	246,368	6,045	7,189	175	12,797	10664	off	off	off	60	NA	
	07/04/04	5.3	804.4	246,455	6,090	7,230	86	12,883	10736	off	off	off	58	NA	
25	07/05/04	8.3	812.7	246,588	6,158	7,301	139	13,022	10852	3.5	3.0	62	56	6	
	07/06/04	9.1	821.8	246,735	6,227	7,385	153	13,175	10979	off	off	off	52	NA	
	07/07/04	6.1	827.9	246,832	6,277	7,437	102	13,277	11064	4.0	3.0	63	54	9	
	07/08/04	13.4	841.3	247,046	6,384	7,554	224	13,501	11251	off	off	off	58	NA	
	07/09/04	8.0	849.3	247,175	6,453	7,621	136	13,637	11364	off	off	off	60	NA	
	07/10/04	9.9	859.2	247,333	6,535	7,705	166	13,803	11503	off	off	off	62	NA	
	07/11/04	8.0	867.2	247,468	6,603	7,777	140	13,943	11619	6.0	6.0	68	56	12	
26	07/12/04	8.3	875.5	247,597	6,667	7,848	135	14,078	11732	3.0	3.0	62	56	6	
	07/13/04	4.7	880.2	247,672	6,703	7,891	79	14,157	11798	off	off	off	54	NA	
	07/14/04	13.4	893.6	247,886	6,815	8,006	227	14,384	11987	off	off	off	56	NA	
	07/15/04	8.3	901.9	248,022	6,886	8,076	141	14,525	12104	off	off	off	56	NA	
	07/16/04	7.0	908.9	248,136	6,947	8,137	122	14,647	12206	3.0	3.0	62	56	6	
	07/17/04	11.7	920.6	248,328	7,046	8,237	199	14,846	12372	off	off	off	52	NA	
	07/18/04	9.0	929.6	248,468	7,120	8,311	148	14,994	12495	off	off	off	52	NA	
27	07/19/04	8.7	938.3	248,609	7,194	8,385	148	15,142	12618	off	off	off	52	NA	
	07/20/04	9.5	947.8	248,763	7,274	8,466	161	15,303	12753	3.5	3.5	61	54	7	
	07/21/04	6.7	954.5	248,872	7,332	8,522	114	15,417	12848	4.0	4.0	68	60	8	
	07/22/04	12.1	966.6	249,069	7,456	8,626	228	15,645	13038	off	off	off	56	NA	
	07/23/04	8.2	974.8	249,197	7,501	8,694	113	15,758	13132	off	off	off	54	NA	
	07/24/04	9.9	984.7	249,349	7,580	8,774	159	15,917	13264	off	off	NM	NM	NA	
	07/25/04	3.8	988.5	249,418	7,651	8,811	108	16,025	13354	5.5	5.5	65	54	11	
28	07/26/04	8.2	996.7	249,549	7,685	8,882	105	16,130	13442	6.5	6.5	65	52	13	
	07/27/04	5.6	1002.3	249,625	7,727	8,924	84	16,214	13512	3.0	3.0	60	54	6	
	07/28/04	14.8	1017.1	249,697	7,765	8,961	75	16,289	13574	off	off	off	56	NA	
	07/29/04	6.2	1023.3	249,798	7,820	9,013	107	16,396	13663	off	off	off	58	NA	
	07/30/04	7.5	1030.8	249,918	7,887	9,072	126	16,522	13768	off	off	off	58	NA	
	07/31/04	5.4	1036.2	250,003	7,934	9,114	89	16,611	13843	3.5	3.5	59	52	7	
	08/01/04	6.6	1042.8	250,112	7,997	9,166	115	16,726	13938	off	off	off	56	NA	
29	08/02/04	4.3	1047.1	250,191	8,041	9,205	83	16,809	14008	4.0	4.0	64	56	8	
	08/03/04	7.8	1054.9	250,310	8,109	9,261	124	16,933	14111	off	off	off	54	NA	
	08/04/04	5.2	1060.1	250,402	8,159	9,308	97	17,030	14192	4.5	4.5	61	52	9	
	08/05/04	9.9	1070.0	250,554	8,246	9,380	159	17,189	14324	off	off	off	56	NA	
	08/06/04	9.0	1079.0	250,647	8,300	9,414	88	17,277	14398	5.6	5.6	66	56	10	
	08/07/04	8.1	1087.1	250,778	8,376	9,486	148	17,425	14521	off	off	off	52	NA	
	08/08/04	8.4	1095.5	250,915	8,446	9,559	143	17,568	14640	off	off	off	56	11	
30	08/09/04	7.7	1103.2	251,038	8,495	9,640	130	17,698	14748	9.5	3.0	66	52	14	
	08/10/04	8.5	1111.7	251,177	8,572	9,708	145	17,843	14869	off	off	off	50	NA	
	08/11/04	8.5	1120.2	251,317	8,647	9,803	170	18,013	15011	off	off	off	56	NA	
	08/12/04	7.1	1127.3	251,423	8,704	9,834	88	18,101	15084	3.0	3.0	64	58	6	
	08/13/04	5.9	1133.2	251,528	8,760	9,888	110	18,211	15176	off	off	off	56	NA	
	08/14/04	4.3	1137.5	251,600	8,796	9,924	72	18,283	15236	off	off	off	54	NA	
	08/15/04	4.0	1141.5	251,665	8,831	9,957	68	18,351	15293	off	off	off	53	NA	

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House						Instrument Panel							
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
31	08/16/04	3.4	1144.9	251,721	8,864	9,986	62	18,413	15344	off	off	off	60	NA	
	08/17/04	3.2	1148.1	251,774	8,892	10,013	55	18,468	15390	off	off	off	58	NA	
	08/18/04	2.0	1150.1	251,807	8,910	10,030	35	18,503	15419	6.0	6.0	64	52	12	
	08/19/04	4.8	1154.9	251,885	8,948	10,073	81	18584	15487	off	off	off	58	NA	
	08/20/04	4.3	1159.2	251,954	8,982	10,112	73	18657	15548	off	off	off	60	NA	
	08/21/04	4.8	1164.0	252,034	9,026	10,152	84	18741	15618	off	off	off	58	NA	
	08/22/04	4.8	1168.8	252,112	9,069	10,190	81	18822	15685	off	off	off	56	NA	
32	08/23/04	5.9	1174.7	252,209	9,123	10,238	102	18924	15770	5.0	5.0	64	54	10	
	08/24/04	10.4	1185.1	252,376	9,216	10,319	174	19098	15915	5.0	5.0	62	52	10	
	08/25/04	3.8	1188.9	252,437	9,249	10,349	63	19161	15968	off	off	off	58	NA	
	08/26/04	5.2	1194.1	252,523	9,282	10,425	109	19270	16058	off	off	off	56	NA	
	08/27/04	6.1	1200.2	252,622	9,322	10,470	85	19355	16129	off	off	off	54	NA	
	08/28/04	4.9	1205.1	252,703	9,365	10,511	84	19439	16199	off	off	off	60	NA	
	08/29/04	5.6	1210.7	252,795	9,414	10,558	96	19535	16279	off	off	off	60	NA	
33	08/30/04	4.9	1215.6	252,880	9,459	10,602	89	19624	16353	off	off	off	58	NA	
	08/31/04	5.5	1221.1	252,965	9,504	10,646	89	19713	16428	off	off	off	60	NA	
	09/01/04	5.9	1227.0	253,060	9,555	10,695	100	19813	16511	3.5	3.5	64	57	7	
	09/02/04	6.0	1233.0	253,167	9,611	10,750	111	19924	16603	off	off	off	60	NA	
	09/03/04	5.6	1238.6	253,250	9,656	10,793	88	20012	16677	off	off	off	58	NA	
	09/04/04	4.6	1243.2	253,326	9,697	10,831	79	20091	16743	off	off	off	56	NA	
	09/05/04	4.4	1247.6	253,397	9,736	10,867	75	20166	16805	off	off	off	54	NA	
34	09/06/04	4.5	1252.1	253,472	9,777	10,904	78	20244	16870	off	off	off	60	NA	
	09/07/04	5.5	1257.6	253,561	9,827	10,947	93	20337	16948	4.0	4.0	off	58	NA	
	09/08/04	4.9	1262.5	253,641	9,871	10,986	83	20420	17017	off	off	off	67	58	9
	09/09/04	5.2	1267.7	253,725	9,918	11,028	89	20509	17091	off	off	off	60	NA	
	09/10/04	5.5	1273.2	253,815	9,969	11,071	94	20603	17169	off	off	off	60	NA	
	09/11/04	5.3	1278.5	253,901	10,018	11,112	90	20693	17244	off	off	off	58	NA	
	09/12/04	6.3	1284.8	254,007	10,071	11,170	111	20804	17337	off	off	off	60	NA	
35	09/13/04	5.8	1290.6	254,101	10,120	11,219	98	20902	17418	3.0	3.0	off	58	NA	
	09/14/04	4.9	1295.5	254,181	10,163	11,261	85	20987	17489	3.0	3.0	off	60	NA	
	09/15/04	5.7	1301.2	254,275	10,212	11,309	97	21084	17570	3.5	4.0	58	50	8	
	09/16/04	5.5	1306.7	254,365	10,261	11,355	95	21179	17649	4.5	5.0	off	58	NA	
	09/17/04	6.0	1312.7	254,465	10,313	11,407	104	21283	17736	4.5	5.0	off	58	NA	
	09/18/04	5.7	1318.4	254,556	10,361	11,454	95	21378	17815	off	off	off	60	NA	
	09/19/04	5.2	1323.6	254,641	10,408	11,496	89	21467	17889	off	off	off	58	NA	
36	09/20/04	3.8	1327.4	254,704	10,439	11,526	61	21528	17940	off	off	off	58	NA	
	09/21/04	3.6	1331.0	254,767	10,477	11,554	66	21594	17995	off	off	off	60	NA	
	09/22/04	4.3	1335.3	254,833	10,513	11,592	74	21668	18057	off	off	off	54	NA	
	09/23/04	3.7	1339.0	254,894	10,545	11,624	64	21732	18110	off	off	off	58	NA	
	09/24/04	4.2	1343.2	254,965	10,582	11,660	73	21805	18171	off	off	off	60	NA	
	09/25/04	3.9	1347.1	255,028	10,615	11,693	66	21871	18226	off	off	off	56	NA	
	09/26/04	3.4	1350.5	255,090	10,648	11,737	77	21948	18290	off	off	off	60	NA	
37	09/27/04	4.0	1354.5	255,150	10,680	11,737	32	21980	18317	off	off	off	60	NA	
	09/28/04	4.3	1358.8	255,221	10,719	11,792	94	22074	18395	4.0	4.0	64	56	8	
	09/29/04	6.4	1365.2	255,324	10,776	11,842	107	22181	18484	6.0	6.0	72	60	12	
	09/30/04	5.4	1370.6	255,411	10,823	11,887	92	22273	18561	7.0	7.0	78	58	20	
	10/01/04	1.6	1372.2	255,439	10,835	11,904	29	22302	18585	off	off	off	56	NA	
	10/02/04	5.5	1377.7	255,530	10,882	11,952	95	22397	18664	off	off	off	58	NA	
	10/03/04	4.6	1382.3	255,606	10,922	11,991	79	22476	18730	off	off	off	56	NA	
38	10/04/04	3.5	1385.8	255,663	10,951	12,021	59	22535	18779	off	off	off	58	NA	
	10/05/04	4.3	1390.1	255,733	10,988	12,057	73	22608	18840	off	off	off	60	NA	
	10/06/04	3.5	1393.6	255,793	11,020	12,088	63	22671	18893	off	off	off	56	NA	
	10/07/04	4.0	1397.6	255,857	11,054	12,122	68	22739	18949	off	off	off	60	NA	
	10/08/04	3.5	1401.1	255,916	11,085	12,152	61	22800	19000	off	off	off	60	NA	
	10/09/04	4.0	1405.1	255,982	11,120	12,186	69	22869	19058	off	off	off	56	NA	
	10/10/04	4.1	1409.2	256,047	11,155	12,219	68	22937	19114	off	off	off	54	NA	
39	10/11/04	3.7	1412.9	256,110	11,188	12,251	65	23002	19168	off	off	off	60	NA	
	10/12/04	3.5	1416.4	256,176	11,223	12,285	69	23071	19226	off	off	off	58	NA	
	10/13/04	4.8	1421.2	256,247	11,261	12,321	74	23145	19288	5.0	5.0	66	56	10	
	10/14/04	6.2	1427.4	256,347	11,313	12,373	104	23249	19374	5.0	5.0	off	58	NA	
	10/15/04	3.4	1430.8	256,403	11,337	12,408	59	23308	19423	5.0	5.0	off	60	NA	
	10/16/04	3.1	1433.9	256,454	11,358	12,441	54	23362	19468	off	off	off	60	NA	
	10/17/04	3.7	1437.6	256,515	11,382	12,481	64	23426	19522	off	off	off	56	NA	
40	10/18/04	3.5	1441.1	256,573	11,402	12,520	59	23485	19571	off	off	off	58	NA	
	10/19/04	3.7	1444.8	256,633	11,423	12,551	62	23547	19623	off	off	off	58	NA	
	10/20/04	3.3	1448.1	256,696	11,445	12,606	67	23614	19678	off	off	off	56	NA	
	10/21/04	5.4	1453.5	256,776	11,485	12,649	83	23697	19748	off	off	off	58	NA	
	10/22/04	3.3	1456.8	256,830	11,513	12,673	52	23749	19791	off	off	off	60	NA	
	10/23/04	2.9	1459.7	256,879	11,538	12,703	55	23804	19837	off	off	off	60	NA	
	10/24/04	4.1	1463.8	256,946	11,573	12,738	70	23874	19895	off	off	off	58	NA	

