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Arsenic Removal from Drinking Water by Adsorptive Media U.S. EPA Demonstration Project at Lead, South Dakota Final Performance Evaluation Report

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Sally Gutierrez, Director
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ABSTRACT

This report documents the activities performed and the results obtained from the arsenic removal treatment technology demonstration project at Lead, South Dakota. The main objective of the project was to evaluate the effectiveness of SolmeteX's adsorptive media system in removing arsenic to meet the new arsenic maximum contaminant level (MCL) of 10 μg/L. Additionally, this project evaluated (1) the reliability of the treatment system, (2) the required system operation and maintenance (O&M) and operator skills, and (3) the capital and O&M cost of the technology. The project also characterized the water in the distribution system. The types of data collected included system operation, water quality (both across the treatment train and in the distribution system), process residuals, and capital and O&M cost.

The demonstration study was divided into two study periods, with Study Period I extending from April 4, 2008, to November 29, 2009, and Study Period II from November 30, 2009, to May 23, 2010. Study Period I focused on evaluating the performance of ArsenX^{np} media. At the end of Study Period I, the lead vessel was replaced with LayneRT™ and the flow through the vessels was switched (such that the lag vessel containing partially exhausted ArsenX^{np} media was placed in the lead position and the former lead vessel containing virgin LayneRT™ media was placed in the lag position) before Study Period II began. ArsenX^{np} is an engineered hybrid inorganic/organic sorbent manufactured by Purolite. The media consists of hydrous iron oxide nanoparticles impregnated into 300 to 1,200 μm anion exchange resin beads. LayneRT™ is a newer generation of the hybrid media.

The treatment system consisted of two 42-in × 72-in fiber glass vessels in series configuration, each containing approximately 28 ft^3 of adsorptive media. The treatment system was designed for a peak flowrate of 75 gal/min (gpm) and an empty bed contact time (EBCT) of approximately 2.8 min/vessel. Over the performance evaluation period, the actual average flowrate was at 71.5 gpm in Study Period I and 69.2 gpm in Study Period II, corresponding to an EBCT of 2.9 and 3.0 min, respectively.

In Study Period I, the treatment system operated for a total of 7,154 hr, treating approximately 27,978,780 gal (or 133,590 bed volumes [BV]) of water. (Unless mentioned otherwise, bed volumes were calculated based on 28 ft^3 of media in one vessel.) The average daily operating time was 12.0 hr/day and the average daily water production was 46,866 gal/day (gpd). In Study Period II, the treatment system operated for a total of 1,787 hr, treating approximately 7,231,940 gal (or 34,530 BV) of water. The average daily operating time was 10.5 hr/day and the average daily water production was 42,541 gpd. Due to leaks from the distribution system, the amount of daily water production in both study periods was significantly higher than the design value of 9,000 gpd. During the 25-month demonstration study, the District located and fixed several leaks from the distribution system.

Total arsenic concentrations in source water ranged from 16.9 to 26.3 μg/L, and averaged 21.6 μg/L. Soluble As(V) was the predominating species with concentrations ranging from 18.6 to 23.1 μg/L and averaging 20.8 μg/L. In Study Period I, arsenic breakthrough at 10 μg/L following the lead vessel occurred after treating 14,725,250 gal (or 70,310 BV) of water, which was about 8% higher than the 65,000 BV working capacity projected by the vendor. By the end of Study Period I, total arsenic concentrations in the system effluent were reduced to 5.8 μg/L. At this point, the system had treated approximately 27,978,780 gal of water (i.e., 133,590 BV – based on 28 ft^3 of media in one vessel, or 66,795 BV – based on 56 ft^3 of media in both vessels). Study Period II ended when the system effluent contained only 0.5 μg/L of total arsenic.

Comparison of the distribution system sampling results before and after system startup showed a significant decrease in arsenic concentration (from an average of 22.5 to 1.1 µg/L). The average lead concentrations reduced from 2.0 µg/L in baseline samples to 0.8 µg/L; the average copper concentration reduced from 164 µg/L to 46.2 µg/L.

The capital investment cost of $87,892 included $60,678 for equipment, $14,214 for site engineering, and $13,000 for installation. Using the system's rated capacity of 75 gpm (or 108,000 gpd), the capital cost was $1,172/gpm (or $0.81/gpd) of design capacity. The unit capital cost would be $0.21/1,000 gal if the 75 gpm system operated around the clock. Based on an average daily operating time of 12.0 hr/day and an average system flowrate of 71.5 gpm, the unit capital cost increased to $0.44/1,000 gal at this reduced rate of use.

The O&M cost included only the cost for media replacement and disposal, electricity consumption, and labor. The media replacement cost represented the majority of the O&M cost. The unit O&M cost is reported in graphical form as a function of projected media run length.

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ABBREVIATIONS AND ACRONYMS

Δp	differential pressure
AAL	American Analytical Laboratories
AM	adsorptive media
As	arsenic
ATS	Aquatic Treatment Systems
bgs	below ground surface
BV	bed volume
Ca	calcium
C/F	coagulation/filtration process
Cl	chlorine
CRF	capital recovery factor
Cu	copper
CWS	community water system
DO	dissolved oxygen
EBCT	empty bed contact time
EPA	U.S. Environmental Protection Agency
F	fluorine
Fe	iron
gpd	gallons per day
gpm	gallons per minute
HDPE	high-density polyethylene
HIX	hybrid ion exchanger
hp	horse power
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
IR	iron removal
IX	ion exchange
LCR	Lead and Copper Rule
MCL	maximum contaminant level
MDL	method detection limit
MEI	Magnesium Elektron, Inc.
Mg	magnesium
Mn	manganese
mV	millivolts
Na	sodium
NA	not analyzed
NRMRL	National Risk Management Research Laboratory

ABBREVIATIONS AND ACRONYMS (Continued)

NSF	NSF International
O&M	operation and maintenance
ORD	Office of Research and Development
ORP	oxidation-reduction potential
PO_4	phosphate
POU	point of use
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RFP	request for proposal
RO	reverse osmosis
RPD	relative percent difference
SD DENR	South Dakota Department of Environmental and Natural Resources
SDWA	Safe Drinking Water Act
SiO_2	silica
SO_4^{2-}	sulfate
STS	Severn Trent Services
TCLP	toxicity characteristic leaching procedure
TDH	total dynamic head
TDS	total dissolved solids
TOC	total organic carbon
VOC	volatile organic compound

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1.0 INTRODUCTION

1.1 Background

The Safe Drinking Water Act (SDWA) mandates that the 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 (As) 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 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.

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.

In 2003, EPA initiated Round 2 arsenic technology demonstration projects that were partially funded with Congressional add-on funding to the EPA budget. In June 2003, EPA selected 32 potential demonstration sites. In September 2003, EPA again solicited proposals from engineering firms and vendors for arsenic removal technologies. EPA received 148 technical proposals for the 32 host sites, with each site receiving from two to eight proposals. In April 2004, another technical panel was convened by EPA to review the proposals and provide recommendations to EPA with the number of proposals per site ranging from none (for two sites) to a maximum of four. The final selection of the treatment technology at the sites that received at least one proposal was made, again, through a joint effort by EPA, the state regulators, and the host site. Since then, four sites have withdrawn from the demonstration program, reducing the number of sites to 28.

With funding from Congress, EPA selected 10 more sites for demonstration under Round 2a. Somewhat different from the Round 1 and Round 2 selection process, Battelle, under EPA's guidance, issued a Request for Proposal (RFP) on February 14, 2007, to solicit technology proposals from vendors and engineering firms. Upon closing of the RFP on April 13, 2007, Battelle received from 14 vendors a total of 44 proposals, which were subsequently reviewed by a three-expert technical review panel convened at EPA on May 2 and 3, 2007. Copies of the proposals and recommendations of the review panel were later provided to and discussed with representatives of the 10 host sites and state regulators in a technology selection meeting held at each host site during April through August 2007. The final selections of the treatment technology were made, again, through a joint effort by EPA, the respective state regulators, and the host sites. A 75-gal/min (gpm) SolmeteX arsenic removal system was selected for demonstration at the Terry Trojan Water District in Lead, South Dakota. The system used a hybrid sorbent, ArsenX^{np}, manufactured by Purolite and a newer generation of the hybrid sorbent, LayneRT™, manufactured by SolmeteX.

As of November 2010, 49 of the 50 systems were operational and the performance evaluations of 48 systems were completed.

1.2 Treatment Technologies for Arsenic Removal

Technologies selected for Rounds 1, 2, and 2a demonstration included adsorptive media (AM), iron removal (IR), coagulation/filtration (C/F), ion exchange (IX), reverse osmosis (RO), point-of-use (POU) RO, and system/process modification. Table 1-1 summarizes the locations, technologies, vendors, system flowrates, and key source water quality parameters (including As, Fe, and pH). Table 1-2 presents the number of sites for each technology. AM technology was demonstrated at 30 sites, including four with IR pretreatment. IR technology was demonstrated at 12 sites, including four with supplemental iron addition. C/F, IX, and RO technologies were demonstrated at three, two, and one sites, respectively. The Sunset Ranch Development site that demonstrated POU RO technology had nine under-the-sink RO units. The Oregon Institute of Technology site classified under AM had three AM systems and eight POU AM units. The Lidgerwood site encompassed only system/process modifications. An overview of the technology selection and system design for the 12 Round 1 demonstration sites and the associated capital costs is provided in two EPA reports (Wang et al., 2004; Chen et al., 2004), which are posted on the EPA Web site at http://www.epa.gov/ORD/NRMRL/arsenic/resource.htm.

1.3 Project Objectives

The objective of the arsenic demonstration program is to conduct full-scale arsenic removal 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 SolmeteX's arsenic treatment system at the Terry Trojan Water District in Lead, South Dakota, from April 4, 2008, through May 23, 2010. The types of data collected included system operation, water quality (both across the treatment train and in the distribution system), residuals characterization, and capital and O&M cost.

Table 1-1. Summary of Rounds 1, 2, and 2a Arsenic Removal Demonstration Locations, Technologies, and Source Water Quality

Demonstration Location	Site Name	Technology (Media)	Vendor	Design Flowrate (gpm)	Source Water Quality		
					As (µg/L)	Fe (µg/L)	pH (S.U.)
Northeast/Ohio							
Carmel, ME	Carmel Elementary School	RO	Norlen's Water	1,200 gpd	21	<25	7.9
Wales, ME	Springbrook Mobile Home Park	AM (A/I Complex)	ATS	14	38[a]	<25	8.6
Bow, NH	White Rock Water Company	AM (G2)	ADI	70[b]	39	<25	7.7
Goffstown, NH	Orchard Highlands Subdivision	AM (E33)	AdEdge	10	33	<25	6.9
Rollinsford, NH	Rollinsford Water and Sewer District	AM (E33)	AdEdge	100	36[a]	46	8.2
Dummerston, VT	Charette Mobile Home Park	AM (A/I Complex)	ATS	22	30	<25	7.9
Houghton, NY[c]	Town of Caneadea	IR (Macrolite)	Kinetico	550	27[a]	1,806[d]	7.6
Woodstock, CT	Woodstock Middle School	AM (Adsorbsia)	Siemens	17	21	<25	7.7
Pomfret, CT	Seely-Brown Village	AM (ArsenX^{np})	SolmeteX	15	25	<25	7.3
Felton, DE	Town of Felton	C/F (Macrolite)	Kinetico	375	30[a]	48	8.2
Stevensville, MD	Queen Anne's County	AM (E33)	STS	300	19[a]	270[d]	7.3
Conneaut Lake, PA	Conneaut Lake Park	IR (Greensand Plus) with ID	AdEdge	250	28[a]	157[d]	8.0
Newark, OH	Buckeye Lake Head Start Building	AM (ARM 200)	Kinetico	10	15[a]	1,312[d]	7.6
Springfield, OH	Chateau Estates Mobile Home Park	IR & AM (E33)	AdEdge	250[e]	25[a]	1,615[d]	7.3
Great Lakes/Interior Plains							
Brown City, MI	City of Brown City	AM (E33)	STS	640	14[a]	127[d]	7.3
Pentwater, MI	Village of Pentwater	IR (Macrolite) with ID	Kinetico	400	13[a]	466[d]	6.9
Sandusky, MI	City of Sandusky	IR (Aeralater)	Siemens	340[e]	16[a]	1,387[d]	6.9
Delavan, WI	Vintage on the Ponds	IR (Macrolite)	Kinetico	40	20[a]	1,499[d]	7.5
Goshen, IN	Clinton Christian School	IR & AM (E33)	AdEdge	25	29[a]	810[d]	7.4
Fountain City, IN	Northeastern Elementary School	IR (G2)	US Water	60	27[a]	1,547[d]	7.5
Waynesville, IL	Village of Waynesville	IR (Greensand Plus)	Peerless	96	32[a]	2,543[d]	7.1
Geneseo Hills, IL	Geneseo Hills Subdivision	AM (E33)	AdEdge	200	25[a]	248[d]	7.4
Greenville, WI	Town of Greenville	IR (Macrolite)	Kinetico	375	17[a]	7,827[d]	7.3
Climax, MN	City of Climax	IR (Macrolite) with ID	Kinetico	140	39[a]	546[d]	7.4
Sabin, MN	City of Sabin	IR (Macrolite)	Kinetico	250	34[a]	1,470[d]	7.3
Sauk Centre, MN	Big Sauk Lake Mobile Home Park	IR (Macrolite)	Kinetico	20	25[a]	3,078[d]	7.1
Stewart, MN	City of Stewart	IR &AM (E33)	AdEdge	250	42[a]	1,344[d]	7.7
Lidgerwood, ND	City of Lidgerwood	Process Modification	Kinetico	250	146[a]	1,325[d]	7.2
Lead, SD	Terry Trojan Water District	AM (ArsenX^{np})	SolmeteX	75	24	<25	7.3