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House						Instrument Panel							
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
41	10/25/04	3.9	1467.7	257,011	11,607	12,772	68	23942	19952	off	off	off	60	NA	
	10/26/04	2.4	1470.1	257,061	11633	12798	52	23994	19995	off	off	off	58	NA	
	10/27/04	9.1	1479.2	257,199	11,705	12,878	152	24146	20122	off	off	off	54	NA	
	10/28/04	6.4	1485.6	257,304	11,761	12,925	103	24249	20208	off	off	off	54	NA	
	10/29/04	5.4	1491.0	257,393	11,807	12,970	91	24340	20283	off	off	off	52	NA	
	10/30/04	6.0	1497.0	257,490	11,855	13,024	102	24442	20368	off	off	off	56	NA	
	10/31/04	3.3	1500.3	257,545	11,877	13,059	57	24499	20416	off	off	off	56	NA	
42	11/01/04	5.9	1506.2	257,641	11,911	13,120	95	24594	20495	off	off	off	56	NA	
	11/02/04	2.8	1509.0	257,687	11935	13149	53	24647	20539	off	off	off	58	NA	
	11/03/04	3.6	1512.6	257,747	11,961	13,186	63	24710	20592	5.0	4.0	65	55	9	
	11/04/04	7.7	1520.3	257,875	12,019	13,259	131	24841	20701	off	off	off	56	NA	
	11/05/04	5.9	1526.2	257,969	12,063	13,316	101	24942	20785	off	off	off	58	NA	
	11/06/04	3.0	1529.2	258,018	12,085	13,344	50	24992	20827	5.0	5.0	64	54	9	
	11/07/04	6.7	1535.9	258,126	12,133	13,410	114	25106	20922	off	off	off	54	NA	
43	11/08/04	6.2	1542.1	258,227	12,177	13,471	105	25211	21009	2.5	5.0	63.5	56	7.5	
	11/09/04	4.1	1546.2	258,295	12214	13,506	72	25283	21069	off	off	off	56	NA	
	11/10/04	6.4	1552.6	258,401	12,269	13,561	110	25393	21161	off	off	off	52	NA	
	11/11/04	5.5	1558.1	258,490	12,315	13,608	93	25486	21238	off	off	off	56	NA	
	11/12/04	3.2	1561.3	258,544	12,343	13,636	56	25542	21285	off	off	off	58	NA	
	11/13/04	0.9	1562.2	258,599	12,371	13,664	56	25598	21332	off	off	off	56	NA	
	11/14/04	8.8	1571.0	258,702	12,423	13,722	110	25708	21423	off	off	off	56	NA	
44	11/15/04	2.9	1573.9	258,749	12,448	13,748	51	25759	21466	off	off	off	58	NA	
	11/16/04	3.0	1576.9	258,797	12474	13772	50	25809	21508	off	off	off	56	NA	
	11/17/04	3.9	1580.8	258,859	12,507	13,808	69	25878	21565	11.0	11.0	80	58	22	
	11/18/04	5.6	1586.4	258,951	12,555	13,850	90	25968	21640	off	off	off	56	NA	
	11/19/04	5.4	1591.8	259,040	12,602	13,897	94	26062	21718	3.0	3.0	70	64	6	
	11/20/04	3.4	1595.2	259,096	12,632	13,926	59	26121	21768	off	off	off	60	NA	
	11/21/04	3.2	1598.4	259,148	12,659	13,952	53	26174	21812	off	off	off	60	NA	
45	11/22/04	2.9	1601.3	259,195	12,685	13,976	50	26224	21853	off	off	off	60	NA	
	11/23/04	2.6	1603.9	259,239	12710	13996	45	26269	21891	off	off	off	56	NA	
	11/24/04	3.0	1606.9	259,286	12,737	14,017	48	26317	21931	off	off	off	58	NA	
	11/25/04	2.8	1609.7	259,333	12,765	14,039	50	26367	21973	off	off	off	60	NA	
	11/26/04	2.9	1612.6	259,377	12,788	14,062	46	26413	22011	off	off	off	60	NA	
	11/27/04	2.5	1615.1	259,418	12,808	14,085	43	26456	22047	off	off	off	58	NA	
	11/28/04	3.3	1618.4	259,469	12,832	14,114	53	26509	22091	off	off	off	58	NA	
46	11/29/04	2.8	1621.2	259,517	12,857	14,138	49	26558	22132	off	off	off	56	NA	
	11/30/04	3.0	1624.2	259,565	12,883	14,164	52	26610	22175	off	off	off	56	NA	
	12/01/04	3.9	1628.1	259,631	12,917	14,197	67	26677	22231	4.0	4.0	66	58	NA	
	12/02/04	7.5	1635.6	259,756	12,982	14,262	130	26807	22339	off	off	off	54	NA	
	12/03/04	4.9	1640.5	259,833	13,022	14,301	79	26886	22405	off	off	off	58	NA	
	12/04/04	4.5	1645.0	259,907	13,063	14,338	78	26964	22470	off	off	off	60	NA	
	12/05/04	3.1	1648.1	259,957	13,091	14,362	52	27016	22513	off	off	off	60	NA	
47	12/06/04	1.2	1649.3	259,976	13,101	14,372	20	27036	22530	12.0	12.0	80	54	26	
	12/07/04	3.9	1653.2	260,052	13,142	14,411	80	27116	22597	off	off	off	60	NA	
	12/08/04	2.4	1655.6	260,082	13,158	14,426	31	27147	22623	off	off	off	54	NA	
	12/09/04	3.6	1659.2	260,141	13,189	14,456	61	27208	22673	off	off	off	52	NA	
	12/10/04	3.3	1662.5	260,197	13,218	14,485	58	27266	22722	off	off	off	60	NA	
	12/11/04	3.0	1665.5	260,246	13,245	14,510	52	27318	22765	off	off	off	58	NA	
	12/12/04	3.4	1668.9	260,302	13,275	14,537	57	27375	22813	off	off	off	58	NA	
48	12/13/04	3.2	1672.1	260,354	13,305	14,561	54	27429	22858	off	off	off	58	NA	
	12/14/04	3.1	1675.2	260,403	13,325	14,583	42	27471	22893	off	off	off	56	NA	
	12/15/04	3.2	1678.4	260,455	13,367	14,615	74	27545	22954	10.0	10.0	78	58	20	
	12/16/04	4.0	1682.4	260,538	13,412	14,646	76	27621	23018	off	off	off	54	NA	
	12/17/04	4.2	1686.6	260,589	13,439	14,672	53	27674	23062	off	off	off	56	NA	
	12/18/04	3.0	1689.6	260,640	13,466	14,698	53	27727	23106	off	off	off	60	NA	
	12/19/04	3.1	1692.7	260,692	13,493	14,724	53	27780	23150	off	off	off	54	NA	
49	12/20/04	3.3	1696.0	260,796	13,523	14,751	57	27837	23198	off	off	off	52	NA	
	12/21/04	4.0	1700.0	260,811	13,561	14,781	68	27905	23254	10.0	10.0	80	60	20	
	12/22/04	3.8	1703.8	260,870	13,595	14,808	61	27966	23305	off	off	off	56	NA	
	12/23/04	3.3	1707.1	260,927	13,625	14,837	59	28025	23354	off	off	off	56	NA	
	12/24/04	3.3	1710.4	260,982	13,654	14,866	58	28083	23403	off	off	off	52	NA	
	12/25/04	7.3	1717.7	261,102	13,719	14,925	124	28207	23506	off	off	off	58	NA	
	12/26/04	2.8	1720.5	261,163	13,755	14,953	64	28271	23559	10.0	10.0	78	58	20	
50	12/27/04	2.9	1723.4	261,195	13,774	14,968	34	28305	23588	12.0	12.0	80	56	24	
	12/28/04	6.7	1730.1	261,305	13,832	15,023	113	28418	23682	off	off	off	52	NA	
	12/29/04	6.8	1736.9	261,417	13,892	15,080	117	28535	23779	5.0	5.0	70	60	10	
	12/30/04	3.3	1740.2	261,472	13,921	15,108	57	28592	23827	7.0	7.0	76	62	14	
	12/31/04	3.6	1743.8	261,530	13,953	15,137	61	28653	23878	10.0	10.0	82	62	20	
	01/01/05	6.3	1750.1	261,634	14,009	15,189	108	28761	23968	3.0	3.0	70	64	6	
	01/02/05	4.1	1754.2	261,702	14,045	15,224	71	28832	24027	off	off	off	58	NA	

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House							Instrument Panel						
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
51	01/03/05	3.2	1757.4	261,755	14,075	15,224	30	28862	24052	7.0	7.0	74	60	14	
	01/04/05	3.4	1760.8	261,812	14,105	15,278	84	28946	24122	off	off	off	62	NA	
	01/05/05	0.7	1761.5	261,823	14,112	15,283	12	28958	24132	11.0	11.0	78	56	22	
	01/06/05	2.3	1763.8	261,863	14,135	15,301	41	28999	24166	12.0	12.0	76	52	24	
	01/07/05	3.4	1767.2	261,920	14,168	15,327	59	29058	24215	10.0	10.0	72	52	20	
	01/08/05	4.9	1772.1	262,001	14,212	15,368	85	29143	24286	off	off	off	58	NA	
	01/09/05	6.8	1778.9	262,112	14,270	15,425	115	29258	24382	off	off	off	56	NA	
52	01/10/05	3.1	1782.0	262,164	14,298	15,452	55	29313	24428	4.0	4.0	64	56	8	
	01/11/05	3.8	1785.8	262,227	14,331	15,484	65	29378	24482	off	off	off	58	NA	
	01/12/05	7.8	1793.6	262,352	14,397	15,549	131	29509	24591	6.0	6.0	70	58	12	
	01/13/05	6.7	1800.3	262,464	14,453	15,605	112	29621	24684	off	off	off	62	NA	
	01/14/05	3.3	1803.6	262,518	14,483	15,634	59	29680	24733	off	off	off	56	NA	
	01/15/05	3.4	1807.0	262,573	14,512	15,662	57	29737	24781	off	8.0	off	56	NA	
	01/16/05	8.0	1815.0	262,691	14,569	15,727	122	29859	24883	8.0	8.0	68	52	16	
53	01/17/05	3.9	1818.9	262,738	14,591	15,755	50	29909	24924	10.0	10.0	72	52	20	
	01/18/05	4.0	1822.9	262,804	14,625	15,788	67	29976	24980	3.0	3.0	62	56	6	
	01/19/05	5.6	1828.5	262,898	14,674	15,836	97	30073	25061	off	off	off	58	NA	
	01/20/05	2.9	1831.4	262,944	14,699	15,861	50	30123	25103	3.0	3.0	64	58	6	
	01/21/05	6.9	1838.3	263,060	14,759	15,928	127	30250	25208	off	off	off	56	NA	
	01/22/05	1.7	1840.0	263,103	14,782	15,942	37	30287	25239	off	off	off	58	NA	
	01/23/05	4.1	1844.1	263,155	14,809	15,969	54	30341	25284	5.0	5.0	66	50	16	
54	01/24/05	4.0	1848.1	263,203	14,835	15,994	51	30392	25327	off	5.0	off	58	NA	
	01/25/05	3.1	1851.2	263,254	14,862	16,019	52	30444	25370	8.0	8.0	70	56	14	
	01/26/05	3.5	1854.7	263,311	14,893	16,046	58	30502	25418	9.0	9.0	76	58	18	
	01/27/05	1.1	1855.8	263,330	14,905	16,056	22	30524	25437	off	off	off	58	NA	
	01/28/05	1.2	1857.0	263,349	14,915	16,065	19	30543	25453	off	off	off	56	NA	
	01/29/05	3.1	1860.1	263,399	14,941	16,090	51	30594	25495	3.0	3.0	62	58	4	
	01/30/05	3.0	1863.1	263,451	14,969	16,117	55	30649	25541	off	off	off	56	NA	
55	01/31/05	3.0	1866.1	263,501	14,995	16,142	51	30700	25583	4.0	4.0	64	56	8	
	02/01/05	3.5	1869.6	263,559	15,026	16,171	60	30760	25633	off	off	off	56	NA	
	02/02/05	3.6	1873.2	263,619	15,058	16,200	61	30821	25684	5.0	5.0	66	56	10	
	02/03/05	8.5	1881.7	263,756	15,135	16,267	144	30965	25804	6.0	6.0	78	66	12	
	02/04/05	3.9	1885.6	263,820	15,171	16,297	66	31031	25859	off	off	off	60	NA	
	02/05/05	2.6	1888.2	263,860	15,194	16,316	42	31073	25894	10.0	10.0	82	62	20	
	02/06/05	0.8	1889.0	263,876	15,204	16,323	17	31090	25908	off	off	off	58	NA	
56	02/07/05	0.0	1889.0	263,876	15,204	16,323	0	31090	25908	10.0	10.0	80	60	20	
	02/08/05	6.3	1895.3	263,981	15,259	16,377	109	31199	25999	5.0	5.0	70	60	10	
	02/09/05	4.2	1899.5	264,045	15,295	16,407	66	31265	26054	off	off	off	56	NA	
	02/10/05	2.4	1901.9	264,089	15,324	16,425	47	31312	26093	5.0	5.0	72	62	10	
	02/11/05	3.1	1905.0	264,140	15,387	16,444	82	31394	26162	off	off	off	56	NA	
	02/12/05	4.1	1909.1	264,210	15,395	16,479	43	31437	26198	off	off	off	56	NA	
	02/13/05	4.1	1913.2	264,277	15,480	16,538	144	31581	26318	off	off	off	58	NA	
57	02/14/05	4.4	1917.6	264,345	15,480	16,538	0	31581	26318	12.0	12.0	90	66	24	
	02/15/05	4.7	1922.3	264,424	15,524	16,574	80	31661	26384	3.0	3.0	70	64	6	
	02/16/05	0.2	1922.5	264,427	15,525	16,576	3	31664	26387	3.0	3.0	60	54	6	
	02/17/05	6.6	1929.1	264,536	15,582	16,631	112	31776	26480	6.0	6.0	68	56	12	
	02/18/05	4.3	1933.4	264,607	15,619	16,669	75	31851	26543	10.0	10.0	78	58	20	
	02/19/05	3.9	1937.3	264,671	15,655	16,703	70	31921	26601	off	off	off	off	NA	
	02/20/05	0.0	1937.3	264,671	15,655	16,703	0	31921	26601	off	off	off	off	NA	
58	02/21/05	2.1	1939.4	264,706	15,675	16,719	36	31957	26631	5.0	5.0	70	60	10	
	02/22/05	5.5	1944.9	264,797	15,727	16,762	95	32052	26710	off	off	off	56	NA	
	02/23/05	7.2	1952.1	264,914	15,797	16,814	122	32174	26812	10.0	10.0	74	54	20	
	02/24/05	7.3	1959.4	265,033	15,865	16,869	123	32297	26914	3.0	3.0	62	56	6	
	02/25/05	6.2	1965.6	265,135	15,919	16,919	104	32401	27001	off	off	off	58	NA	
	02/26/05	5.2	1970.8	265,221	15,967	16,961	90	32491	27076	off	off	off	58	NA	
	02/27/05	5.3	1976.1	265,307	16,015	17,003	90	32581	27151	10.0	10.0	82	62	20	
59	02/28/05	2.4	1978.5	265,346	16,039	17,021	42	32623	27186	10.0	10.0	80	60	20	
	03/01/05	8.4	1986.9	265,485	16,112	17,091	143	32766	27305	3.0	3.0	68	62	6	
	03/02/05	5.9	1992.8	265,582	16,163	17,139	99	32865	27388	off	off	off	58	NA	
	03/03/05	7.3	2000.1	265,700	16,227	17,198	123	32988	27490	off	off	off	56	NA	
	03/04/05	7.5	2007.6	265,821	16,292	17,253	120	33108	27590	4.0	4.0	68	60	8	
	03/05/05	5.3	2012.9	265,910	16,339	17,304	98	33206	27672	off	off	off	58	NA	
	03/06/05	7.7	2020.6	266,039	16,409	17,368	134	33340	27783	6.0	6.0	76	64	12	
60	03/07/05	2.8	2023.4	266,091	16,438	17,393	54	33394	27828	7.0	7.0	74	60	14	
	03/08/05	8.0	2031.4	266,209	16,505	17,448	122	33516	27930	10.0	10.0	82	62	20	
	03/09/05	9.8	2041.2	266,369	16,591	17,528	166	33682	28068	3.0	3.0	62	56	6	
	03/10/05	5.5	2046.7	266,460	16,638	17,575	94	33776	28147	off	off	off	62	NA	
	03/11/05	2.9	2049.6	266,509	16,664	17,600	51	33827	28189	5.0	5.0	64	54	10	
	03/12/05	5.0	2054.6	266,591	16,706	17,642	84	33911	28259	off	off	off	62	NA	
	03/13/05	4.8	2059.4	266,666	16,743	17,683	78	33989	28324	15.0	15.0	90	60	30	

Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System Operation Log Sheet (Continued)

Week No.	Date	Pump House							Instrument Panel						
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
71	05/23/05	15.4	2643.7	275,956	21,649	22,369	249	43,581	36318	10.0	10.0	80	60	20	
	05/24/05	13.4	2657.1	276,169	21,764	22,472	218	43,799	36499	3.0	3.0	62	56	6	
	05/25/05	12.4	2669.5	276,368	21,869	22,571	204	44,003	36669	4.0	4.0	60	54	6	
	05/26/05	12.7	2682.2	276,569	21,983	22,663	206	44,209	36841	off	off	off	56	NA	
	05/27/05	9.1	2691.3	276,706	22,063	22,733	150	44,359	36966	off	off	off	54	NA	
	05/28/05	6.7	2698.0	276,789	22,102	22,771	77	44,436	37030	5.0	5.0	62	52	10	
	05/29/05	5.7	2703.7	276,881	22,150	22,817	94	44,530	37108	6.0	6.0	66	54	12	
72	05/30/05	6.0	2709.7	276,978	22,201	22,865	99	44,629	37191	off	off	off	54	NA	
	05/31/05	11.3	2721.0	277,160	22,297	22,956	187	44,816	37347	3.0	3.0	62	56	6	
	06/01/05	9.3	2730.3	277,309	22,377	23,028	152	44,968	37473	off	off	off	56	NA	
	06/02/05	13.7	2744.0	277,527	22,495	23,133	223	45,191	37659	off	off	off	58	NA	
	06/03/05	19.0	2763.0	277,653	22,565	23,192	129	45,320	37767	10.0	10.0	76	56	20	
	06/04/05	10.8	2773.8	277,826	22,656	23,279	178	45,498	37915	3.0	3.0	60	54	6	
	06/05/05	22.9	2796.7	277,946	22,719	23,339	123	45,621	38018	4.0	4.0	62	54	8	
73	06/06/05	17.1	2813.8	278,188	22,847	23,458	247	45,868	38223	7.0	7.0	70	56	14	
	06/07/05	8.9	2822.7	278,324	22,923	23,527	145	46,013	38344	10.0	10.0	74	54	20	
	06/08/05	12.1	2834.8	278,523	23,024	23,624	198	46,211	38509	off	off	off	58	NA	
	06/09/05	14.0	2848.8	278,745	23,143	23,734	229	46,440	38700	off	off	off	56	NA	
	06/10/05	10.4	2859.2	278,907	23,231	23,812	166	46,606	38838	10.0	10.0	76	56	10	
	06/11/05	11.3	2870.5	279,087	23,326	23,902	185	46,791	38993	off	off	off	54	NA	
	06/12/05	10.1	2880.6	279,249	23,412	23,982	166	46,957	39131	5.0	5.0	64	54	10	
74	06/13/05	10.1	2890.7	279,409	23,502	24,057	165	47,122	39268	6.0	6.0	66	54	12	
	06/14/05	13.7	2904.4	279,620	23,629	24,147	217	47,339	39449	10.0	10.0	76	56	20	
	06/15/05	11.7	2916.1	279,808	23,727	24,241	192	47,531	39609	off	off	off	56	NA	
	06/16/05	13.7	2929.8	280,026	23,842	24,350	224	47,755	39796	5.0	5.0	64	54	NA	
	06/17/05	13.3	2943.1	280,235	23,953	24,454	215	47,970	39975	10.0	10.0	76	56	20	
	06/18/05	12.5	2955.6	280,432	24,058	24,551	202	48,172	40143	off	off	off	58	NA	
	06/19/05	9.4	2965.0	280,581	24,137	24,624	152	48,324	40270	6.0	6.0	66	54	12	
75	06/20/05	11.3	2976.3	280,759	24,242	24,701	182	48,506	40422	10.0	10.0	76	56	20	
	06/21/05	9.6	2985.9	280,912	24,327	24,775	159	48,665	40554	off	off	off	54	NA	
	06/22/05	7.9	2993.8	281,038	24,394	24,837	129	48,794	40662	5.0	5.0	64	54	10	
	06/23/05	15.0	3008.8	281,273	24,523	24,949	241	49,035	40863	off	off	off	60	NA	
	06/24/05	9.5	3018.3	281,424	24,604	25,027	159	49,194	40995	3.0	3.0	66	60	6	
	06/25/05	10.7	3029.0	281,593	24,701	25,100	170	49,364	41137	10.0	10.0	80	60	20	
	06/26/05	10.2	3039.2	281,753	24,797	25,168	164	49,528	41273	off	off	off	60	NA	
76	06/27/05	11.3	3050.5	281,931	24,893	25,255	183	49,711	41426	5.0	5.0	70	60	10	
	06/28/05	12.1	3062.6	282,122	24,994	25,350	196	49,907	41589	off	off	off	58	NA	
	06/29/05	13.2	3075.8	282,327	25,117	25,439	212	50,119	41766	10.0	10.0	74	54	20	
	06/30/05	14.3	3090.1	282,548	25,237	25,544	225	50,344	41953	6.0	6.0	68	56	12	
	07/01/05	20.4	3110.5	282,859	25,410	25,689	318	50,662	42218	off	off	off	60	NA	
	07/02/05	10.2	3120.7	283,015	25,507	25,754	162	50,824	42353	5.0	5.0	68	58	10	
	07/03/05	11.3	3132.0	283,191	25,602	25,838	179	51,003	42503	off	off	off	58	NA	
77	07/04/05	12.5	3144.5	283,383	25,708	25,929	197	51,200	42667	10.0	10.0	74	54	20	
	07/05/05	16.0	3160.5	283,626	25,839	26,047	249	51,449	42874	off	off	off	58	NA	
	07/06/05	10.0	3170.5	283,783	25,922	26,123	159	51,608	43007	6.0	6.0	66	54	12	
	07/07/05	10.7	3181.2	283,947	26,013	26,200	168	51,776	43147	10.0	10.0	76	56	20	
	07/08/05	12.0	3193.2	284,126	26,112	26,285	184	51,960	43300	4.0	4.0	64	58	6	
	07/09/05	9.5	3202.7	284,253	26,183	26,344	130	52,090	43408	5.0	5.0	68	58	10	
	07/10/05	10.5	3213.2	284,407	26,260	26,427	160	52,250	43542	off	off	off	60	NA	
78	07/11/05	5.7	3218.9	284,496	26,306	26,478	97	52,347	43623	25.0	25.0	110	60	50	
	07/12/05	6.5	3225.4	284,596	26,364	26,516	96	52,443	43703	15.0	15.0	80	50	30	
	07/13/05	7.1	3232.5	284,710	26,424	26,574	118	52,561	43801	14.0	14.0	86	58	28	
	07/14/05	5.1	3237.6	284,793	26,466	26,616	84	52,645	43871	off	off	off	off	NA	
	07/15/05														
	07/16/05														
	07/17/05														
79	07/18/05														
	07/19/05														
	07/20/05														
	07/21/05														
	07/22/05														
80	07/23/05														
	07/24/05														
	07/25/05														
	07/26/05														
	07/27/05														
	07/28/05														
	07/29/05	NA	NA	285,730	26,488	26,638	NA	NA	NA	3.0	3.0	60	54	6	
07/30/05	10.8	10.8	285,903	26,576	26,724	174	174	188	off	off	off	58	NA		
07/31/05	7.1	17.9	286,014	26,632	26,782	114	288	310	6.0	6.0	64	52	12		

System was switched off from 07/14/05 through 07/28/05. The bottom laterals, under bedding, and media were replaced and other system repairs were performed during the down time.

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House					Instrument Panel								
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
81	08/01/05	8.1	26.0	286,141	26,698	26,846	130	418	450	9.0	9.0	70	52	18	
	08/02/05	7.7	33.7	286,261	26,760	26,906	122	540	582	10.0	10.0	76	56	20	
	08/03/05	12.4	46.1	286,456	26,860	27,006	200	740	797	3.0	3.0	62	56	6	
	08/04/05	11.8	57.9	286,642	26,952	27,106	192	932	1004	off	off	off	58	NA	
	08/05/05	6.2	64.1	286,742	26,997	27,161	100	1,032	1112	9.0	9.0	78	60	18	
	08/06/05	8.4	72.5	286,875	27,068	27,229	139	1,171	1262	off	off	off	58	NA	
	08/07/05	9.1	81.6	287,021	27,142	27,305	150	1,321	1423	3.0	3.0	66	60	6	
82	08/08/05	10.9	92.5	287,194	27,229	27,395	177	1,498	1614	off	off	off	60	NA	
	08/09/05	5.9	98.4	287,288	27,274	27,445	95	1,593	1717	off	off	off	56	NA	
	08/10/05	9.1	107.5	287,433	27,349	27,532	162	1,755	1891	3.5	3.5	61	54	7	
	08/11/05	13.9	121.4	287,653	27,459	27,648	226	1,981	2135	3.0	3.0	64	58	6	
	08/12/05	9.5	130.9	287,804	27,535	27,727	155	2,136	2302	3.0	3.0	60	54	6	
	08/13/05	8.9	139.8	287,936	27,603	27,794	135	2,271	2447	off	off	off	58	NA	
	08/14/05	7.7	147.5	288,058	27,662	27,868	133	2,404	2591	off	off	off	60	NA	
83	08/15/05	5.4	152.9	288,145	27,705	27,906	81	2,485	2678	9.0	9.0	74	56	18	
	08/16/05	5.0	157.9	288,224	27,744	27,947	80	2,565	2764	5.0	5.0	64	54	10	
	08/17/05	10.2	168.1	288,387	27,825	28,033	167	2,732	2944	9.0	9.8	74	56	18	
	08/18/05	14.1	182.2	288,609	27,936	28,147	225	2,957	3186	2.0	2.0	62	58	4	
	08/19/05	6.7	188.9	288,717	27,990	28,201	108	3,065	3303	off	off	off	58	NA	
	08/20/05	6.9	195.8	288,826	28,043	28,260	112	3,177	3423	off	off	off	60	NA	
	08/21/05	9.6	205.4	288,981	28,121	28,340	158	3,335	3594	4.0	4.0	62	54	8	
84	08/22/05	8.7	214.1	289,117	28,192	28,406	137	3,472	3741	5.0	5.0	68	58	10	
	08/23/05	8.1	222.2	289,245	28,259	28,470	131	3,603	3883	off	off	off	60	NA	
	08/24/05	8.2	230.4	289,374	28,323	28,537	131	3,734	4024	7.0	7.0	70	56	14	
	08/25/05	9.2	239.6	289,517	28,393	28,612	145	3,879	4180	off	off	off	54	NA	
	08/26/05	9.6	249.2	289,668	28,468	28,690	153	4,032	4345	8.0	8.0	74	58	16	
	08/27/05	13.1	262.3	289,872	28,569	28,795	206	4,238	4567	off	off	off	56	NA	
	08/28/05	9.7	272.0	290,024	28,645	28,874	155	4,393	4734	off	off	off	58	NA	
85	08/29/05	9.5	281.5	290,174	28,718	28,953	152	4,545	4898	9.0	9.0	74	56	18	
	08/30/05	5.0	286.5	290,252	28,756	28,994	79	4,624	4983	9.0	9.0	62	54	8	
	08/31/05	8.4	294.9	290,385	28,823	29,062	135	4,759	5128	2.0	2.0	60	50	10	
	09/01/05	10.2	305.1	290,549	28,905	29,146	166	4,925	5307	off	off	off	off	NA	
	09/02/05	7.9	313.0	290,674	28,966	29,211	126	5,051	5443	3.0	3.0	60	54	6	
	09/03/05	7.2	320.2	290,781	29,021	29,265	109	5,160	5560	off	off	off	54	NA	
	09/04/05	9.0	329.2	290,922	29,091	29,336	141	5,301	5712	off	off	off	58	NA	
86	09/05/05	6.2	335.4	291,019	29,139	29,388	100	5,401	5820	6.0	6.0	76	64	12	
	09/06/05	7.8	343.2	291,142	29,199	29,452	124	5,525	5954	off	off	off	58	NA	
	09/07/05	8.0	351.2	291,266	29,261	29,515	125	5,650	6088	8.0	8.0	70	54	16	
	09/08/05	7.3	358.5	291,383	29,323	29,572	119	5,769	6217	2.0	2.0	60	56	4	
	09/09/05	9.0	367.5	291,527	29,394	29,648	147	5,916	6375	off	off	off	58	NA	
	09/10/05	6.9	374.4	291,638	29,447	29,707	112	6,028	6496	off	off	off	58	NA	
	09/11/05	6.2	380.6	291,735	29,493	29,759	98	6,126	6601	6.0	6.0	68	56	12	
87	09/12/05	5.5	386.1	291,824	29,537	29,805	90	6,216	6698	7.0	7.0	68	54	14	
	09/13/05	5.5	391.6	291,911	29,580	29,850	88	6,304	6793	8.0	8.0	70	54	16	
	09/14/05	8.0	399.6	292,037	29,643	29,915	128	6,432	6931	8.0	8.0	72	56	16	
	09/15/05	7.7	407.3	292,159	29,704	29,978	124	6,556	7065	9.0	9.0	72	54	18	
	09/16/05	9.6	416.9	292,314	29,781	30,058	157	6,713	7234	off	off	off	58	NA	
	09/17/05	8.2	425.1	292,444	29,846	30,125	132	6,845	7376	off	off	off	60	NA	
	09/18/05	8.8	433.9	292,583	29,917	30,195	141	6,986	7528	6.0	6.0	72	60	12	
88	09/19/05	8.6	442.5	292,723	29,990	30,264	142	7,128	7681	off	off	off	58	NA	
	09/20/05	9.3	451.8	292,869	30,065	30,332	143	7,271	7835	8.0	8.0	70	54	16	
	09/21/05	9.6	461.4	293,014	30,154	30,410	167	7,438	8015	4.0	4.0	70	61	9	
	09/22/05	9.6	471.0	293,168	30,244	30,475	155	7,593	8182	3.0	3.0	62	56	6	
	09/23/05	9.7	480.7	293,319	30,335	30,538	154	7,747	8348	off	off	off	58	NA	
	09/24/05	9.1	489.8	293,461	30,407	30,618	152	7,899	8512	off	off	off	56	NA	
	09/25/05	9.9	499.7	293,618	30,498	30,679	152	8,051	8676	off	off	off	60	NA	
89	09/26/05	11.0	510.7	293,793	30,579	30,775	177	8,228	8866	6.0	6.0	68	56	12	
	09/27/05	10.9	521.6	293,964	30,657	30,870	173	8,401	9053	off	off	off	58	NA	
	09/28/05	7.8	529.4	294,087	30,714	30,938	125	8,526	9188	9.0	9.0	72	54	18	
	09/29/05	11.1	540.5	294,263	30,800	31,030	178	8,704	9379	2.0	2.0	58	54	4	
	09/30/05	7.4	547.9	294,381	30,859	31,091	120	8,824	9509	off	off	off	58	NA	
	10/01/05	7.5	555.4	294,500	30,918	31,152	120	8,944	9638	off	off	off	56	NA	
	10/02/05	9.3	564.7	294,645	30,988	31,238	156	9,100	9806	9.0	9.0	76	58	18	
90	10/03/05	9.3	574.0	294,793	31,053	31,314	141	9,241	9958	4.0	4.0	66	58	8	
	10/04/05	7.7	581.7	294,916	31,114	31,378	125	9,366	10093	6.0	5.0	65	54	11	
	10/05/05	5.3	587.0	294,983	31,149	31,411	68	9,434	10166	3.0	3.0	62	56	6	
	10/06/05	10.2	597.2	295,151	31,233	31,498	171	9,605	10350	off	off	off	58	NA	
	10/07/05	6.3	603.5	295,252	31,282	31,551	102	9,707	10460	5.0	5.0	66	56	10	
	10/08/05	8.6	612.1	295,388	31,346	31,624	137	9,844	10608	off	off	off	58	NA	
	10/09/05	7.7	619.8	295,510	31,420	31,676	126	9,970	10744	3.0	3.0	62	56	6	

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House							Instrument Panel						
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
91	10/10/05	8.2	628.0	295,572	31,449	31,708	81	10,031	10809	4.0	4.0	62	54	8	
	10/11/05	5.3	633.3	295,657	31,490	31,754	87	10,118	10903	off	off	off	58	NA	
	10/12/05	6.9	640.2	295,767	31,541	31,814	111	10,229	11023	9.0	9.0	76	58	18	
	10/13/05	8.1	648.3	295,898	31,605	31,882	132	10,361	11165	2.0	2.0	58	54	4	
	10/14/05	6.0	654.3	295,994	31,654	31,931	98	10,459	11270	off	off	off	58	NA	
	10/15/05	5.3	659.6	296,079	31,697	31,973	85	10,544	11362	off	off	off	56	NA	
	10/16/05	5.7	665.3	296,178	31,742	32,020	92	10,636	11461	off	off	off	54	NA	
92	10/17/05	5.5	670.8	296,257	31,784	32,065	87	10,723	11555	9.0	9.0	74	56	18	
	10/18/05	6.2	677.0	296,357	31,835	32,117	103	10,826	11666	2.0	2.0	58	54	4	
	10/19/05	6.9	683.9	296,468	31,891	32,173	112	10,938	11787	off	off	off	60	NA	
	10/20/05	4.4	688.3	296,538	31,937	32,215	88	11,026	11881	4.0	4.0	66	58	8	
	10/21/05	6.2	694.5	296,638	31,978	32,259	85	11,111	11973	6.0	6.0	70	58	12	
	10/22/05	8.7	703.2	296,778	32,064	32,325	152	11,263	12137	off	off	off	56	NA	
	10/23/05	6.3	709.5	296,878	32,109	32,372	92	11,355	12236	9.0	9.0	80	62	18	
93	10/24/05	4.4	713.9	296,947	32,145	32,405	69	11,424	12310	10.0	10.0	78	58	20	
	10/25/05	9.6	723.5	297,101	32,224	32,482	156	11,580	12478	off	off	off	58	NA	
	10/26/05	6.7	730.2	297,209	32,278	32,537	109	11,689	12596	4.0	4.0	64	56	8	
	10/27/05	6.9	737.1	297,318	32,333	32,592	110	11,799	12714	off	off	off	60	NA	
	10/28/05	11.0	748.1	297,483	32,416	32,678	169	11,968	12897	off	off	off	60	NA	
	10/29/05	6.3	754.4	297,599	32,475	32,738	119	12,087	13025	off	off	off	58	NA	
	10/30/05	8.0	762.4	297,728	32,540	32,803	130	12,217	13165	off	off	off	58	NA	
94	10/31/05	8.1	770.5	297,859	32,606	32,870	133	12,350	13308	4.0	4.0	70	62	8	
	11/01/05	5.4	775.9	297,937	32,645	32,910	79	12,429	13393	5.0	5.0	68	58	10	
	11/02/05	4.9	780.8	298,024	32,695	32,964	104	12,533	13505	off	off	off	56	NA	
	11/03/05	6.1	786.9	298,122	32,747	33,012	100	12,633	13613	off	off	off	56	NA	
	11/04/05	5.7	792.6	298,214	32,794	33,057	92	12,725	13712	6.0	6.0	70	58	12	
	11/05/05	7.1	799.7	298,327	32,853	33,113	115	12,840	13836	off	off	off	60	NA	
	11/06/05	5.9	805.6	298,423	32,901	33,161	96	12,936	13940	off	off	off	60	NA	
95	11/07/05	5.7	811.3	298,518	32,946	33,210	94	13,030	14041	6.0	6.0	68	56	12	
	11/08/05	6.5	817.8	298,616	32,996	33,262	102	13,132	14151	off	off	off	58	NA	
	11/09/05	5.6	823.4	298,707	33,035	33,315	92	13,224	14250	10.0	10.0	76	56	20	
	11/10/05	7.1	830.5	298,833	33,113	33,396	159	13,383	14421	off	off	off	58	NA	
	11/11/05	9.0	839.5	298,968	33,164	33,448	103	13,486	14532	off	off	off	58	NA	
	11/12/05	6.0	845.5	299,062	33,212	33,490	90	13,576	14629	4.0	4.0	64	56	8	
	11/13/05	6.0	851.5	299,159	33,259	33,549	106	13,682	14744	off	off	off	58	NA	
96	11/14/05	6.2	857.7	299,258	33,306	33,603	101	13,783	14852	off	off	off	60	NA	
	11/15/05	6.3	864.0	299,358	33,351	33,659	101	13,884	14961	7.0	7.0	72	58	14	
	11/16/05	5.5	869.5	299,445	33,388	33,709	87	13,971	15055	8.0	8.0	70	54	16	
	11/17/05	7.2	876.7	299,561	33,443	33,772	118	14,089	15182	off	off	off	58	NA	
	11/18/05	7.6	884.3	299,684	33,503	33,836	124	14,213	15316	4.0	4.0	64	56	8	
	11/19/05	7.7	892.0	299,807	33,562	33,906	129	14,342	15455	off	off	off	60	NA	
	11/20/05	5.4	897.4	299,894	33,603	33,949	84	14,426	15545	off	off	off	off	NA	
97	11/21/05	6.0	903.4	299,981	33,643	33,996	87	14,513	15639	5.0	5.0	68	58	10	
	11/22/05	3.9	907.3	300,053	33,672	34,039	72	14,585	15717	9.0	9.0	76	58	18	
	11/23/05	8.4	915.7	300,188	33,740	34,110	139	14,724	15866	off	off	off	60	NA	
	11/24/05	5.3	921.0	300,275	33,783	34,154	87	14,811	15960	off	off	off	62	NA	
	11/25/05	5.3	926.3	300,371	33,826	34,197	86	14,897	16053	off	off	off	60	NA	
	11/26/05	5.6	931.9	300,450	33,870	34,244	91	14,988	16151	5.0	5.0	66	56	10	
	11/27/05	5.4	937.3	300,543	33,911	34,290	87	15,075	16245	off	off	off	60	NA	
98	11/28/05	5.2	942.5	300,619	33,949	34,335	83	15,158	16334	5.0	5.0	66	56	10	
	11/29/05	5.4	947.9	300,704	33,986	34,384	86	15,244	16427	6.0	6.0	70	58	12	
	11/30/05	3.2	951.1	300,757	34,008	34,421	59	15,303	16490	3.0	3.0	64	58	6	
	12/01/05	6.3	957.4	300,860	34,060	34,473	104	15,407	16602	off	off	off	60	NA	
	12/02/05	5.4	962.8	300,945	34,103	34,516	86	15,493	16695	off	off	off	58	NA	
	12/03/05	17.5	980.3	301,008	34,134	34,548	63	15,556	16763	off	off	off	58	NA	
	12/04/05	11.1	991.4	301,084	34,169	34,590	77	15,633	16846	off	off	off	60	NA	
99	12/05/05	7.8	999.2	301,177	34,211	34,642	94	15,727	16947	off	off	off	58	NA	
	12/06/05	5.1	1004.3	301,259	34,250	34,685	82	15,809	17036	6.0	6.0	68	56	12	
	12/07/05	6.7	1011.0	301,367	34,296	34,748	109	15,918	17153	7.0	7.0	70	56	14	
	12/08/05	7.0	1018.0	301,477	34,338	34,817	111	16,029	17273	10.0	10.0	78	58	20	
	12/09/05	6.9	1024.9	301,585	34,378	34,886	109	16,138	17390	11.0	11.0	78	56	22	
	12/10/05	8.6	1033.5	301,724	34,447	34,957	140	16,278	17541	off	off	off	60	NA	
	12/11/05	5.7	1039.2	301,816	34,493	35,003	92	16,370	17640	off	off	off	60	NA	
100	12/12/05	5.8	1045.0	301,909	34,539	35,051	94	16,464	17741	off	off	off	58	NA	
	12/13/05	5.3	1050.3	302,003	34,585	35,099	94	16,558	17843	4.0	4.0	66	58	8	
	12/14/05	3.5	1053.8	302,051	34,616	35,132	64	16,622	17912	4.0	4.0	64	56	8	
	12/15/05	6.9	1060.7	302,162	34,675	35,184	111	16,733	18031	off	off	off	56	NA	
	12/16/05	7.4	1068.1	302,281	34,737	35,241	119	16,852	18159	off	off	off	58	NA	
	12/17/05	5.3	1073.4	302,365	34,780	35,283	85	16,937	18251	6.0	6.0	70	58	12	
12/18/05	5.7	1079.1	302,456	34,823	35,331	91	17,028	18349	off	off	off	56	NA		