Table 1-1. Summary of Rounds 1, 2, and 2a Arsenic Removal Demonstration Locations, Technologies, and Source Water Quality (Continued)

Demonstration Location	Site Name	Technology (Media)	Vendor	Design Flowrate (gpm)	Source Water Quality As (µg/L)	Fe (µg/L)	pH (S.U.)
Midwest/Southwest							
Willard, UT	Hot Springs Mobile Home Park	IR & AM (Adsorbsia)	Filter Tech	30	15.4[a]	332[d]	7.5
Arnaudville, LA	United Water Systems	IR (Macrolite)	Kinetico	770[e]	35[a]	2,068[d]	7.0
Alvin, TX	Oak Manor Municipal Utility District	AM (E33)	STS	150	19[a]	95	7.8
Bruni, TX	Webb Consolidated Independent School District	AM (E33)	AdEdge	40	56[a]	<25	8.0
Wellman, TX	City of Wellman	AM (E33)	AdEdge	100	45	<25	7.7
Anthony, NM	Desert Sands Mutual Domestic Water Consumers Association	AM (E33)	STS	320	23[a]	39	7.7
Nambe Pueblo, NM	Nambe Pueblo Tribe	AM (E33)	AdEdge	145	33	<25	8.5
Taos, NM	Town of Taos	AM (E33)	STS	450	14	59	9.5
Rimrock, AZ	Arizona Water Company	AM (E33)	AdEdge	90[b]	50	170	7.2
Tohono O'odham Nation, AZ	Tohono O'odham Utility Authority	AM (E33)	AdEdge	50	32	<25	8.2
Valley Vista, AZ	Arizona Water Company	AM (AAFS50/ARM 200)	Kinetico	37	41	<25	7.8
Far West							
Three Forks, MT	City of Three Forks	C/F (Macrolite)	Kinetico	250	64	<25	7.5
Fruitland, ID	City of Fruitland	IX (A300E)	Kinetico	250	44	<25	7.4
Homedale, ID	Sunset Ranch Development	POU RO[f]	Kinetico	75 gpd	52	134	7.5
Okanogan, WA	City of Okanogan	C/F (Electromedia-I)	Filtronics	750	18	69[d]	8.0
Klamath Falls, OR	Oregon Institute of Technology	POE AM (Adsorbsia/ ARM 200/ArsenX^{np}) and POU AM (ARM 200)[g]	Kinetico	60/60/30	33	<25	7.9
Vale, OR	City of Vale	IX (Arsenex II)	Kinetico	525	17	<25	7.5
Reno, NV	South Truckee Meadows General Improvement District	AM (GFH)	Siemens	350	39	<25	7.4
Susanville, CA	Richmond School District	AM (A/I Complex)	ATS	12	37[a]	125	7.5
Lake Isabella, CA	Upper Bodfish Well CH2-A	AM (HIX)	VEETech	50	35	125	7.5
Tehachapi, CA	Golden Hills Community Service District	AM (Isolux)	MEI	150	15	<25	6.9

AM = adsorptive media process; C/F = coagulation/filtration; HIX = hybrid ion exchanger; IR = iron removal; IR with ID = iron removal with iron addition; IX = ion exchange process; RO = reverse osmosis

ATS = Aquatic Treatment Systems; MEI = Magnesium Elektron, Inc.; STS = Severn Trent Services

(a) Arsenic existing mostly as As(III).
(b) Design flowrate reduced by 50% due to system reconfiguration from parallel to series operation.
(c) Withdrew from program in 2007. Selected originally to replace Village of Lyman, NE site, which withdrew from program in June 2006.
(d) Iron existing mostly as Fe(II).
(e) Facilities upgraded systems in Springfield, OH from 150 to 250 gpm, Sandusky, MI from 210 to 340 gpm, and Arnaudville, LA from 385 to 770 gpm.
(f) Including nine residential units.
(g) Including eight under-the-sink units.

Table 1-2. Number of Demonstration Sites Under Each Arsenic Removal Technology

Technologies	Number of Sites
Adsorptive Media[(a)]	26
Adsorptive Media with Iron Removal Pretreatment	4
Iron Removal (Oxidation/Filtration)	8
Iron Removal with Supplemental Iron Addition	4
Coagulation/Filtration	3
Ion Exchange	2
Reverse Osmosis	1
Point-of-use Reverse Osmosis[(b)]	1
System/Process Modifications	1

(a) Oregon Institute of Technology site at Klamath Falls, OR, had three AM systems and eight POU AM units.
(b) Including nine under-the-sink RO units.

2.0 SUMMARY AND CONCLUSIONS

SolmeteX's arsenic treatment system at Lead, South Dakota began operation on April 4, 2008. Based on the information collected from April 4, 2008, through May 23, 2010, the following summary and conclusion statements are made:

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

- ArsenX^{np} media was effective in removing arsenic. Arsenic breakthrough at 10 µg/L from the lead vessel occurred after treating 14,725,250 gal (or 70,310 bed volumes [BV]) of water (based on 28 ft^3 of media in one vessel). This media run length was about 8% higher than the working capacity projected by the vendor.

  The media in the lead vessel was changed out when the arsenic concentration from the lag vessel was 5.8 µg/L. The system could have run longer and likely would have reached the 10 µg/L level after the two bed system (56 ft^3) had treated more than 70,000 BV of water.

- The operation of the treatment system significantly lowered arsenic concentrations in the distribution system water to below 1.1 µg/L (on average). The treatment system also reduced lead and copper concentrations in distribution system water.

Required system O&M and operator skill levels:

- Under normal operating conditions, the skill requirements to operate the system were minimal, with a typical daily demand on the operator of about 60 min. Operation of the system did not appear to require additional skills beyond those necessary to operate the existing water supply equipment.

Process residuals produced by the technology:

- No backwash residuals were produced because the hybrid media did not need backwash.

Cost-effectiveness of the technology:

- Based on the system's rated capacity of 75 gpm (or 108,000 gal/day [gpd]), the capital cost was $1,172/gpm (or $0.81/gpd) of design capacity.

- O&M cost included only the cost for media replacement and disposal, electricity, and labor. There was no chemical consumption cost.

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 SolmeteX AM system began on April 4, 2008, and ended on May 23, 2010. Table 3-2 summarizes the types of data collected and/or considered as part of the technology evaluation study. Overall performance of the system was evaluated based on its ability to consistently remove arsenic to below the arsenic MCL of 10 µg/L through the collection of water samples across the treatment plant, as described in a Performance Evaluation Study Plan (Battelle, 2007). The reliability of the system was evaluated by tracking the unscheduled system downtime and frequency and extents of repair. The plant operator recorded unscheduled downtime and repair information on a Repair and Maintenance Log Sheet.

Table 3-1. Predemonstration Study Activities and Completion Dates

Activities	Date
Introductory Meeting Held	12/08/06
Project Planning Meeting Held	07/17/07
Draft Letter of Understanding Issued	07/24/07
Final Letter of Understanding Issued	07/27/07
Request for Quotation Issued to Vendor	07/30/07
Vendor Quotation Received by Battelle	08/10/07
Purchase Order Completed and Signed	08/30/07
Engineering Package Submitted to SD DENR	09/13/07
System Permit Granted by SD DENR	09/14/07
One-Time Ground Discharge Permit Granted by SD DENR	09/17/07
Equipment Shipped	10/30/07
Final Study Plan Issued	10/30/07
System Installation Completed/Air Bubbles Observed in System	11/02/07
System Operation Suspended due to Air Bubbles	11/19/07
Modified Engineering Package Submitted	03/12/07
System Shakedown Completed/Air Bubbles Issue Resolved	03/31/08
Modified Engineering Package Approved by SD DENR	04/01/08
Performance Evaluation Begun	04/04/08

SD DENR = South Dakota Department of Environment and Natural Resources

The required system O&M and operator skill levels were evaluated through quantitative data and qualitative considerations, including the need for pre- and/or post-treatment, level of system automation, extent of preventive 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 system operation were recorded on an Operator Labor Hour Log Sheet.

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 required tracking the capital cost for equipment, site engineering, and installation, as well as the O&M cost for media replacement and disposal, chemical consumption, electrical power usage, and labor.

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

Evaluation Objectives	Data Collection
Performance	-Ability to consistently meet 10 µg/L of arsenic MCL 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 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 of relevant chemical processes and health and safety practices
Residual Management	-Quantity and characteristics of aqueous and solid residuals generated by system process
System Cost	-Capital cost for equipment, engineering, and installation -O&M cost for media replacement, 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 according to instructions provided by the vendor and Battelle. The plant operator recorded system operational data such as pressure, flowrate, system throughput, and hour meter readings on a Daily System Operation Log Sheet, and conducted visual inspections to ensure normal system operations. If any problem occurred, the plant operator contacted the Battelle Study Lead, who determined if the vendor should be contacted for troubleshooting. The plant operator recorded all relevant information, including problems encountered, course of actions taken, materials and supplies used, and associated cost and labor incurred, on the Repair and Maintenance 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 expenditure for media replacement and disposal, incremental electricity consumption, and labor. Incremental electricity consumption was tracked through electric bills before and after system startup. Labor hours for routine system O&M, system troubleshooting and repairs, and demonstration-related work, were tracked using an Operator Labor Hour Log Sheet. Routine O&M included activities such as completing field logs, performing system inspections, and others as recommended by the vendor. Demonstration-related work, including activities such as performing field measurements, collecting and shipping samples, and communicating with the Battelle Study Lead and vendor, was recorded but not used for the cost analysis.

No chemicals were required by the arsenic treatment system. The existing chlorine addition system was moved from the shed next to the storage tank to the treatment building for post-chlorination. The cost for the chlorine addition was not included in O&M cost.

3.3 Sample Collection Procedures and Schedules

To evaluate system performance, samples were collected from the wellhead, across the treatment plant, and from the distribution system. Table 3-3 provides the sampling schedule and analytes measured during each sampling event. Specific sampling requirements for analytical methods, sample volumes,

Table 3-3. Sampling Schedule and Analytes

Sample Type	Sampling Locations[(a)]	No. of Sampling Locations	Frequency	Analytes	Sampling Date
Source Water	IN	1	Once during initial site visit	Onsite: pH, temperature, and ORP Offsite: As (total and soluble), As(III), As(V), Fe (total and soluble), Mn (total and soluble), Sb (total and soluble), Al, V, Na, Ca, Mg, Cl, F, NO_3, NO_2, NH_3, SO_4, SiO_2, P (total), TOC, TDS, turbidity, and alkalinity	12/08/06
Treatment Plant Water	IN, TA, TB	3	Once in each 8-week cycle[(b)] (Speciation Sampling)	Onsite: pH, temperature, DO, ORP, and Cl_2 (total and free)[(d)] Offsite: As(total and soluble), As(III), As(V), Fe (total and soluble), Mn (total and soluble), Ca, Mg, F, NO_3, SO_4, SiO_2, P (total), turbidity, and alkalinity	See Appendix B
			Three times in each 8-week cycle[(c)] (Regular Sampling)	Onsite: pH, temperature, DO, ORP, and Cl_2 (total and free)[(d)] Offsite: As (total), Fe (total), Mn (total), SiO_2, P (total), turbidity, and alkalinity	See Appendix B
Distribution Water	Three LCR locations	3	Monthly[(e)]	pH, alkalinity, and total As, Fe, Mn, Pb, and Cu	Baseline sampling: See Table 4-10 Monthly sampling: See Table 4-10
Spent Media	Top, middle and bottom of Vessel A	3	Once	As, Fe, Mn, Ba, Ca, Mg, P, and Si	11/30/2009