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House							Instrument Panel						
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
										hr	hr	kgal	kgal		kgal
101	12/19/05	8.2	1087.3	302,587	34,885	35,401	132	17,160	18491	off	off	off	60	NA	
	12/20/05	4.9	1092.2	302,665	34,923	35,441	78	17,238	18575	4.0	4.0	64	56	8	
	12/21/05	7.2	1099.4	302,780	34,978	35,502	116	17,354	18700	off	off	off	56	NA	
	12/22/05	5.7	1105.1	302,871	35,019	35,553	92	17,446	18800	off	off	off	58	NA	
	12/23/05	5.2	1110.3	302,958	35,056	35,603	87	17,533	18893	6.0	6.0	60	58	2	
	12/24/05	5.8	1116.1	303,043	35,092	35,652	85	17,618	18985	7.0	7.0	72	58	14	
	12/25/05	5.5	1121.6	303,131	35,131	35,702	89	17,707	19081	off	off	off	60	NA	
102	12/26/05	5.0	1126.6	303,211	35,169	35,745	81	17,788	19168	off	off	off	58	NA	
	12/27/05	5.7	1132.3	303,302	35,211	35,795	92	17,880	19267	5.0	5.0	66	56	10	
	12/28/05	5.2	1137.5	303,386	35,249	35,840	83	17,963	19357	off	off	off	56	NA	
	12/29/05	5.7	1143.2	303,475	35,286	35,894	91	18,054	19455	7.0	7.0	72	58	14	
	12/30/05	5.9	1149.1	303,570	35,335	35,942	97	18,151	19559	off	off	off	56	NA	
	12/31/05	7.7	1156.8	303,694	35,397	36,004	124	18,275	19693	off	off	off	60	NA	
	01/01/06	5.6	1162.4	303,783	35,441	36,050	90	18,365	19790	off	off	off	58	NA	
103	01/02/06	5.0	1167.4	303,862	35,480	36,090	79	18,444	19875	off	off	off	60	NA	
	01/03/06	5.8	1173.2	303,954	35,525	36,137	92	18,536	19974	5.0	5.0	64	54	10	
	01/04/06	4.1	1177.3	304,018	35,558	36,169	65	18,601	20044	7.0	7.0	70	56	14	
	01/05/06	8.0	1185.3	304,148	35,623	36,236	132	18,733	20186	off	off	off	56	NA	
	01/06/06	5.3	1190.6	304,233	35,664	36,280	85	18,818	20278	4.0	4.0	66	58	8	
	01/07/06	5.4	1196.0	304,319	35,704	36,325	85	18,903	20370	off	off	off	56	NA	
	01/08/06	5.6	1201.6	304,408	35,748	36,372	91	18,994	20468	off	off	off	56	NA	
104	01/09/06	6.2	1207.8	304,507	35,793	36,426	99	19,093	20574	off	off	off	56	NA	
	01/10/06	5.8	1213.6	304,598	35,832	36,480	93	19,186	20675	off	off	off	56	NA	
	01/11/06	5.9	1219.5	304,693	35,865	36,542	95	19,281	20777	off	off	off	58	NA	
	01/12/06	5.9	1225.4	304,787	35,915	36,586	94	19,375	20878	off	off	off	58	NA	
	01/13/06	5.7	1231.1	304,878	35,962	36,632	93	19,468	20978	4.0	4.0	66	58	8	
	01/14/06	5.3	1236.4	304,963	36,005	36,674	85	19,553	21070	off	off	off	56	NA	
	01/15/06	5.8	1242.2	305,055	36,053	36,719	93	19,646	21170	off	off	off	58	NA	
105	01/16/06	5.2	1247.4	305,141	36,099	36,760	87	19,733	21264	5.0	7.0	68	56	12	
	01/17/06	4.2	1251.6	305,206	36,133	36,790	64	19,797	21333	off	off	off	56	NA	
	01/18/06	9.5	1261.1	305,354	36,217	36,856	150	19,947	21495	off	off	off	58	NA	
	01/19/06	4.3	1265.4	305,424	36,249	36,895	71	20,018	21571	3.0	3.0	62	56	6	
	01/20/06	3.7	1269.1	305,483	36,277	36,926	59	20,077	21635	off	off	off	56	NA	
	01/21/06	4.6	1273.7	305,557	36,313	36,964	74	20,151	21714	off	off	off	58	NA	
	01/22/06	5.2	1278.9	305,641	36,353	37,000	76	20,227	21796	off	off	off	56	NA	
106	01/23/06	5.9	1284.8	305,734	36,397	37,050	94	20,321	21898	off	off	off	56	NA	
	01/24/06	5.5	1290.3	305,821	36,435	37,107	95	20,416	22000	6.0	5.0	67	56	11	
	01/25/06	5.4	1295.7	305,907	36,478	37,166	102	20,518	22110	off	off	off	58	NA	
	01/26/06	5.6	1301.3	305,996	36,526	37,207	89	20,607	22206	off	off	off	56	NA	
	01/27/06	5.7	1307.0	306,088	36,576	37,250	93	20,700	22306	off	off	off	58	NA	
	01/28/06	5.1	1312.1	306,169	36,618	37,289	81	20,781	22393	4.0	4.0	66	58	8	
	01/29/06	5.3	1317.4	306,254	36,662	37,376	131	20,912	22534	off	off	off	56	NA	
107	01/30/06	6.4	1323.8	306,345	36,708	37,376	46	20,958	22584	5.0	5.0	66	56	10	
	01/31/06	5.2	1329.0	306,438	36,756	37,421	93	21,051	22684	off	off	off	58	NA	
	02/01/06	3.2	1332.2	306,488	36,780	37,447	50	21,101	22738	8.0	8.0	70	54	16	
	02/02/06	10.0	1342.2	306,660	36,866	37,534	173	21,274	22925	off	off	off	58	NA	
	02/03/06	5.8	1348.0	306,744	36,908	37,576	84	21,358	23015	off	off	off	58	NA	
	02/04/06	5.4	1353.4	306,829	36,950	37,620	86	21,444	23108	off	off	off	56	NA	
	02/05/06	5.5	1358.9	306,917	36,993	37,664	87	21,531	23202	off	off	off	56	NA	
108	02/06/06	5.6	1364.5	307,006	37,036	37,711	90	21,621	23298	8.0	8.0	72	56	16	
	02/07/06	5.4	1369.9	307,072	37,077	37,756	86	21,707	23391	off	off	off	60	NA	
	02/08/06	5.3	1375.2	307,188	37,122	37,806	95	21,802	23494	9.0	9.0	74	56	18	
	02/09/06	6.6	1381.8	307,279	37,164	37,855	91	21,893	23592	off	off	off	56	NA	
	02/10/06	4.9	1386.7	307,356	37,199	37,898	78	21,971	23676	4.0	4.0	66	58	8	
	02/11/06	4.5	1391.2	307,428	37,234	37,936	73	22,044	23754	off	off	off	58	NA	
	02/12/06	5.0	1396.2	307,509	37,273	37,997	100	22,144	23862	off	off	off	56	NA	
109	02/13/06	8.1	1404.3	307,638	37,335	38,043	108	22,252	23978	off	off	off	58	NA	
	02/14/06	5.4	1409.7	307,723	37,375	38,089	86	22,338	24071	6.0	6.0	70	58	12	
	02/15/06	2.5	1412.2	307,764	37,393	38,113	42	22,380	24116	7.0	6.0	67	54	13	
	02/16/06	7.9	1420.1	307,889	37,455	38,176	125	22,505	24251	off	off	off	58	NA	
	02/17/06	5.4	1425.5	307,975	37,499	38,218	86	22,591	24344	off	off	off	58	NA	
	02/18/06	4.9	1430.4	308,054	37,538	38,258	79	22,670	24429	off	off	off	56	NA	
	02/19/06	5.1	1435.5	308,135	37,579	38,298	81	22,751	24516	off	off	off	56	NA	
110	02/20/06	5.0	1440.5	308,214	37,619	38,337	79	22,830	24601	off	off	off	56	NA	
	02/21/06	5.8	1446.3	308,307	37,668	38,381	93	22,923	24702	6.0	6.0	70	58	12	
	02/22/06	5.9	1452.2	308,398	37,721	38,419	91	23,014	24800	off	off	off	56	NA	
	02/23/06	5.9	1458.1	308,493	37,765	38,470	95	23,109	24902	off	off	off	56	NA	
	02/24/06	5.8	1463.9	308,585	37,810	38,516	91	23,200	25000	off	off	off	58	NA	
	02/25/06	5.0	1468.9	308,665	37,850	38,557	81	23,281	25087	6.0	6.0	74	62	12	
	02/26/06	5.4	1474.3	308,749	37,890	38,600	83	23,364	25177	off	off	off	58	NA	

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House					Instrument Panel								
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
111	02/27/06	5.4	1479.7	308,833	37,925	38,648	83	23,447	25266	off	off	off	58	NA	
	02/28/06	6.6	1486.3	308,939	37,973	38,707	107	23,554	25381	off	off	off	56	NA	
	03/01/06	3.1	1489.4	308,988	37,996	38,733	49	23,603	25434	4.0	4.0	64	56	8	
	03/02/06	18.1	1507.5	309,082	38,039	38,784	94	23,697	25536	off	off	off	58	NA	
	03/03/06	8.4	1515.9	309,210	38,090	38,797	64	23,761	25605	off	off	off	60	NA	
	03/04/06	5.7	1521.6	309,301	38,136	38,843	92	23,853	25704	off	off	off	56	NA	
03/05/06	6.2	1527.8	309,400	38,186	38,893	100	23,953	25811	off	off	off	56	NA		
112	03/06/06	6.5	1534.3	309,503	38,236	38,945	102	24,055	25921	7.0	7.0	74	60	14	
	03/07/06	6.0	1540.3	309,605	38,289	38,994	102	24,157	26031	off	off	off	60	NA	
	03/08/06	6.1	1546.4	309,694	38,339	39,045	101	24,258	26140	off	off	off	58	NA	
	03/09/06	5.0	1551.4	309,774	38,380	39,084	80	24,338	26226	4.0	4.0	62	54	8	
	03/10/06	5.8	1557.2	309,866	38,426	39,128	90	24,428	26323	off	off	off	56	NA	
	03/11/06	5.1	1562.3	309,947	38,468	39,168	82	24,510	26412	off	off	off	56	NA	
03/12/06	4.4	1566.7	310,020	38,505	39,204	73	24,583	26490	5.0	5.0	66	56	10		
113	03/13/06	7.8	1574.5	310,141	38,565	39,263	119	24,702	26619	off	off	off	58	NA	
	03/14/06	8.6	1583.1	310,276	38,634	39,328	134	24,836	26763	off	off	off	58	NA	
	03/15/06	5.1	1588.2	310,355	38,670	39,361	69	24,905	26837	8.0	8.0	70	54	16	
	03/16/06	7.8	1596.0	310,481	38,735	39,434	138	25,043	26986	off	off	off	58	NA	
	03/17/06	6.9	1602.9	310,589	38,789	39,487	107	25,150	27101	off	off	off	54	NA	
	03/18/06	6.4	1609.3	310,690	38,840	39,537	101	25,251	27210	off	off	off	56	NA	
03/19/06	6.6	1615.9	310,785	38,888	39,583	94	25,345	27311	5.0	5.0	66	56	10		
114	03/20/06	5.5	1621.4	310,880	38,935	39,630	94	25,439	27413	off	off	off	58	NA	
	03/21/06	7.2	1628.6	310,992	38,989	39,688	112	25,551	27533	off	off	off	56	NA	
	03/22/06	6.8	1635.4	311,100	39,033	39,753	109	25,660	27651	off	off	off	56	NA	
	03/23/06	7.4	1642.8	311,216	39,089	39,812	115	25,775	27775	4.0	4.0	62	54	8	
	03/24/06	8.5	1651.3	311,350	39,154	39,881	134	25,909	27919	off	off	off	56	NA	
	03/25/06	6.1	1657.4	311,446	39,199	39,931	95	26,004	28022	off	off	off	58	NA	
03/26/06	6.4	1663.8	311,545	39,242	39,986	98	26,102	28127	5.0	5.0	66	56	10		
115	03/27/06	5.8	1669.6	311,636	39,279	40,040	91	26,193	28225	6.0	6.0	66	54	12	
	03/28/06	7.3	1676.9	311,753	39,330	40,104	115	26,308	28349	off	off	off	58	NA	
	03/29/06	3.0	1679.9	311,800	39,352	40,129	47	26,355	28400	4.0	4.0	62	54	8	
	03/30/06	8.9	1688.8	311,943	39,424	40,201	144	26,499	28555	off	off	off	56	NA	
	03/31/06	9.2	1698.0	312,088	39,495	40,274	144	26,643	28710	off	off	off	60	NA	
	04/01/06	7.9	1705.9	312,213	39,555	40,338	124	26,767	28844	5.0	5.0	66	56	10	
04/02/06	8.6	1714.5	312,348	39,625	40,402	134	26,901	28988	off	off	off	56	NA		
116	04/03/06	9.1	1723.6	312,491	39,695	40,471	139	27,040	29138	off	off	off	58	NA	
	04/04/06	8.0	1731.6	312,614	39,759	40,532	125	27,165	29273	off	off	off	58	NA	
	04/05/06	8.2	1739.8	312,744	39,822	40,598	129	27,294	29412	7.0	7.0	70	56	14	
	04/06/06	7.1	1746.9	312,854	39,870	40,657	107	27,401	29527	off	off	off	56	NA	
	04/07/06	7.0	1753.9	312,963	39,919	40,717	109	27,510	29644	3.0	3.0	66	58	8	
	04/08/06	11.1	1765.0	313,139	40,001	40,809	174	27,684	29832	off	off	off	58	NA	
04/09/06	9.9	1774.9	313,294	40,072	40,892	154	27,838	29998	off	off	off	58	NA		
117	04/10/06	9.7	1784.6	313,446	40,141	40,973	150	27,988	30159	7.0	7.0	72	58	14	
	04/11/06	8.1	1792.7	313,571	40,192	41,004	82	28,070	30248	9.0	9.0	74	56	18	
	04/12/06	8.2	1800.9	313,701	40,257	41,069	130	28,200	30388	3.0	3.0	62	56	6	
	04/13/06	8.8	1809.7	313,843	40,325	41,184	183	28,383	30585	off	off	off	58	NA	
	04/14/06	10.0	1819.7	314,000	40,401	41,262	154	28,537	30751	off	off	off	58	NA	
	04/15/06	10.0	1829.7	314,155	40,476	41,340	153	28,690	30916	off	off	off	56	NA	
04/16/06	8.0	1837.7	314,279	40,536	41,405	125	28,815	31051	5.0	5.0	66	56	10		
118	04/17/06	7.4	1845.1	314,394	40,591	41,462	112	28,927	31171	off	off	off	58	NA	
	04/18/06	7.5	1852.6	314,509	40,645	41,521	113	29,040	31293	4.0	4.0	62	54	8	
	04/19/06	7.3	1859.9	314,625	40,706	41,593	133	29,173	31436	5.0	5.0	66	56	10	
	04/20/06	8.8	1868.7	314,763	40,780	41,635	116	29,289	31561	off	off	off	58	NA	
	04/21/06	8.0	1876.7	314,890	40,848	41,714	147	29,436	31720	5.0	5.0	68	58	10	
	04/22/06	6.9	1883.6	314,998	40,903	41,765	106	29,542	31834	off	off	off	58	NA	
04/23/06	8.1	1891.7	315,125	40,967	41,827	126	29,668	31970	8.0	8.0	76	60	16		
119	04/24/06	8.6	1900.3	315,258	41,032	41,894	132	29,800	32112	9.0	9.0	74	56	18	
	04/25/06	8.2	1908.5	315,388	41,092	41,962	128	29,928	32250	4.0	4.0	64	56	8	
	04/26/06	5.4	1913.9	315,474	41,132	42,006	84	30,012	32341	5.0	5.0	66	56	10	
	04/27/06	8.5	1922.4	315,607	41,192	42,176	NA	30,242	32588	off	off	off	56	NA	
	04/28/06	6.8	1929.2	315,714	41,240	42,135	NA	30,249	32596	8.0	8.0	72	56	16	
	04/29/06	6.2	1935.4	315,812	41,288	42,185	98	30,347	32702	off	off	off	56	NA	
04/30/06	7.7	1943.1	315,933	41,348	42,245	120	30,467	32831	off	off	off	58	NA		
120	05/01/06	8.2	1951.3	316,061	41,411	42,308	126	30,593	32967	5.0	5.0	64	54	10	
	05/02/06	8.7	1960.0	316,198	41,487	42,375	143	30,736	33121	off	off	off	56	NA	
	05/03/06	8.6	1968.6	316,331	41,545	42,432	115	30,851	33245	8.0	8.0	72	56	16	
	05/04/06	8.8	1977.4	316,467	41,614	42,505	142	30,993	33398	9.0	9.0	76	58	18	
	05/05/06	9.6	1987.0	316,617	41,685	42,583	149	31,142	33558	9.0	9.0	64	56	8	
	05/06/06	7.2	1994.2	316,729	41,738	42,640	110	31,252	33677	off	off	off	58	NA	
05/07/06	8.5	2002.7	316,861	41,801	42,708	131	31,383	33818	off	off	off	56	NA		