(a) Abbreviations in parentheses corresponding to sample locations shown in Figure 4-7: IN = at wellhead; TA = after Vessel A; and TB = after Vessel B.
(b) Actual sampling frequency varied from once every 4 to 14 weeks. Speciation sampling discontinued after July 21, 2009.
(c) Actual sampling frequency varied from once every 1 to 3 weeks; analytes reduced after July 21, 2009, to total arsenic, pH, temperature, DO, ORP, and chlorine.
(d) Measured only at TB.
(e) Monthly distribution water sampling discontinued after July 7, 2009.
DO = dissolved oxygen; LCR = Lead and Copper Rule; ORP = oxidation-reduction potential; TDS = total dissolved solids; TOC = total organic carbon

containers, preservation, and holding times are presented in Table 4-1 of the EPA-endorsed Quality Assurance Project Plan (QAPP) (Battelle, 2003).

3.3.1 Source Water Sample Collection. During the initial visit to the site on December 8, 2006, one set of source water samples was collected by Battelle for detailed water quality analyses. Source water also was speciated onsite using a speciation kit (see Section 3.4.1). The sample tap was flushed for several minutes before sampling; special care was taken to avoid agitation, which might cause unwanted oxidation. Analytes for the source water sample are listed in Table 3-3.

3.3.2 Treatment Plant Water Sample Collection. During the system performance evaluation study, the plant operator collected water samples across the treatment train for onsite and offsite analyses. The Battelle Study Plan called for biweekly sampling. Once in each 8-week cycle, treatment plant samples were collected at the wellhead (IN), after Vessel A (TA), and after Vessel B (TB). These samples were speciated and analyzed for the analytes listed under "Speciation Sampling" in Table 3-3. Three additional biweekly samples were collected at the same three locations in the same 8-week cycle and analyzed for the analytes listed under "Regular Sampling" in Table 3-3. The actual sampling frequency varied from 4 to 14 weeks for speciation sampling and 1 to 3 weeks for regular sampling.

Because only trace amounts of As(III) existed in source water, speciation sampling was discontinued on July 21, 2009, 15 month into the demonstration study. Meanwhile, analytes for the regular sampling were reduced to total arsenic plus five water quality measurements, i.e., pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and total and free chlorine performed onsite by the operator.

3.3.3 Backwash Wastewater/Solids and Spent Media Samples. Because the system was not backwashed during the entire study period, no backwash residuals were produced.

Three spent media samples were collected from the top, middle, and bottom of the lead vessel (Vessel A) during the media changeout on November 30, 2009. Spent media were removed from the vessel using a shop vac. Representative samples were collected at each level and stored in an unpreserved, 1-gal wide-mouth high-density polyethylene (HDPE) bottle. One aliquot of each sample was air-dried and acid-digested for the analytes listed in Table 3-3.

3.3.4 Distribution System Water Sample Collection. 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 arsenic, lead, and copper levels. Prior to system startup, three sets of baseline samples were collected at three locations on October 31, 2007, December 19, 2007, and February 21, 2008. Following system startup, distribution system water sampling continued at the same three locations on a monthly basis. The monthly distribution water sampling discontinued after July 7, 2009.

The three locations selected were residences within the District's historic Lead and Copper Rule (LCR) sampling network, designated as DS1 (i.e., 21111 Barefoot Loop), DS2 (i.e., 21193 High Ridge), and DS3 (i.e., 21163 Last Chance). The baseline and monthly samples were collected following an instruction sheet developed according to the *Lead and Copper Monitoring and Reporting Guidance for Public Water Systems* (EPA, 2002). 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. Samplers recorded the date and time of last water use before sampling and the date and time of sample collection for calculations of the stagnation time. The samples were analyzed for the analytes listed in Table 3-3. Arsenic speciation was not performed for the distribution system water samples.

3.4 Sampling Logistics

All sampling logistics, including preparation of arsenic speciation kits and sample coolers, and sample 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 soluble arsenic species, As(V) and As(III) (Edwards et al., 1998). Resin columns were prepared in batches at Battelle laboratories in accordance with the procedures detailed in Appendix A of the EPA-endorsed QAPP (Battelle, 2007).

3.4.2 Preparation of Sampling Coolers. For each sampling event, a sample 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, color-coded, and 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 for designating the arsenic speciation bottle (if necessary). The sampling locations at the treatment plant were color-coded for easy identification. For example, red, yellow, and blue were used to designate sampling locations for IN, TA, and TB, respectively. The pre-labeled bottles for each sampling location were placed in separate zip lock bags and packed in the cooler. When needed, the sample cooler also included bottles for the distribution system water sampling.

In addition, all sampling and shipping-related materials, such as latex gloves, sampling instructions, chain-of-custody forms, pre-paid/pre-addressed FedEx air bills, and bubble wrap, were included in each cooler. Except for the operator's signature, the chain-of-custody forms and air bills had already been completed with the required information. The sample coolers were shipped via FedEx to the facility approximately 1 week prior to the scheduled sampling date.

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 verified that all samples indicated on the chain-of-custody forms were included and intact. Sample IDs were checked against the chain-of-custody forms and the samples were logged into the laboratory sample receipt log. Discrepancies noted by the sample custodian were addressed with the plant operator by the Battelle Study Lead.

Samples for metal analyses were stored and analyzed 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 Lexington, OH, both of which were under contract with Battelle for this demonstration study. 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 detail in Section 4.0 of the EPA-endorsed QAPP (Battelle, 2007) were followed by Battelle ICP-MS, AAL, 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 limits (MDLs), and completeness met the criteria established in the QAPP (i.e., relative percent difference [RPD] of 20%, percent recovery of 80 to 120%, and completeness of

80%). The 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 VWR Symphony SP90M5 Handheld Multimeter, 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 a standard solution and comparing it to the expected value. The plant operator collected a water sample in a clean, plastic beaker and placed the Symphony SP90M5 probe in the beaker until a stable value was obtained. The plant operator also performed free and total chlorine measurements at a sample tap after post-chlorination using Hach chlorine test kits following the user's manual.