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House						Instrument Panel							
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP	
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig	
121	05/08/06	8.7	2011.4	316,996	41,864	42,777	132	31,515	33960	off	off	off	58	NA	
	05/09/06	9.1	2020.5	317,136	41,928	42,852	139	31,654	34110	8.0	8.0	72	56	16	
	05/10/06	8.5	2029.0	317,267	41,984	42,925	129	31,783	34249	9.0	9.0	74	56	18	
	05/11/06	8.8	2037.8	317,404	42,052	42,995	138	31,921	34398	off	off	off	56	NA	
	05/12/06	6.9	2044.7	317,514	42,105	43,050	108	32,029	34514	4.0	4.0	66	58	8	
	05/13/06	9.6	2054.3	317,663	42,176	43,128	149	32,178	34675	off	off	off	56	NA	
	05/14/06	9.8	2064.1	317,814	42,248	43,203	147	32,325	34833	off	off	off	58	NA	
122	05/15/06	8.7	2072.8	317,948	42,310	43,272	131	32,456	34974	off	off	off	56	NA	
	05/16/06	9.6	2082.4	318,096	42,378	43,350	146	32,602	35131	8.0	8.0	NM	58	NA	
	05/17/06	12.4	2094.8	318,286	42,463	43,451	186	32,788	35332	10.0	10.0	78	58	20	
	05/18/06	13.2	2108.0	318,492	42,568	43,550	204	32,992	35552	3.0	3.0	62	56	6	
	05/19/06	9.4	2117.4	318,636	42,648	43,620	150	33,142	35713	off	off	off	56	NA	
	05/20/06	6.7	2124.1	318,741	42,693	43,680	105	33,247	35827	off	off	off	58	NA	
	05/21/06	14.2	2138.3	318,959	42,805	43,773	205	33,452	36047	off	off	off	58	NA	
123	05/22/06	11.0	2149.3	319,129	42,894	43,773	NA	33,541	36143	off	off	off	58	NA	
	05/23/06	11.3	2160.6	319,303	42,978	43,940	NA	33,792	36414	9.0	10.0	77	58	19	
	05/24/06	8.2	2168.8	319,430	43,038	44,004	124	33,916	36547	3.0	3.0	60	54	6	
	05/25/06	12.4	2181.2	319,624	43,130	44,103	191	34,107	36753	off	off	off	56	NA	
	05/26/06	11.0	2192.2	319,792	43,206	44,193	166	34,273	36932	off	off	off	56	NA	
	05/27/06	12.3	2204.5	319,984	43,301	44,288	190	34,463	37137	4.0	4.0	66	58	8	
	05/28/06	8.9	2213.4	320,121	43,368	44,355	134	34,597	37281	off	off	off	56	NA	
124	05/29/06	7.0	2220.4	320,231	43,422	44,092	NA	34,388	37056	5.0	5.0	64	54	10	
	05/30/06	13.5	2233.9	320,438	43,525	44,509	NA	34,908	37616	6.0	6.0	68	56	12	
	05/31/06	11.7	2245.6	320,617	43,619	44,592	177	35,085	37807	off	off	off	58	NA	
	06/01/06	10.8	2256.4	320,785	43,710	44,682	181	35,266	38002	off	off	off	56	NA	
	06/02/06	11.8	2268.2	320,965	43,800	44,700	108	35,374	38119	off	off	off	56	NA	
	06/03/06	7.3	2275.5	321,079	43,856	44,826	182	35,556	38315	off	off	off	56	NA	
	06/04/06	13.2	2288.7	321,284	43,954	44,928	200	35,756	38530	6.0	6.0	68	56	12	
125	06/05/06	10.8	2299.5	321,448	44,028	45,015	161	35,917	38704	off	off	off	58	NA	
	06/06/06	13.0	2312.5	321,644	44,111	45,125	193	36,110	38912	9.0	8.0	73	56	17	
	06/07/06	13.0	2325.5	321,849	44,211	45,227	202	36,312	39129	4.0	4.0	66	58	8	
	06/08/06	11.8	2337.3	322,027	44,298	45,315	175	36,487	39318	off	off	off	56	NA	
	06/09/06	9.4	2346.7	322,172	44,367	45,389	143	36,630	39472	off	off	off	56	NA	
	06/10/06	12.6	2359.3	322,365	44,457	45,488	189	36,819	39676	off	off	off	56	NA	
	06/11/06	15.3	2374.6	322,508	44,522	45,564	141	36,960	39828	8.0	8.0	74	58	16	
126	06/12/06	5.3	2379.9	322,629	44,581	45,679	174	37,134	40015	10.0	10.0	70	58	12	
	06/13/06	13.2	2393.1	322,882	44,702	45,752	194	37,328	40224	3.0	3.0	62	56	6	
	06/14/06	12.6	2405.7	323,072	44,796	45,844	186	37,514	40425	off	off	off	58	NA	
	06/15/06	11.9	2417.6	323,258	44,891	45,931	182	37,696	40621	off	off	off	58	NA	
	06/16/06	13.0	2430.6	323,455	44,993	46,024	195	37,891	40831	off	off	off	54	NA	
	06/17/06	9.0	2439.6	323,597	45,066	46,089	138	38,029	40980	6.0	6.0	72	60	12	
	06/18/06	10.2	2449.8	323,747	45,137	46,165	147	38,176	41138	7.0	7.0	74	60	14	
127	06/19/06	14.4	2464.2	323,970	45,241	46,281	220	38,396	41375	3.0	3.0	60	54	6	
	06/20/06	10.5	2474.7	324,131	45,318	46,362	158	38,554	41545	off	off	off	56	NA	
	06/21/06	10.2	2484.9	324,289	45,343	46,441	104	38,658	41657	5.0	5.0	64	54	10	
	06/22/06	11.6	2496.5	324,462	45,473	46,531	220	38,878	41894	9.0	9.0	72	54	18	
	06/23/06	11.0	2507.5	324,637	45,562	46,615	173	39,051	42081	off	off	off	56	NA	
	06/24/06	13.0	2520.5	324,838	45,661	46,712	196	39,247	42292	off	off	off	58	NA	
	06/25/06	11.6	2532.1	325,016	45,751	46,796	174	39,421	42480	off	off	off	54	NA	
128	06/26/06	7.3	2539.4	325,128	45,808	46,849	110	39,531	42598	8.0	8.0	70	54	16	
	06/27/06	7.7	2547.1	325,246	45,871	46,901	115	39,646	42722	off	off	off	54	NA	
	06/28/06	13.1	2560.2	325,448	45,972	47,001	201	39,847	42939	3.0	3.0	62	56	6	
	06/29/06	9.5	2569.7	325,596	46,041	47,075	143	39,990	43093	off	off	off	58	NA	
	06/30/06	11.6	2581.3	325,775	46,125	47,167	176	40,166	43282	off	off	off	56	NA	
	07/01/06	8.1	2589.4	325,900	46,179	47,235	122	40,288	43414	off	off	off	54	NA	
	07/02/06	7.9	2597.3	326,027	46,230	47,308	124	40,412	43547	10.0	10.0	74	54	20	
129	07/03/06	11.1	2608.4	326,196	46,314	47,387	163	40,575	43723	off	off	off	54	NA	
	07/04/06	12.6	2621.0	326,388	46,410	47,482	191	40,766	43929	off	off	off	56	NA	
	07/05/06	8.8	2629.8	326,524	46,476	47,548	132	40,898	44071	4.0	4.0	64	56	8	
	07/06/06	12.4	2642.2	326,689	46,558	47,624	158	41,056	44241	off	off	off	54	NA	
	07/07/06	6.5	2648.7	326,815	46,628	47,682	128	41,184	44379	6.0	6.0	68	56	12	
	07/08/06	5.8	2654.5	326,904	46,679	47,718	87	41,271	44473	off	off	off	58	NA	
	07/09/06	5.6	2660.1	326,992	46,718	47,765	86	41,357	44566	off	off	off	56	NA	
130	07/10/06	6.2	2666.3	327,089	46,763	47,814	94	41,451	44667	5.0	5.0	66	56	10	
	07/11/06	11.7	2678.0	327,270	46,846	47,904	173	41,624	44853	off	off	off	58	NA	
	07/12/06	9.8	2687.8	327,421	46,913	47,988	151	41,775	45016	off	off	off	58	NA	
	07/13/06	11.1	2698.9	327,595	47,007	48,081	187	41,962	45218	off	off	off	56	NA	
	07/14/06	9.9	2708.8	327,746	47,081	48,155	148	42,110	45377	5.0	5.0	64	54	10	
	07/15/06	12.0	2720.8	327,932	47,169	48,248	181	42,291	45572	off	off	off	56	NA	
	07/16/06	10.3	2731.1	328,092	47,242	48,331	156	42,447	45740	8.0	8.0	80	54	26	

**Table A-1. EPA Arsenic Demonstration Project at Desert Sands MDWCA, NM - Daily System
Operation Log Sheet (Continued)**

Week No.	Date	Pump House						Instrument Panel						
		Operation Hours	Cumulative Operation Hours	Master Flow Meter	Flow Totalizer Vessel A	Flow Totalizer Vessel B	Total Flow Daily	Cumulative Flow Totalizer	Cumulative Total Bed Volumes	Head Loss (psi)		System Pressure (psig)		ΔP
		hr	hr	kgal	kgal	kgal	kgal	kgal	# of BV	Vessel A	Vessel B	Influent	Effluent	psig
131	07/17/06	10.0	2741.1	328,243	47,309	48,412	148	42,595	45900	off	off	off	58	NA
	07/18/06	2.7	2743.8	328,288	47,328	48,436	43	42,638	45946	9.0	9.0	72	54	18
	07/19/06	12.7	2756.5	328,488	47,425	48,535	196	42,834	46157	4.0	4.0	67	56	11
	07/20/06	16.4	2772.9	328,739	47,545	48,660	245	43,079	46421	off	off	off	58	NA
	07/21/06	11.5	2784.4	328,916	47,629	48,750	174	43,253	46609	off	off	off	56	NA
	07/22/06	11.9	2796.3	329,098	47,713	48,843	177	43,430	46800	off	off	off	56	NA
	07/23/06	10.2	2806.5	329,254	47,783	48,924	151	43,581	46962	8.0	8.0	70	54	16
132	07/24/06	11.2	2817.7	329,425	47,860	49,016	169	43,750	47144	off	off	off	58	NA
	07/25/06	10.7	2828.4	329,591	47,937	49,100	161	43,911	47318	4.0	4.0	62	54	8
	07/26/06	10.8	2839.2	329,758	48,013	49,186	162	44,073	47492	off	off	off	56	NA
	07/27/06	11.5	2850.7	329,935	48,092	49,280	173	44,246	47679	off	off	off	56	NA
	07/28/06	10.4	2861.1	330,093	48,159	49,366	153	44,399	47844	9.0	9.0	72	54	18
	07/29/06	8.0	2869.1	330,216	48,221	49,426	122	44,521	47975	off	off	off	56	NA
	07/30/06	7.8	2876.9	330,338	48,290	49,485	128	44,649	48113	4.0	4.0	66	58	8
133	07/31/06	9.8	2886.7	330,488	48,353	49,557	135	44,784	48259	off	off	off	56	NA
	08/01/06	5.3	2892.0	330,568	48,393	49,595	78	44,862	48343	off	off	off	56	NA
	08/02/06	4.2	2896.2	330,633	48,426	49,617	55	44,917	48402	5.0	6.0	65	54	11
	08/03/06	10.4	2906.6	330,795	48,505	49,697	159	45,076	48573	off	off	off	54	NA
	08/04/06	4.3	2910.9	330,863	48,535	49,732	65	45,141	48643	4.0	4.0	64	56	8
	08/05/06	5.5	2916.4	330,948	48,576	49,775	84	45,225	48734	off	off	off	58	NA
	08/06/06	8.7	2925.1	331,085	48,635	49,848	132	45,357	48876	6.0	6.0	68	56	12
134	08/07/06	8.6	2933.7	331,215	48,686	49,925	128	45,485	49014	off	off	off	56	NA
	08/08/06	8.0	2941.7	331,340	48,740	49,992	121	45,606	49144	4.0	4.0	62	54	8
	08/09/06	9.5	2951.2	331,488	48,814	50,062	144	45,750	49300	off	off	off	54	NA
	08/10/06	6.5	2957.7	331,590	48,863	50,113	100	45,850	49407	off	off	off	56	NA
	08/11/06	9.1	2966.8	331,733	48,932	50,183	139	45,989	49557	4.0	4.0	66	58	8
	08/12/06	7.0	2973.8	331,841	48,984	50,236	105	46,094	49670	off	off	off	54	NA
	08/13/06	7.2	2981.0	331,954	49,040	50,290	110	46,204	49789	off	off	off	56	NA
135	08/14/06	7.2	2988.2	332,065	49,092	50,347	109	46,313	49906	4.0	4.0	64	56	8
	08/15/06	8.5	2996.7	332,197	49,154	50,414	129	46,442	50045	off	off	off	56	NA
	08/16/06	3.4	3000.1	332,251	49,179	50,441	52	46,494	50101	6.0	6.0	70	58	12
	08/17/06	3.9	3004.0	332,310	49,207	50,472	59	46,553	50165	off	off	off	off	NA

Note: BV calculation for Run 1 (01/23/04-07/14/05) based on 80 ft³ of E33-S media per vessel.

Note: BV calculation for Run 2 (07/29/05-08/16/06) based on 62 ft³ of E33-P media per vessel.

APPENDIX B
ANALYTICAL DATA

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA

Sampling Date		01/23/04 ^(c)			01/28/04				02/04/04				02/11/04			
Sampling Location	Parameter Unit	IN	AC	TT	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume		–	–	0	–	–	362	353	–	–	657	775	–	–	963	1,183
Alkalinity	mg/L ^(a)	173	173	173	173	173	169	169	180	176	180	178	186	190	186	182
Fluoride	mg/L	0.5	0.5	0.5	–	–	–	–	–	–	–	–	–	–	–	–
Sulfate	mg/L	180	170	180	–	–	–	–	–	–	–	–	–	–	–	–
Orthophosphate	mg/L ^(b)	0.2	0.2	0.2	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silica (as SiO ₂)	mg/L	41.8	41.7	37.2	40.5	40.8	38.5	39.2	36.4	37.3	35.3	36.4	36.6	37.4	36.2	37.0
Sulfide	µg/L	<5 <5	–	–	–	–	–	–	<5 <5	–	–	–	–	–	–	–
NO ₃ -N	mg/L	<0.05	<0.05	<0.05	–	–	–	–	–	–	–	–	–	–	–	–
Turbidity	NTU	3.5	1.2	0.1	0.2	0.2	0.1	<0.1	0.5	0.8	0.2	0.2	0.4	0.5	0.2	0.2
pH	–	7.8	7.9	7.9	8.1	8.0	8.0	7.9	8.1	8.0	7.9	7.9	7.9	7.9	7.9	7.9
Temperature	°C	28.7	29.4	29.7	28.4	28.8	28.9	29.0	30.2	29.5	29.9	29.8	29.9	30.0	30.2	29.9
DO	mg/L	1.0	1.4	2.3	1.9	2.0	2.0	1.9	1.1	1.8	1.5	1.5	1.0	1.6	1.5	1.4
ORP	mV	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Free Chlorine	mg/L	–	0.5	0.3	–	0.3	0.3	0.3	–	–	0.4	0.4	–	–	–	–
Total Hardness	mg/L ^(a)	81.1	80.7	81.5	–	–	–	–	–	–	–	–	–	–	–	–
Ca Hardness	mg/L ^(a)	65.5	67.5	67.6	–	–	–	–	–	–	–	–	–	–	–	–
Mg Hardness	mg/L ^(a)	15.6	13.2	13.9	–	–	–	–	–	–	–	–	–	–	–	–
As (total)	µg/L	26.1	26.7	1.5	26.0	25.9	1.9	1.5	26.2	27.0	2.0	1.7	25.3	27.5	2.0	2.0
As (total soluble)	µg/L	23.2	23.0	1.2	–	–	–	–	–	–	–	–	–	–	–	–
As (particulate)	µg/L	2.9	3.7	0.2	–	–	–	–	–	–	–	–	–	–	–	–
As (III)	µg/L	17.6	1.1	0.9	–	–	–	–	–	–	–	–	–	–	–	–
As (V)	µg/L	5.6	21.9	0.3	–	–	–	–	–	–	–	–	–	–	–	–
Total Fe	µg/L	45	43	<25	73	70	<25	<25	106	112	45	35	98	97	46	42
Dissolved Fe	µg/L	<25	<25	<25	–	–	–	–	–	–	–	–	–	–	–	–
Total Mn	µg/L	9.1	8.4	0.2	10.1	10.3	0.3	0.1	9.4	9.5	0.1	0.1	9.6	9.0	0.1	0.2
Dissolved Mn	µg/L	9.4	8.1	0.1	–	–	–	–	–	–	–	–	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Water quality parameters sampled on January 27, 2004.

IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		02/18/04			02/25/04				03/03/04				03/10/04			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume		-	-	1,496	-	-	1,715	2,167	-	-	2,042	2,610	-	-	2,350	3,010
Alkalinity	mg/L ^(a)	193	191	189	185	185	185	185	177	179	179	181	181	189	185	181
Fluoride	mg/L	0.6	0.6	0.6	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	190	190	190	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate	mg/L ^(b)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silica (as SiO ₂)	mg/L	38.4	39.0	38.2	39.3	38.9	39.0	38.5	37.9	37.3	37.9	38.3	36.4	36.4	36.0	36.3
Sulfide	µg/L	-	-	-	-	-	-	-	<5	-	-	-	-	-	-	-
NO ₃ -N	mg/L	<0.08	<0.08	<0.08	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	2.4	0.2	0.7	0.3	0.3	0.1	0.1	0.3	0.1	0.2	<0.1	0.4	0.3	0.2	0.2
pH	-	7.8	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	-	-	8.0	7.9	7.8	7.8
Temperature	°C	29.8	30.1	30.2	29.7	28.9	29.0	29.4	29.9	29.7	-	-	30.4	30.8	30.6	30.6
DO	mg/L	1.2	1.3	1.4	1.2	1.2	1.1	1.6	1.3	1.3	-	-	1.3	1.2	1.2	1.2
ORP	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Free Chlorine	mg/L	-	0.4	0.4	-	0.4	0.4	0.4	-	-	-	-	-	0.4	0.4	0.4
Total Chlorine	mg/L	-	0.5	0.5	-	0.5	0.5	0.5	-	-	-	-	-	0.5	0.5	0.5
Total Hardness	mg/L ^(a)	89.4	87.4	89.2	-	-	-	-	-	-	-	-	-	-	-	-
Ca Hardness	mg/L ^(a)	71.9	70.7	71.1	-	-	-	-	-	-	-	-	-	-	-	-
Mg Hardness	mg/L ^(a)	17.5	16.7	18.1	-	-	-	-	-	-	-	-	-	-	-	-
As (total)	µg/L	28.6	28.7	1.5	27.6	27.9	1.7	1.5	29.8	28.6	1.8	1.7	23.0	23.2	1.4	1.4
As (total soluble)	µg/L	23.9	23.6	1.4	-	-	-	-	-	-	-	-	-	-	-	-
As (particulate)	µg/L	4.7	5.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-
As (III)	µg/L	22.8	1.1	1.1	-	-	-	-	-	-	-	-	-	-	-	-
As (V)	µg/L	1.1	22.6	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Total Fe	µg/L	55	36	<25	35	31	<25	<25	39	30	<25	<25	53	47	<25	<25
Dissolved Fe	µg/L	<25	<25	<25	-	-	-	-	-	-	-	-	-	-	-	-
Total Mn	µg/L	9.9	9.4	0.3	9.7	9.5	0.1	0.1	9.5	9.1	0.1	0.1	8.3	8.2	0.2	0.3
Dissolved Mn	µg/L	9.0	6.0	0.1	-	-	-	-	-	-	-	-	-	-	-	-

(a) As CaCO₃. (b) As PO₄.

IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		03/17/04			03/24/04				03/31/04				04/07/04			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume		-	-	3,177	-	-	3,112	3,995	-	-	3,467	4,447	-	-	3,738	4,790
Alkalinity	mg/L ^(a)	182	182	178	189	189	185	193	183	181	185	181	180	180	184	180
Fluoride	mg/L	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	190	180	190	-	-	-	-	-	-	-	-	-	-	-	-
Orthophosphate	mg/L ^(b)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silica (as SiO ₂)	mg/L	38.7	38.4	38.6	38.5	38.3	38.0	38.4	37.9	37.2	37.6	37.8	39.4	40.2	39.9	40.0
Sulfide	µg/L	-	-	-	-	-	-	-	<5	<5	-	-	-	-	-	-
NO ₃ -N	mg/L	<0.05	<0.05	<0.05	-	-	-	-	-	-	-	-	-	-	-	-
Turbidity	NTU	0.5	0.2	0.2	0.4	0.3	0.1	0.1	1.0	1.5	0.5	0.2	0.9	1.0	0.2	0.4
pH	-	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.9	7.9	7.9	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
Temperature	°C	30.4	30.4	30.6	30.4	31.0	30.9	31.1	30.2	30.6	31.0	31.0	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
DO	mg/L	1.3	1.2	1.3	1.5	1.2	1.1	1.1	1.2	1.2	1.3	1.1	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
ORP	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Free Chlorine	mg/L	-	0.4	0.4	-	0.4	0.5	0.4	-	0.5	0.5	-	-	-	-	-
Total Chlorine	mg/L	-	0.5	0.5	-	0.5	0.5	0.5	-	0.6	0.6	-	-	-	-	-
Total Hardness	mg/L ^(a)	78.4	82.1	81.9	-	-	-	-	-	-	-	-	-	-	-	-
Ca Hardness	mg/L ^(a)	63.9	67.4	66.6	-	-	-	-	-	-	-	-	-	-	-	-
Mg Hardness	mg/L ^(a)	14.5	14.7	15.3	-	-	-	-	-	-	-	-	-	-	-	-
As (total)	µg/L	22.6	22.3	0.9	25.9	25.9	2.4	2.5	20.7	21.2	1.8	1.9	30.1	30.1	1.9	1.8
As (total soluble)	µg/L	22.4	22.1	0.8	-	-	-	-	-	-	-	-	-	-	-	-
As (particulate)	µg/L	0.2	0.2	0.1	-	-	-	-	-	-	-	-	-	-	-	-
As (III)	µg/L	20.7	0.5	0.3	-	-	-	-	-	-	-	-	-	-	-	-
As (V)	µg/L	1.7	21.6	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Total Fe	µg/L	49	32	<25	33	30	<25	<25	71	69	<25	<25	<25	<25	<25	<25
Dissolved Fe	µg/L	<25	<25	<25	-	-	-	-	-	-	-	-	-	-	-	-
Total Mn	µg/L	8.5	7.6	<0.1	8.4	7.9	0.1	0.1	9.0	9.4	<0.1	0.1	7.5	7.3	0.1	0.1
Dissolved Mn	µg/L	7.5	5.3	<0.1	-	-	-	-	-	-	-	-	-	-	-	-

(a) As CaCO₃. (b) As PO₄. (c) Operator was not available to take water quality readings.

IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		04/14/04			04/30/04				05/12/04			05/26/04				
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB	
	Bed Volume	–	–	4,572	–	–	4,603	6,057	–	–	6,176	–	–	5,897	7,605	
	Alkalinity	mg/L ^(a)	164	170	178	199	175	199	179	194	194	188	226 194	190 186	194 190	194 194
	Fluoride	mg/L	0.7	0.7	0.7	–	–	–	–	0.6	0.6	0.6	–	–	–	–
	Sulfate	mg/L	190	190	180	–	–	–	–	180	180	180	–	–	–	–
	Orthophosphate	mg/L ^(b)	<0.10	<0.10	<0.10	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	<0.10	<0.10	<0.10	<0.10 <0.10	<0.10 <0.10	<0.10 <0.10	<0.10 <0.10
	Silica (as SiO ₂)	mg/L	38.2	38.1	37.6	38.1	38.0	38.0	37.9	37.4	37.5	37.7	38.3 38.1	37.3 37.1	37.9 37.1	37.6 37.2
	Sulfide	µg/L	–	–	–	–	–	–	–	<5 <5	–	–	–	–	–	–
	NO ₃ -N	mg/L	<0.05	<0.05	<0.05	–	–	–	–	<0.05	<0.05	<0.05	–	–	–	–
	Turbidity	NTU	0.6	0.3	0.3	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	0.7	0.6	0.5	2.8 1.5	0.8 0.5	0.4 0.7	0.5 0.8
	pH	–	7.9	7.9	8.0	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.9	7.8	7.8	7.7
	Temperature	°C	29.6	29.5	29.5	30.3	30.6	30.1	30.5	30.7	30.9	31.2	31.0	31.3	31.2	31.1
	DO	mg/L	1.3	1.3	1.3	1.2	1.2	1.1	1.2	1.2	1.1	1.3	1.2	1.1	1.6	1.5
	ORP	mV	42	550	561	48	542	521	525	52	537	541	62	525	503	510
	Free Chlorine	mg/L	–	0.4	0.5	–	0.4	0.4	0.4	–	0.4	0.4	–	0.5	0.5	0.5
	Total Chlorine	mg/L	–	0.5	0.6	–	0.5	0.5	0.5	–	0.5	0.5	–	0.6	0.6	0.6
	Total Hardness	mg/L ^(a)	85.7	85.3	84.0	–	–	–	–	101.1	111.1	110.1	–	–	–	–
	Ca Hardness	mg/L ^(a)	71.1	70.9	69.4	–	–	–	–	83.7	91.9	86.6	–	–	–	–
	Mg Hardness	mg/L ^(a)	14.6	14.4	14.6	–	–	–	–	17.4	19.2	23.5	–	–	–	–
	As (total)	µg/L	28.5	29.6	1.5	24.2	23.6	1.7	1.6	25.8	25.4	1.6	21.4 21.2	21.7 21.7	1.7 2.0	2.1 2.4
	As (total soluble)	µg/L	24.8	24.7	1.6	–	–	–	–	22.0	20.3	1.4	–	–	–	–
	As (particulate)	µg/L	3.7	4.9	<0.1	–	–	–	–	3.8	5.1	0.2	–	–	–	–
	As (III)	µg/L	22.0	1.1	0.9	–	–	–	–	21.2	0.9	0.8	–	–	–	–
	As (V)	µg/L	2.8	23.6	0.7	–	–	–	–	0.8	19.4	0.6	–	–	–	–
	Total Fe	µg/L	<25	<25	<25	32	27	<25	<25	<25	<25	<25	64 51	40 38	<25 <25	<25 <25
	Dissolved Fe	µg/L	<25	<25	<25	–	–	–	–	<25	<25	<25	–	–	–	–
	Total Mn	µg/L	8.3	8.1	0.2	9.1	7.9	0.5	0.5	7.0	7.1	<0.1	9.9 9.1	8.6 8.4	0.3 0.3	0.3 0.3
	Dissolved Mn	µg/L	8.0	6.2	0.1	–	–	–	–	7.1	5.9	<0.1	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Sample out of holding time for laboratory analysis.
 IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		06/09/04			06/23/04				07/07/04			07/21/04			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB
Bed Volume	10 ³	–	–	8.1	–	–	8.7	10.6	–	–	11.1	–	–	11.9	13.8
Alkalinity	mg/L ^(a)	187	187	182	195	179	171	175	197	197	189	180 180	180 180	180 188	184 188
Fluoride	mg/L	0.6	0.6	0.6	–	–	–	–	0.6	0.6	0.6	–	–	–	–
Sulfate	mg/L	170	170	180	–	–	–	–	190	190	190	–	–	–	–
Orthophosphate	mg/L ^(b)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silica (as SiO ₂)	mg/L	37.8	37.8	37.2	38.7	38.3	38.1	38.9	38.0	37.9	38.2	38.0 37.8	37.3 38.1	36.9 38.2	37.4 37.6
Sulfide	µg/L	–	–	–	<5 <5	–	–	–	–	–	–	–	–	–	–
NO ₃ -N	mg/L	<0.04	<0.04	<0.04	–	–	–	–	<0.20	<0.20	<0.20	–	–	–	–
Turbidity	NTU	2.6	0.6	0.3	0.8	0.7	0.4	0.5	0.2	0.2	0.1	0.4 0.4	0.5 0.4	0.3 0.3	0.4 0.3
pH	–	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.6	7.7	7.6	7.6	7.7	7.7	7.7
Temperature	°C	31.6	31.5	31.6	31.1	31.3	30.9	30.8	30.6	31.2	31.0	30.2	31.0	30.6	30.8
DO	mg/L	1.8	1.4	1.7	1.7	1.5	1.5	1.4	1.3	1.2	1.5	1.3	1.3	1.2	1.2
ORP	mV	55	488	495	62	501	531	528	81	486	502	62	460	520	507
Free Chlorine	mg/L	–	0.4	0.5	–	0.5	0.5	0.4	–	0.4	0.4	–	0.4	0.4	0.5
Total Chlorine	mg/L	–	0.5	0.5	–	0.5	0.5	0.5	–	0.4	0.5	–	0.5	0.5	0.5
Total Hardness	mg/L ^(a)	89.8	90.1	86.6	–	–	–	–	80.2	79.2	74.5	–	–	–	–
Ca Hardness	mg/L ^(a)	72.5	73.0	70.1	–	–	–	–	64.1	63.1	60.6	–	–	–	–
Mg Hardness	mg/L ^(a)	17.3	17.1	16.5	–	–	–	–	16.1	16.1	13.9	–	–	–	–
As (total)	µg/L	25.1	25.4	3.0	25.0	25.6	2.4	2.8	23.7	23.9	2.8	23.9 23.7	24.3 24.1	3.5 3.4	3.9
As (total soluble)	µg/L	23.1	23.5	2.8	–	–	–	–	21.9	22.5	2.6	–	–	–	–
As (particulate)	µg/L	2.0	1.9	0.2	–	–	–	–	1.8	1.4	0.2	–	–	–	–
As (III)	µg/L	22.6	21.1 ^(c)	1.8	–	–	–	–	21.0	1.1	1.2	–	–	–	–
As (V)	µg/L	0.5	2.4 ^(c)	1.0	–	–	–	–	0.9	21.4	1.4	–	–	–	–
Total Fe	µg/L	50	28	<25	36	34	<25	<25	58	50	<25	46 46	42 43	<25 <25	<25
Dissolved Fe	µg/L	<25	<25	<25	–	–	–	–	43	<25	<25	–	–	–	–
Total Mn	µg/L	11.0	8.8	0.8	7.9	7.7	<0.1	<0.1	8.9	9.4	0.5	8.0 8.3	7.5 7.8	0.2 0.1	0.2
Dissolved Mn	µg/L	10.5	9.2	0.5	–	–	–	–	8.6	5.7	0.3	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Data is questionable.

IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		08/04/04			08/18/04				09/01/04			09/15/04			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB
Bed Volume	10 ³	–	–	14.2	–	–	14.5	16.4	–	–	16.5	–	–	16.7	18.5
Alkalinity	mg/L ^(a)	184	188	184	184	180	176	180	181	181	181	182	182	186	182
Fluoride	mg/L	0.5	0.5	0.5	–	–	–	–	0.4	0.4	0.4	–	–	–	–
Sulfate	mg/L	170	170	180	–	–	–	–	170	160	200	–	–	–	–
Orthophosphate	mg/L ^(b)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.06	<0.06	<0.06	<0.06
Silica (as SiO ₂)	mg/L	38.1	38.0	37.8	38.8	38.1	38.2	38.1	38.2	38.0	38.4	38.5	38.3	38.4	38.8
Sulfide	µg/L	<5 <5	–	–	–	–	–	–	<5 <5	–	–	–	–	–	–
NO ₃ -N	mg/L	<0.04	<0.04	<0.04	–	–	–	–	<0.04	<0.04	<0.04	–	–	–	–
Turbidity	NTU	0.2	0.2	0.1	0.6	0.6	0.1	0.1	0.9	0.2	0.2	0.7	0.7	0.4	0.4
pH	–	7.6	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.7	7.6	7.6	7.6	7.6
Temperature	°C	30.4	30.8	31.2	30.2	30.5	30.8	30.6	30.1	30.4	30.4	29.9	30.1	30.3	30.2
DO	mg/L	1.1	1.2	1.1	0.9	0.9	1.3	1.4	0.9	1.0	0.8	0.8	1.1	1.3	1.2
ORP	mV	92	454	468	101	476	471	485	NA	495	515	74	480	490	502
Free Chlorine	mg/L	–	0.5	0.4	–	0.4	0.4	0.4	–	0.5	0.5	–	0.5	0.5	0.5
Total Chlorine	mg/L	–	0.5	0.5	–	0.5	0.5	0.5	–	0.6	0.6	–	0.6	0.5	0.5
Total Hardness	mg/L ^(a)	98.3	99.2	99.3	–	–	–	–	–	–	–	–	–	–	–
Ca Hardness	mg/L ^(a)	82.0	83.0	82.9	–	–	–	–	–	–	–	–	–	–	–
Mg Hardness	mg/L ^(a)	16.3	16.2	16.4	–	–	–	–	–	–	–	–	–	–	–
As (total)	µg/L	21.5	22.0	2.8	22.4	22.8	4.2	4.2	24.9	27.2	7.4	21.6	23.2	3.1	3.5
As (total soluble)	µg/L	21.5	21.7	2.8	–	–	–	–	24.5	25.2	7.4	–	–	–	–
As (particulate)	µg/L	<0.1	0.3	<0.1	–	–	–	–	0.4	5.0	<0.1	–	–	–	–
As (III)	µg/L	21.0	0.8	0.8	–	–	–	–	22.2	3.3 ^(c)	4.1 ^(c)	–	–	–	–
As (V)	µg/L	0.5	20.9	2.0	–	–	–	–	2.3	21.9	3.3	–	–	–	–
Total Fe	µg/L	49	61	<25	89	88	<25	<25	68	56	<25	108	112	48	44
Dissolved Fe	µg/L	38	<25	<25	–	–	–	–	27	<25	<25	–	–	–	–
Total Mn	µg/L	8.7	10.7	0.2	8.6	8.7	0.2	0.6	9.0	11.9	0.3	10.1	14.7	0.6	0.7
Dissolved Mn	µg/L	8.8	5.9	0.5	–	–	–	–	9.6	6.0	0.4	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Prechlorination system failed the day before sampling. System repaired and chlorine residual returned to normal prior to collecting samples. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		09/29/04			10/13/04				10/28/04			11/03/04			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB
Bed Volume	10 ³	–	–	18.5	–	–	18.4	20.2	–	–	20.2	–	–	19.6	21.6
Alkalinity	mg/L ^(a)	176	185	185	171 171	171 175	187 183	175 175	185	189	189	185	185	181	185
Fluoride	mg/L	0.3	0.3	0.3	–	–	–	–	0.2	0.2	0.2	–	–	–	–
Sulfate	mg/L	180	170	170	–	–	–	–	170	170	170	–	–	–	–
Orthophosphate	mg/L ^(b)	<0.06	<0.06	<0.06	<0.06 <0.06	<0.06 <0.06	<0.06 <0.06	<0.06 <0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Silica (as SiO ₂)	mg/L	37.8	38.4	37.7	37.5 37.4	37.2 37.2	37.2 37.4	37.8 36.5	38.0	38.2	37.8	36.8	36.9	37.3	37.3
Sulfide	µg/L	–	–	–	<5 <5	–	–	–	–	–	–	<5 <5	–	–	–
NO ₃ -N	mg/L	<0.04	<0.04	<0.04	–	–	–	–	<0.04	<0.04	<0.04	–	–	–	–
Turbidity	NTU	0.8	0.3	<0.1	0.5 0.4	0.4 0.4	0.2 0.1	0.4 0.2	0.3	0.3	0.3	0.2	0.2	0.1	0.2
pH	–	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.7	7.7	7.7
Temperature	°C	30.2	30.4	30.5	30.1	30.1	30.4	30.4	30.1	30.3	30.4	29.0	29.2	29.4	29.4
DO	mg/L	0.9	1.1	1.2	0.5	1.0	1.0	0.9	0.3	0.6	0.5	0.5	0.7	0.7	0.6
ORP	mV	90	506	520	79	529	545	552	28	502	392	56	458	494	502
Free Chlorine	mg/L	–	0.5	0.5	–	0.6	0.6	0.6	–	0.6	0.5	–	0.5	0.5	0.5
Total Chlorine	mg/L	–	0.6	0.6	–	0.6	0.6	0.6	–	0.7	0.5	–	0.6	0.5	0.6
Total Hardness	mg/L ^(a)	101.6	101.0	102.4	–	–	–	–	90.4	95.0	99.6	–	–	–	–
Ca Hardness	mg/L ^(a)	83.4	83.1	84.1	–	–	–	–	70.4	76.0	81.7	–	–	–	–
Mg Hardness	mg/L ^(a)	18.2	17.9	18.3	–	–	–	–	20.0	19.0	17.9	–	–	–	–
As (total)	µg/L	24.8	25.4	6.8	22.1 23.0	22.4 22.1	3.7 3.7	3.5 3.6	23.8	27.9	9.3	23.0	23.0	6.8	7.2
As (total soluble)	µg/L	24.5	24.7	6.6	–	–	–	–	25.4	27.2	7.4	–	–	–	–
As (particulate)	µg/L	0.3	0.7	0.2	–	–	–	–	<0.1	0.2	1.9	–	–	–	–
As (III)	µg/L	23.2	3.2 ^(c)	3.4 ^(c)	–	–	–	–	25.2	4.6 ^(c)	4.1 ^(c)	–	–	–	–
As (V)	µg/L	1.3	21.5	3.2	–	–	–	–	0.2	22.6	3.3	–	–	–	–
Total Fe	µg/L	64	49	<25	78 81	85 63	<25 <25	<25 <25	39	26	<25	<25	<25	<25	<25
Dissolved Fe	µg/L	47	<25	<25	–	–	–	–	<25	<25	<25	–	–	–	–
Total Mn	µg/L	9.4	8.3	0.4	24.8 9.7	10.0 9.2	4.9 3.1	1.4 0.1	7.9	7.5	0.3	7.7	7.4	0.1	<0.1
Dissolved Mn	µg/L	9.2	6.0	0.3	–	–	–	–	7.8	5.8	0.4	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Prechlorination system failed the day before sampling. System repaired and chlorine residual returned to normal prior to collecting samples. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		11/17/04			12/01/04				12/15/04			01/05/05			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB
Bed Volume	10 ³	–	–	21.6	–	–	21.2	23.3	–	–	23.0	–	–	23.2	25.1
Alkalinity	mg/L ^(a)	185	189	189	183	183	175	187	183	183	187	186 186	190 186	198 198	194 190
Fluoride	mg/L	0.5	0.5	0.7	–	–	–	–	0.5	0.5	0.5	–	–	–	–
Sulfate	mg/L	170	160	170	–	–	–	–	190	190	190	–	–	–	–
Orthophosphate	mg/L ^(b)	<0.06	<0.06	1.4 ^(c)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06 <0.06	<0.06 <0.06	<0.06 <0.06	<0.06 <0.06
Silica (as SiO ₂)	mg/L	37.7	37.6	37.5	37.8	37.4	37.6	37.5	38.9	38.3	38.9	38.7 39.5	38.4 38.9	39.1 38.9	38.7 39.7
Sulfide	µg/L	–	–	–	<5 <5	–	–	–	–	–	–	<5 <5	–	–	–
NO ₃ -N	mg/L	<0.04	<0.04	<0.04	–	–	–	–	<0.04	<0.04	<0.04	–	–	–	–
Turbidity	NTU	0.5	0.3	0.3	0.4	0.3	0.1	0.2	1.1	0.3	0.4	0.4 0.5	0.3 0.4	0.1 0.1	0.2 0.1
pH	–	7.6	7.6	7.6	7.6	7.6	7.7	7.7	7.6	7.6	7.7	7.8	7.8	7.7	7.7
Temperature	°C	29.3	30.1	30.1	29.6	30.1	29.9	30.0	29.6	30.1	30.3	29.0	30.2	30.4	30.4
DO	mg/L	0.4	0.6	0.5	0.6	0.7	0.8	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.5
ORP	mV	27	540	502	78	530	548	565	63	562	520	52	540	566	576
Free Chlorine	mg/L	–	0.7	0.7	–	0.6	0.6	0.6	–	0.6	0.6	–	0.5	0.5	0.4
Total Chlorine	mg/L	–	0.8	0.8	–	0.7	0.7	0.7	–	0.7	0.7	–	0.5	0.5	0.5
Total Hardness	mg/L ^(a)	82.7	83.4	82.7	–	–	–	–	97.0	97.4	99.3	–	–	–	–
Ca Hardness	mg/L ^(a)	67.2	67.7	67.1	–	–	–	–	80.8	81.0	82.4	–	–	–	–
Mg Hardness	mg/L ^(a)	15.5	15.7	15.6	–	–	–	–	16.2	16.4	16.9	–	–	–	–
As (total)	µg/L	22.7	23.0	5.8	26.7	27.8	10.4	11.4	23.9	23.7	5.3	20.6 20.9	21.1 21.2	4.2 4.2	4.4 4.6
As (total soluble)	µg/L	22.5	23.1	5.8	–	–	–	–	22.1	23.6	4.4	–	–	–	–
As (particulate)	µg/L	0.2	<0.1	<0.1	–	–	–	–	1.8	0.1	1.0	–	–	–	–
As (III)	µg/L	22.0	1.4	0.1	–	–	–	–	22.0	2.2	1.9	–	–	–	–
As (V)	µg/L	0.5	21.7	5.7	–	–	–	–	0.1	21.4	2.5	–	–	–	–
Total Fe	µg/L	34	<25	<25	64	58	<25	<25	154	73	<25	82 75	68 71	<25 <25	<25 <25
Dissolved Fe	µg/L	<25	<25	<25	–	–	–	–	57	<25	<25	–	–	–	–
Total Mn	µg/L	9.1	8.8	0.3	8.2	8.3	0.4	0.3	9.7	9.6	0.4	18.1 10.1	11.0 10.3	0.2 <0.1	<0.1 <0.1
Dissolved Mn	µg/L	8.9	7.3	<0.1	–	–	–	–	9.0	5.4	0.2	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Data is questionable due to potential sampling or analytical error. All other results from January 28, 2004 through March 2, 2005 have been below reporting limits. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		01/20/05			02/02/05				02/16/05			03/02/05			
Sampling Location	Parameter	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB
Bed Volume	10 ³	–	–	25.1	–	–	24.7	26.6	–	–	26.4	–	–	26.5	28.2
Alkalinity	mg/L ^(a)	181	172	189	200	200	191	195	201	201	201	187	178	187	182
Fluoride	mg/L	0.7	0.8	0.7	–	–	–	–	0.5	0.5	0.5	–	–	–	–
Sulfate	mg/L	251	249	250	–	–	–	–	255	255	255	–	–	–	–
Orthophosphate	mg/L ^(b)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silica (as SiO ₂)	mg/L	37.3	36.8	36.6	36.5	37.3	37.1	36.2	39.8	40.2	40.6	39.1	39.4	39.1	38.9
Sulfide	µg/L	–	–	–	<5 <5	–	–	–	–	–	–	<5 <5	–	–	–
NO ₃ -N	mg/L	<0.05	<0.05	<0.05	–	–	–	–	<0.05	<0.05	<0.05	–	–	–	–
Turbidity	NTU	0.2	0.2	<0.1	0.2	0.1	<0.1	<0.1	0.4	0.3	<0.1	0.3	0.2	<0.1	<0.1
pH	–	7.6	7.6	7.6	7.6	7.6	7.7	7.7	7.6	7.6	7.6	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)
Temperature	°C	30.6	31.0	31.2	30.8	31.2	30.9	30.8	30.6	30.7	30.7	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)
DO	mg/L	0.3	0.4	0.4	0.3	0.3	0.4	0.4	0.2	0.2	0.4	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)
ORP	mV	48	518	537	28	523	544	546	20	520	522	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)
Free Chlorine	mg/L	–	0.7	0.6	–	0.6	0.5	0.5	–	0.6	0.5	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)
Total Chlorine	mg/L	–	0.7	0.7	–	0.6	0.6	0.5	–	0.6	0.6	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)
Total Hardness	mg/L ^(a)	90.3	81.1	80.2	–	–	–	–	76.8	82.8	68.3	–	–	–	–
Ca Hardness	mg/L ^(a)	74.8	67.0	65.8	–	–	–	–	63.6	70.2	55.9	–	–	–	–
Mg Hardness	mg/L ^(a)	15.5	14.1	14.4	–	–	–	–	13.2	12.6	12.4	–	–	–	–
As (total)	µg/L	23.0	21.3 ^(c)	5.0	19.9	19.6	3.7	3.8	20.6	22.3	3.5	23.2	23.3	5.3	4.6
As (total soluble)	µg/L	22.0	22.0 ^(c)	4.3	–	–	–	–	22.1	22.7	3.1	–	–	–	–
As (particulate)	µg/L	1.0	<0.1	0.7	–	–	–	–	<0.1	<0.1	0.4	–	–	–	–
As (III)	µg/L	22.1	21.6 ^(c)	2.5	–	–	–	–	21.7	1.6	1.6	–	–	–	–
As (V)	µg/L	<0.1	0.4	1.8	–	–	–	–	<0.1	21.1	1.5	–	–	–	–
Total Fe	µg/L	93	43	<25	54	49	<25	<25	119	96	<25	43	37	<25	<25
Dissolved Fe	µg/L	30	25	<25	–	–	–	–	55	<25	<25	–	–	–	–
Total Mn	µg/L	10.5	10.2	0.3	8.7	8.1	0.1	0.7	8.4	11.2	0.1	10.7	8.3	5.0	0.1
Dissolved Mn	µg/L	9.2	9.1	0.1	–	–	–	–	9.1	4.7	<0.1	–	–	–	–

(a) As CaCO₃. (b) As PO₄. (c) Data is questionable due to suspected sampling error. It is speculated that the AC sample may actually have been collected from the IN sample tap on this date. Confirmatory analysis of sample produced similar values. (d) In order to reduce the work load, the operator will be taking on-site water quality parameters once every month. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		03/16/05			03/30/05				04/13/05			04/27/05			
Sampling Location	Parameter Unit	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB
Bed Volume	10 ³	-	-	28.6	-	-	28.9	30.4	-	-	31.0	-	-	32.1	33.5
Alkalinity	mg/L ^(a)	196	196	192	189	189	180	189	211	216	180	220	202	202	198
Fluoride	mg/L	0.5	0.5	0.5	-	-	-	-	0.4	0.5	0.4	-	-	-	-
Sulfate	mg/L	214	199	200	-	-	-	-	201	200	195	-	-	-	-
Orthophosphate	mg/L ^(b)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silica (as SiO ₂)	mg/L	39.0	38.9	39.2	38.4	38.3	37.5	38.4	39.4	39.2	39.4	39.9	40.5	39.7	40.0
Sulfide	µg/L	-	-	-	-	-	-	-	-	-	-	<5 <5	-	-	-
NO ₃ -N	mg/L	<0.05	<0.05	<0.05	-	-	-	-	<0.05	<0.05	0.06	-	-	-	-
Turbidity	NTU	0.3	0.3	<0.1	0.2	0.2	<0.1	<0.1	0.5	0.5	0.1	0.5	0.3	<0.1	<0.1
pH	-	7.6	7.6	7.7	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	7.6	7.6	7.6	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
Temperature	°C	29.9	30.2	30.4	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	30.3	30.5	30.6	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
DO	mg/L	0.7	0.2	0.2	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	0.2	0.3	0.2	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
ORP	mV	31	540	558	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	63	505	522	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
Free Chlorine	mg/L	-	0.4	0.4	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	-	0.4	0.5	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
Total Chlorine	mg/L	-	0.4	0.4	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	-	0.5	0.5	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)
Total Hardness	mg/L ^(a)	82.9	83.1	87.1	-	-	-	-	83.0	83.1	81.2	-	-	-	-
Ca Hardness	mg/L ^(a)	67.0	67.6	71.9	-	-	-	-	68.4	68.8	66.2	-	-	-	-
Mg Hardness	mg/L ^(a)	15.9	15.5	15.2	-	-	-	-	14.6	14.3	15.0	-	-	-	-
As (total)	µg/L	20.5	21.1	5.3	22.1	22.6	6.5	6.5	26.2	21.1	5.8	25.4	25.4	8.1	9.0
As (total soluble)	µg/L	21.7	22.1	5.4	-	-	-	-	26.8	20.5	5.8	-	-	-	-
As (particulate)	µg/L	<0.1	<0.1	<0.1	-	-	-	-	<0.1	0.6	<0.1	-	-	-	-
As (III)	µg/L	21.7	2.0	2.6	-	-	-	-	20.1	2.1	2.1	-	-	-	-
As (V)	µg/L	<0.1	20.1	2.8	-	-	-	-	6.7	18.4	3.7	-	-	-	-
Total Fe	µg/L	48	59	<25	56	48	<25	<25	90	72	<25	52	47	<25	<25
Dissolved Fe	µg/L	29	<25	<25	-	-	-	-	<25	49	<25	-	-	-	-
Total Mn	µg/L	8.3	13.9	<0.1	9.0	9.3	0.2	0.2	9.6	15.8	0.2	8.6	8.5	0.4	0.5
Dissolved Mn	µg/L	8.8	6.3	<0.1	-	-	-	-	6.3	7.6	0.2	-	-	-	-