4.0 RESULTS AND DISCUSSION

4.1 Facility Description and Pre-Existing Treatment System Infrastructure

Located at 21111 Barefoot Loop, Lead, SD, the community water system (CWS) at the Terry Trojan Water District provided drinking water to 177 residential and 10 commercial service connections. The commercial service connections included 37 condominium units at the Barefoot Condominiums, four condominium units at the Shake Condominiums, 16 motel units at the Terry Peak Lodge, and the Terry Peak Ski Resort that had an office, a ski rental shop, a cafeteria/dining hall, and a lounge. The CWS was supplied by the Two Johns II Well, which operated approximately 2 hr/day to meet the District's average daily demand of approximately 9,000 gal prior to this demonstration project. A second well also existed; however, it was not in use due to the high total arsenic concentration.

The 6-in diameter Two Johns II Well was drilled into an abandoned mine "decline" and equipped with a 30-horsepower (hp) Grundfos 855 30-26 submersible pump rated for 50 gpm at 564 lb/in^2 (psi) or 1,300 ft H_2O of total dynamic head (TDH). The submersible pump was set at 360 ft below ground surface (bgs). Figure 4-1 presents a photo of the wellhead.

Figure 4-1. Wellhead of Two Johns II Well at Terry Trojan Water District, SD

Water from the wellhead at an elevation of 5,924 ft was pumped via a 4-in polyvinyl chloride (PVC) transmission line to a booster station (Figure 4-2), which was 306 ft above the wellhead. At the booster station, a 30-hp Sterling Fluid Systems C1020 AMBF booster pump was used to pump water via a 6-in PVC transmission line to a 90,000-gal (56 ft × 32 ft × 12 ft) concrete storage reservoir (see Figure 4-3) located on a small peak near the Barefoot Condominiums. The total length of the transmission line was 14,000 ft and the total elevation difference between the wellhead (at 5,924 ft) and the storage reservoir (at

Figure 4-2. Booster Station *(left)* and Booster Pump *(right)* at Terry Trojan Water District

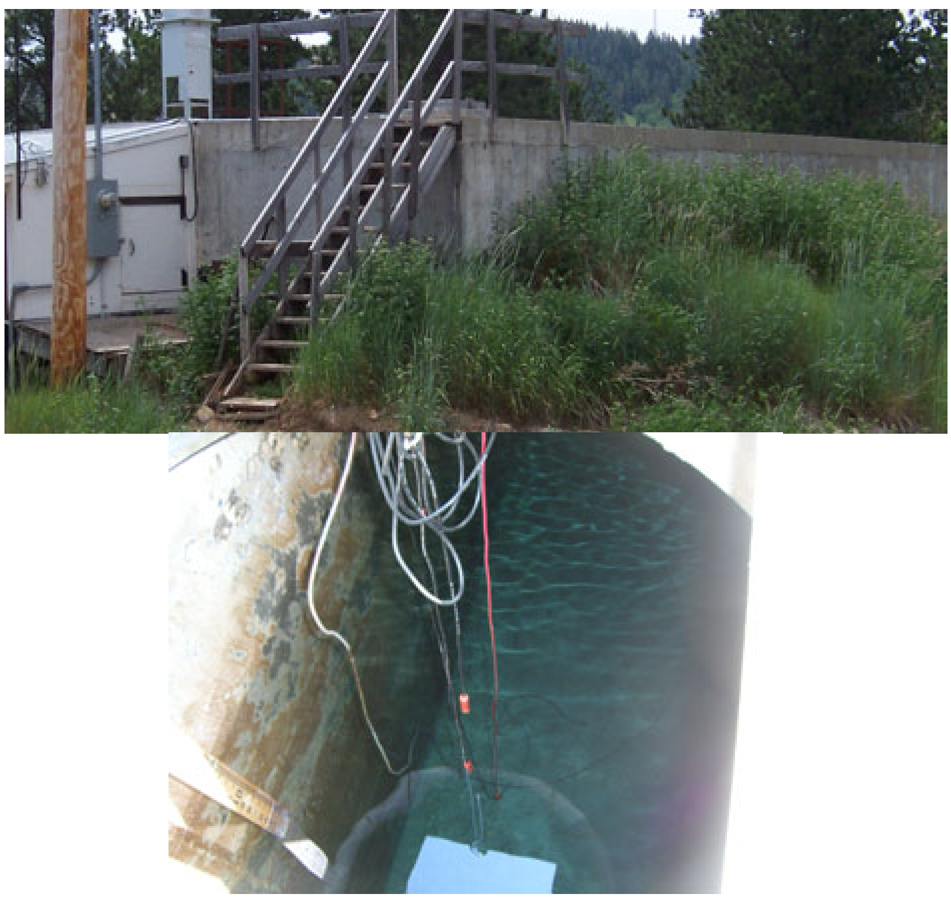


Figure 4-3. Concrete Water Storage Reservoir and Partition *(left)* and Level Sensors *(right)* in Reservoir

6,646 ft) was 722 ft H_2O. On/off of the well pump was controlled by level sensors in the storage reservoir with the high and low level sensors set at 10 ft 5 in (1 ft 1 in below the overflow line) and 9 ft 10 in (1 ft 8 in below the over flow line), respectively. The overflow line is 11 ft 6 in ft above ground level.

As shown in Figure 4-4, a small partition attached to the storage reservoir housed the pre-existing treatment system, including a flow meter/totalizer on the incoming transmission line and a chlorine addition system. The chlorine addition system (see Figure 4-5) consisted of a 15-gal polyethylene chemical day tank and a 3.0-gpd peristaltic metering pump, which was interlocked with the well pump. Chlorination was accomplished using a 12.5% NaOCl stock solution for a target dosage of 1.25 mg/L (as Cl_2) and a target free chlorine residual level of 0.75 mg/L (as Cl_2) in the distribution system. The state of South Dakota required that free chlorine residuals be maintained at 0.5 mg/L (as Cl_2) within the distribution system. The pre-existing chlorination system was relocated to a new treatment building for post-chlorination.

Figure 4-4. Interior of Partition Housing Chemical Addition System

4.1.1 Source Water Quality. Source water samples were collected on December 8, 2006, when a Battelle staff member traveled to the site to conduct an introductory meeting for the demonstration project. Source water also was filtered for soluble arsenic, iron, manganese, and antimony, and then speciated for As(III) and As(V) using the field speciation method modified from Edwards et al. (1998) by Battelle (Wang et al., 2000). Onsite measurements for pH, temperature, DO, and ORP were performed using the VWR Symphony SP90M5 Handheld Multimeter. Table 4-1 presents analytical results of the December 8, 2006, sampling event. Also presented in the table are results of EPA's February 21, 2006, sampling event, and the historic data from November 26, 1996, through July 15, 2003, as documented in an engineering report prepared by Itasco E.S.C (Schreier, 2005). These historic data represent quality of water after chlorination. Overall, Battelle's data are comparable to EPA's and the historic data.

Figure 4-5. 15-gal Chemical Day Tank, Chlorine Injection Point, and Raw Water Totalizer at Inlet to Storage Reservoir

Arsenic. Total arsenic concentrations in source water ranged from 14.0 to 23.9 μg/L. Based on Battelle's results obtained on December 8, 2006, out of 23.9 μg/L of total arsenic, 22.5 μg/L (or 94%) existed as soluble As(V) and 0.5 μg/L (or 2.1%) as soluble As(III). Low levels of As(III) in source water suggest that without pre-oxidation, adsorptive media can be an effective process. Battelle and EPA's total arsenic results were slightly higher than those provided by Itasco E.S.C.

Iron and Manganese. Total iron concentrations in source water were below the MDL of 25 μg/L. Due to the low iron content in source water, this site was an ideal candidate for adsorptive media, which works best with low influent iron levels. The total manganese concentration obtained by Battelle was 2.8 μg/L with almost all existing as particulate manganese. Battelle's data were consistent with EPA data, which showed 2.3 μg/L for total manganese.

Competing Anions. For adsorptive media, removal of arsenic can be influenced by competing anions such as silica and phosphate. Adsorptive media has been reported to be affected by elevated levels of silica and phosphate (Meng et al., 2002; Meng et al., 2000). The Two Johns II Well water contained 14.4 to 15.0 mg/L of silica and <0.01 mg/L of total phosphate (as P), which did not appear to be high enough to impact the adsorptive media treatment process.

Other Water Quality Parameters. Battelle's data indicated a moderate pH of 7.3, which was within the commonly-agreed target range of 5.5 to 8.5 for arsenic removal. Total alkalinity concentrations ranged from 141 to 162 mg/L (as $CaCO_3$); total hardness from 136 to 163 mg/L (as $CaCO_3$); turbidity at 0.7 NTU; total dissolved solids (TDS) from 144 to 178 mg/L; and nitrate from 0.4 to 2.7 mg/L. Total organic carbon (TOC) and ammonia were below the respective MDLs of 1.0 and 0.05 mg/L. All other analytes were below detection limits and/or low enough not to adversely affect the arsenic removal process.

4.1.2 Distribution System. The Terry Trojan Water District distribution system consisted of 187 service connections (or water meters), including 177 for residential and 10 for commercial (one commercial has five meters; one has three; and the other two have one each). The distribution system material was comprised of 2 to 6-in diameter steel and polyvinyl (PVC) pipes. The District sampled water from the distribution system monthly for bacterial analysis; quarterly for pesticides; yearly for nitrate; and once every three years for LCR, volatile organic compounds (VOCs), and inorganics.

4.2 Treatment Process Description

The treatment system installed at the Terry Trojan Water District consisted of arsenic adsorption using either ArsenX^{np} or LayneRT™ media. The performance evaluation was sub-divided into two study periods. Study Period I took place from April 4, 2008, through November 29, 2009, using ArsenX^{np} and Study Period II followed from November 30, 2009, through May 23, 2010, using LayneRT™. Manufactured by Purolite, ArsenX^{np} is an engineered hybrid inorganic/organic adsorbent that incorporates a nanoparticle technology originally developed by researchers at Lehigh University, PA and further refined by SolmeteX, Inc., of Northborough, MA. According to the manufacturer, the hybrid material contains approximately 25% of iron (dry weight) or 36% of iron oxide, Fe_2O_3. Because the hybrid resin beads are attrition-resistant, they do not generate fines and do not require backwash. The media is regenerable and is NSF International (NSF) 61 certified for use in municipal water treatment systems. Table 4-2 summarizes ArsenX^{np} media's physical properties.

LayneRT™ media also is a hybrid adsorbent; physical properties of the media are summarized in Table 4-3. Similar to ArsenX^{np}, LayneRT™ does not require backwashing, is regenerable, and is NSF 61 certified for use in municipal water treatment systems.

Table 4-1. Raw and Treated Water Quality Data for Two Johns II Well in Lead, SD

Parameter	Unit	EPA Raw Water Data	Battelle Raw Water Data	Historic Treated Water Data[(a,b)]
Sampling Date		02/21/06	12/08/06	11/26/96–07/15/03
pH	S.U.	NA	7.3	7.6–7.7
Temperature	°C	NA	10.4	NA
DO	mg/L	NA	NA	NA
ORP	mV	NA	300	NA
Total Alkalinity (as $CaCO_3$)	mg/L	147	162	141
Total Hardness (as $CaCO_3$)	mg/L	150	163	136
Turbidity	NTU	NA	0.7	NA
Total Dissolved Solids (TDS)	mg/L	NA	178	144–147
Total Organic Carbon (TOC)	mg/L	NA	<1.0[(c)]	NA
Nitrate (as N)	mg/L	0.4	0.5	0.35–2.7 [0.75]
Nitrite (as N)	mg/L	<0.01	<0.05	<0.05
Ammonia (as N)	mg/L	<0.03	<0.05	NA
Chloride	mg/L	<5.0	1.0	0.5–2.0
Fluoride	mg/L	NA	0.7	0.78–0.86
Sulfate	mg/L	10.8	2.0	<10.0–20.9 [<10.0]
Silica (as SiO_2)	mg/L	14.4	15.0	NA
Orthophosphate (as P)	mg/L	0.09	NA	NA
Total P (as P)	mg/L	<0.065	<0.01	NA
Al (total)	µg/L	<25	NA	<50
As (total)	µg/L	23	23.9	14.0–21.0 [18.0]
As (soluble)	µg/L	NA	23.0	15.0-18.0
As (particulate)	µg/L	NA	0.9	NA
As (III)	µg/L	NA	0.5	NA
As (V)	µg/L	NA	22.5	NA
Fe (total)	µg/L	14	<25	NA
Fe (soluble)	µg/L	NA	<25	NA
Mn (total)	µg/L	2.3	2.8	NA
Mn (soluble)	µg/L	NA	0.8	NA
Sb (total)	µg/L	<25	0.3	NA
Sb (soluble)	µg/L	NA	0.3	NA
V (total)	µg/L	NA	0.7	NA
Na	mg/L	2.0	2.4	NA
Ca	mg/L	46.3	49.9	38.7–47.5
Mg	mg/L	8.4	9.3	8.1–10.2