(a) As CaCO₃. (b) As PO₄. (c) In order to reduce the work load, the operator will be taking on-site water quality parameters once every month. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		05/11/05			05/25/05				06/07/05				06/22/05		
Sampling Location	Parameter Unit	IN	AC	TT	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TT
Bed Volume	10 ³	–	–	34.6	–	–	36.1	37.3	–	–	37.8	38.9	–	–	40.6
Alkalinity	mg/L ^(a)	198	198	198	178	201	187	187	194	189	194	198	185	189	185
Fluoride	mg/L	0.5	0.5	0.5	–	–	–	–	–	–	–	–	0.4	0.4	0.4
Sulfate	mg/L	174	178	186	–	–	–	–	–	–	–	–	176	169	177
Orthophosphate	mg/L ^(b)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silica (as SiO ₂)	mg/L	38.4	39.0	38.9	37.9	37.7	37.6	37.7	39.1	39.0	38.6	38.5	37.6	37.9	37.4
Sulfide	µg/L	<5 <5	–	–	<5 <5	–	–	–	–	–	–	–	<5 <5	–	–
NO ₃ -N	mg/L	<0.05	0.6	<0.05	–	–	–	–	–	–	–	–	<0.05	<0.05	0.09
Turbidity	NTU	0.2	0.2	<0.1	0.2	2.4	2.7	0.7	0.8	1.1	<0.1	<0.1	1.8	0.8	0.3
pH	–	7.6	7.6	7.6	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)	7.6	7.6	7.7
Temperature	°C	31.2	31.4	31.5	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)	31.4	31.6	31.7
DO	mg/L	0.2	0.3	0.3	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)	0.1	0.3	0.2
ORP	mV	50	476	502	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)	35	502	514
Free Chlorine	mg/L	–	0.6	0.5	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)	–	0.7	0.6
Total Chlorine	mg/L	–	0.7	0.6	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(d)	NA ^(d)	NA ^(d)	NA ^(d)	–	0.7	0.7
Total Hardness	mg/L ^(a)	82.6	82.3	80.5	–	–	–	–	–	–	–	–	85.3	86.1	83.3
Ca Hardness	mg/L ^(a)	69.0	69.3	66.5	–	–	–	–	–	–	–	–	70.3	71.0	68.5
Mg Hardness	mg/L ^(a)	13.7	13.0	14.0	–	–	–	–	–	–	–	–	15.0	15.0	14.8
As (total)	µg/L	21.2	22.1	7.1	21.0	22.1	7.5	7.3	24.3	24.8	9.0	9.2	22.8	23.7	10.1
As (total soluble)	µg/L	21.2	22.8	7.2	–	–	–	–	–	–	–	–	22.9	24.8	9.1
As (particulate)	µg/L	<0.1	<0.1	<0.1	–	–	–	–	–	–	–	–	<0.1	<0.1	1.1
As (III)	µg/L	21.2	2.0	1.6	–	–	–	–	–	–	–	–	22.5	3.0	2.8
As (V)	µg/L	<0.1	20.8	5.6	–	–	–	–	–	–	–	–	0.4	21.8	6.2
Total Fe	µg/L	59	64	<25	32	30	<25	<25	73	59	<25	<25	90	65	<25
Dissolved Fe	µg/L	37	<25	<25	–	–	–	–	–	–	–	–	46	25	<25
Total Mn	µg/L	9.3	22.0	0.3	8.4	8.0	0.2	0.1	9.2	10.2	0.2	0.2	9.6	17.4	0.5
Dissolved Mn	µg/L	10.5	7.5	0.4	–	–	–	–	–	–	–	–	10.4	8.2	0.3

(a) As CaCO₃. (b) As PO₄. (c) In order to reduce the work load, the operator will be taking on-site water quality parameters once every month. (d) Operator left early for training and was not able to take on-site water quality parameters.

IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		07/06/05				08/03/05 ^(d)			08/17/05 ^(e)			08/31/05		
Sampling Location	Parameter	IN	AC	TA	TB	IN	AC	TT	IN	AC	TT	IN	AC	TT
Bed Volume	10 ³	-	-	42.8	43.2	-	-	0.8	-	-	2.9	-	-	5.1
Alkalinity	mg/L ^(a)	176	198	176	198	185	185	189	-	-	-	185	180	185
Fluoride	mg/L	-	-	-	-	0.5	0.5	0.5	-	-	-	0.5	0.5	0.5
Sulfate	mg/L	-	-	-	-	176	175	162	-	-	-	194	192	194
Orthophosphate	mg/L ^(b)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05
Silica (as SiO ₂)	mg/L	38.9	37.9	38.3	38.2	37.5	36.8	33.7	-	-	-	39.6	39.6	38.7
Sulfide	µg/L	<5 <5	-	-	-	<5 <5	-	-	-	-	-	<5 -	-	-
NO ₃ -N	mg/L	-	-	-	-	0.06	<0.05	<0.05	-	-	-	0.2	0.3	1.0
Turbidity	NTU	0.3	0.4	<0.1	<0.1	0.7	0.3	<0.1	-	-	-	1.5	0.2	0.2
TSS	mg/L	-	-	-	-	-	-	-	-	-	-	1	-	-
pH	-	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.7
Temperature	°C	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	31.6	31.8	31.6	29.9	30.9	31.2	31.4	31.7	31.9
DO	mg/L	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.3
ORP	mV	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	14	512	520	52	370	410	65	502	518
Free Chlorine	mg/L	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	-	1.0	0.5	-	0.6	0.3	-	0.6	0.4
Total Chlorine	mg/L	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	-	-	-	-	-	-	-	-	-
Total Hardness	mg/L ^(a)	-	-	-	-	83.2	80.7	82.6	-	-	-	83.1	85.0	85.5
Ca Hardness	mg/L ^(a)	-	-	-	-	69.4	67.0	68.7	-	-	-	69.2	70.5	70.9
Mg Hardness	mg/L ^(a)	-	-	-	-	13.8	13.7	13.9	-	-	-	13.9	14.6	14.5
As (total)	µg/L	22.3	22.9	11.9	8.9	24.1	31.5	6.8	24.5	24.7	7.6	25.7	27.1	2.2
As (total soluble)	µg/L	-	-	-	-	21.5	21.9	2.7	-	-	-	22.5	23.7	1.8
As (particulate)	µg/L	-	-	-	-	2.6	9.6	4.1	-	-	-	3.3	3.4	0.5
As (III)	µg/L	-	-	-	-	23.1	3.8	3.3	-	-	-	21.3	1.7	1.6
As (V)	µg/L	-	-	-	-	<0.1	18.1	<0.1	-	-	-	1.2	22.0	0.2
Total Fe	µg/L	51	51	<25	<25	77	41	<25	290	33	<25	186	47	<25
Dissolved Fe	µg/L	-	-	-	-	<25	<25	<25	-	-	-	30	18	<25
Total Mn	µg/L	8.4	9.4	0.6	0.4	8.9	9.1	0.3	10.6	8.0	0.4	10.6	9.7	0.4
Dissolved Mn	µg/L	-	-	-	-	8.7	7.3	0.2	-	-	-	10.3	8.3	0.5

(a) As CaCO₃. (b) As PO₄. (c) In order to reduce the work load, the operator will be taking on-site water quality parameters once every month. (d) System was switched off July 14, 2005 and placed back online July 29, 2005. The bottom laterals, under bedding, and media were replaced and other system repairs were performed during the downtime. (e) The sampling schedule has been modified to reduce the number of analytes starting August 17, 2005.

IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		09/14/05 ^(c)			09/28/05			10/12/05 ^(c)				10/26/05		
Sampling Location	Parameter	IN	AC	TT	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT
Bed Volume	10 ³	-	-	6.9	-	-	9.2	-	-	10.9	11.2	-	-	12.6
Alkalinity	mg/L ^(a)	-	-	-	180	198	189	198	198	198	198	198	198	198
Fluoride	mg/L	-	-	-	0.4	0.4	0.4	-	-	-	-	0.4	0.4	0.4
Sulfate	mg/L	-	-	-	156	157	158	-	-	-	-	201	200	199
Orthophosphate	mg/L ^(b)	-	-	-	<0.05	<0.05	<0.05	-	-	-	-	-	-	-
Total P (as PO ₄)	mg/L ^(b)	-	-	-	-	-	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silica (as SiO ₂)	mg/L	-	-	-	38.7	38.6	38.9	36.8	36.2	36.1	35.6	37.7	38.5	38.4
Sulfide	µg/L	-	-	-	<5	-	-	<5	-	-	-	<5	-	-
NO ₃ -N	mg/L	-	-	-	<0.05	0.4	<0.05	-	-	-	-	<0.05	<0.05	<0.05
Turbidity	NTU	-	-	-	1.0	0.2	0.2	0.5	0.3	<0.1	<0.1	0.3	0.1	<0.1
TSS	mg/L	-	-	-	-	-	-	-	-	-	-	<1	<1	<1
pH	-	NA ^(c)	NA ^(c)	NA ^(c)	7.8	7.9	7.9	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	7.8	7.8	7.8
Temperature	°C	NA ^(c)	NA ^(c)	NA ^(c)	31.5	31.7	31.8	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	30.2	30.8	30.9
DO	mg/L	NA ^(c)	NA ^(c)	NA ^(c)	0.2	0.2	0.2	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	0.2	0.2	0.2
ORP	mV	NA ^(c)	NA ^(c)	NA ^(c)	51	507	576	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	22	514	522
Free Chlorine	mg/L	NA ^(c)	0.8	0.6	-	0.8	0.5	NA ^(c)	0.6	NA ^(c)	NA ^(c)	-	0.6	0.6
Total Chlorine	mg/L	NA ^(c)	NA ^(c)	NA ^(c)	-	-	-	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	-	0.8	0.6
Total Hardness	mg/L ^(a)	-	-	-	81.4	74.5	75.2	-	-	-	-	84.2	87.4	86.4
Ca Hardness	mg/L ^(a)	-	-	-	68.2	61.1	61.4	-	-	-	-	69.9	72.4	71.3
Mg Hardness	mg/L ^(a)	-	-	-	13.2	13.4	13.8	-	-	-	-	14.2	15.1	15.1
As (total)	µg/L	21.8	22.5	2.8	24.6	22.5	4.0	23.5	23.1	4.5	4.3	23.8	23.3	3.9
As (total soluble)	µg/L	-	-	-	24.4	22.7	3.7	-	-	-	-	23.1	22.3	3.7
As (particulate)	µg/L	-	-	-	0.2	<0.1	0.2	-	-	-	-	0.7	1.1	0.2
As (III)	µg/L	-	-	-	22.3	2.6	2.9	-	-	-	-	22.2	1.9	2.0
As (V)	µg/L	-	-	-	2.1	20.1	0.9	-	-	-	-	1.0	20.4	1.8
Total Fe	µg/L	77	53	<25	187	33	<25	62	65	<25	<25	43	36	<25
Dissolved Fe	µg/L	-	-	-	<25	<25	<25	-	-	-	-	39	<25	<25
Total Mn	µg/L	8.7	9.9	0.2	10.2	9.4	<0.1	8.9	9.4	0.1	0.2	8.8	8.8	0.2
Dissolved Mn	µg/L	-	-	-	10.1	6.9	<0.1	-	-	-	-	9.0	6.6	0.2

(a) As CaCO₃. (b) As PO₄. (c) Operator did not have time to collect on-site water quality parameters although free Cl₂ was collected for AC and TT on 09/14/05. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		11/09/05				11/30/05			12/14/05				01/04/06		
Sampling Location	Parameter	IN	AC	TA	TB	IN	AC	TT	IN	AC	TA	TB	IN	AC	TT
Bed Volume	10 ³	-	-	14.1	14.4	-	-	16.5	-	-	17.5	18.3	-	-	20.1
Alkalinity	mg/L ^(a)	189	189	198	194	185	189	189	185	194	198	198	189	198	194
Fluoride	mg/L	-	-	-	-	0.4	0.4	0.4	-	-	-	-	0.4	0.4	0.4
Sulfate	mg/L	-	-	-	-	161	162	161	-	-	-	-	165	170	165
Orthophosphate	mg/L ^(b)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total P (as PO ₄)	mg/L ^(b)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silica (as SiO ₂)	mg/L	36.5	37.0	36.7	36.9	38.2	38.4	38.5	37.4	37.9	38.1	38.1	38.2	36.9	37.6
Sulfide	µg/L	<5	-	-	-	<5	-	-	-	-	-	-	<5	-	-
NO ₃ -N	mg/L	-	-	-	-	<0.05	<0.05	<0.05	-	-	-	-	<0.05	<0.05	<0.05
Turbidity	NTU	0.2	0.1	<0.1	<0.1	0.2	0.1	<0.1	1.0	1.4	0.6	0.8	0.5	0.5	0.2
TSS	mg/L	-	-	-	-	1	<1	<1	-	-	-	-	<1	-	-
pH	-	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	7.7	7.7	7.7	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	7.7	7.7	7.8
Temperature	°C	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	31.0	31.3	31.4	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	30.6	30.8	30.8
DO	mg/L	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	0.3	0.3	0.2	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	0.1	0.2	0.2
ORP	mV	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	33	505	524	NA ^(c)	NA ^(c)	NA ^(c)	NA ^(c)	18	495	512
Free Chlorine	mg/L	-	NA ^(c)	NA ^(c)	NA ^(c)	-	0.8	0.6	-	NA ^(c)	NA ^(c)	NA ^(c)	-	0.8	0.7
Total Chlorine	mg/L	-	NA ^(c)	NA ^(c)	NA ^(c)	-	NA	NA	-	NA ^(c)	NA ^(c)	NA ^(c)	-	NA	NA
Total Hardness	mg/L ^(a)	-	-	-	-	90.2	87.1	88.1	-	-	-	-	86.3	86.7	86.1
Ca Hardness	mg/L ^(a)	-	-	-	-	75.5	73.1	74.2	-	-	-	-	71.3	72.0	71.3
Mg Hardness	mg/L ^(a)	-	-	-	-	14.8	14.0	13.9	-	-	-	-	15.0	14.7	14.8
As (total)	µg/L	24.7	24.1	3.7	3.7	18.6	21.8	5.0	21.4	21.1	4.3	4.3	21.5	21.8	3.9
As (total soluble)	µg/L	-	-	-	-	19.7	21.0	4.9	-	-	-	-	22.2	22.6	3.9
As (particulate)	µg/L	-	-	-	-	<0.1	0.8	<0.1	-	-	-	-	<0.1	<0.1	<0.1
As (III)	µg/L	-	-	-	-	19.1	2.0	2.2	-	-	-	-	21.8	0.9	1.0
As (V)	µg/L	-	-	-	-	0.5	19.0	2.7	-	-	-	-	0.4	21.6	2.9
Total Fe	µg/L	32	26	<25	<25	46	27	<25	42	36	<25	<25	65	53	<25
Dissolved Fe	µg/L	-	-	-	-	27	<25	<25	-	-	-	-	29	<25	<25
Total Mn	µg/L	7.9	7.4	<0.1	<0.1	8.8	8.9	0.6	8.9	8.6	0.8	0.6	9.1	9.5	0.4
Dissolved Mn	µg/L	-	-	-	-	9.0	7.8	0.4	-	-	-	-	9.0	7.6	0.3

(a) As CaCO₃. (b) As PO₄. (c) In order to reduce work load, the operator will be taking on-site water quality parameters once every month. IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B; TT = after tanks combined. NA = data not available.

Table B-1. Analytical Results from Long-Term Sampling, Desert Sands MDWCA (Continued)

Sampling Date		02/01/06 ^(a)				02/15/06				03/01/06				03/15/06			
Sampling Location	Parameter Unit	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume	10 ³	–	–	22.2	23.3	–	–	23.5	24.7	–	–	24.8	26.1	–	–	26.3	27.4
As (total)	µg/L	24.8	24.8	5.8	6.3	23.6	25.1	6.8	7.0	21.5	22.6	4.6	5.7	25.3	24.1	5.6	5.7
Fe (total)	µg/L	66.8	73.6	<25	<25	<25	<25	<25	<25	70.7	50.3	<25	<25	66.3	61.0	<25	<25
Mn (total)	µg/L	10.3	11.6	0.5	0.5	6.9	7.7	<0.1	0.2	9.5	9.3	<0.1	0.2	9.3	12.8	0.3	0.3

Sampling Date		03/29/06				04/12/06				04/26/06				05/10/06			
Sampling Location	Parameter Unit	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume	10 ³	–	–	27.7	29.1	–	–	29.7	31.1	–	–	31.6	33.1	–	–	33.4	35.1
As (total)	µg/L	23.0	22.4	4.7	5.7	23.9	24.0	6.9	7.3	22.4	22.0	5.4	6.2	23.4 23.5	24.0 23.6	6.1 6.2	6.7 6.7
Fe (total)	µg/L	82.3	59.5	<25	<25	97.3	56.5	<25	<25	56.4	34.8	<25	<25	234 250	112 110	<25 <25	<25 <25
Mn (total)	µg/L	8.4	8.4	0.1	0.5	9.2	9.7	0.6	0.7	8.6	9.0	0.2	0.5	15.7 14.3	13.7 13.6	0.7 0.6	0.8 0.7

Sampling Date		05/24/06				06/07/06				06/21/06				07/05/06			
Sampling Location	Parameter Unit	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume	10 ³	–	–	35.7	37.4	–	–	38.2	40.1	–	–	40.6	42.7	–	–	43.1	45.1
As (total)	µg/L	22.1	23.6	6.3	7.4	23.1	22.5	7.6	7.7	24.9	24.7	7.5	8.3	21.6	22.0	8.8	7.3
Fe (total)	µg/L	83.2	70.8	<25	<25	119	77.2	<25	<25	62.9	53.8	<25	<25	90.5	64.5	<25	<25
Mn (total)	µg/L	7.5	8.1	<0.1	0.5	9.8	10.1	0.6	0.7	9.5	10.1	0.5	0.6	10.6	10.0	1.0	0.8

Sampling Date		07/19/06				08/02/06											
Sampling Location	Parameter Unit	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB	IN	AC	TA	TB
Bed Volume	10 ³	–	–	45.1	47.2	–	–										
As (total)	µg/L	24.9	24.7	8.7	9.2	25.9	24.8	9.6	10.1								
Fe (total)	µg/L	1151	65.7	<25	<25	65.2	39.5	<25	<25								
Mn (total)	µg/L	12.9	14.2	0.8	0.8	9.5	10.1	0.4	0.3								

(a) Sampling reduced to biweekly for As, Fe, and Mn only.
 IN = inlet; AC = after prechlorination; TA = after tank A; TB = after tank B.