(a) Source: Schreier, 2005
(b) Minimum–maximum [average].
(c) Sample analyzed out of hold time.
NA = not available.

Table 4-2. Properties of ArsenX^{np} Media

Property	Value
Physical Form and Appearance	Reddish-brown spherical beads 
Particle Size (µm)	300 to 1,200
Operating Temperature (ºF)	33 to 176
Operating pH (S.U.)	5.0 to 8.5
Bulk Density (g/cm^3 [lb/ft^3])	0.79 to 0.84 [49−52]
Moisture Content (%)	55−60
Base Polymer	Macroporous Polystyrene
Active Component	Hydrous Iron Oxide
Minimum Bed Depth (in.)	18

Source: SolmeteX

Table 4-3. Properties of LayneRT™ Media

Property	Value
Physical Form and Appearance	Reddish-brown spherical beads 
Particle Size (µm)	300 to 1,200
Operating Temperature (ºF)	33 to 172
Operating pH (S.U.)	5.0 to 8.5
Bulk Density (g/cm^3 [lb/ft^3])	0.79 to 0.84 [49−52]
Minimum Contact Time (min)	2
Base Polymer	Macroporous Polystyrene
Active Component	Hydrous Iron Oxide

Source: SolmeteX

As shown in Figure 4-6, the arsenic removal system at Lead, SD consists of two skid-mounted adsorption vessels and associated piping/valves and instrumentation on a welded carbon steel frame (note that neither the 50-µm pre-filter nor the post-chlorination system is shown). Table 4-4 specifies the key system design parameters of the treatment system.

Figure 4-7 presents a process flowchart, along with the sampling/analysis schedule, for the 75-gpm ArsenX^{np} arsenic removal system. Figure 4-8 is a photograph of the system.

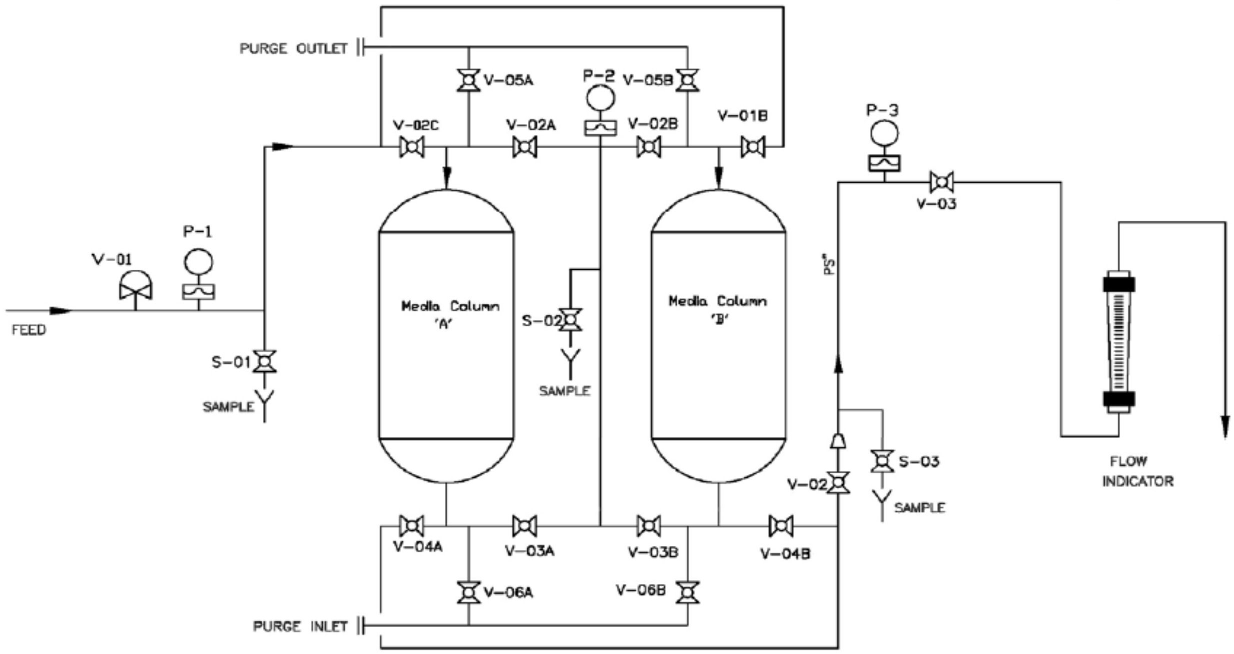


Figure 4-6. Schematic of SolmeteX Arsenic Removal System for Lead, SD

Table 4-4. Design Features of SolmeteX Arsenic Adsorption System

Parameter	Value	Remarks
Pre-treatment		
Pre-filter	One 50-µm bag filter	–
Adsorption		
No. of Vessels	2	–
Configuration	Series	–
Vessel Size (in)	42 D × 72 H	–
Vessel Cross Section (ft^2)	9.6	–
Media Volume (ft^3/vessel)	28	56 ft^3 total
Media Depth (in)	35	–
Hydraulic Loading Rate (gpm/ft^2)	7.8	Based on 75 gpm flowrate
EBCT (min/vessel)	2.8	Based 28 ft^3 of media and 75 gpm flowrate
Differential Pressure across Tank (psi)	10	Across a clean bed
Maximum Daily Production (gpd)	108,000	Based on peak flowrate, 24 hr/day
Average Daily Production (gpd)	9,000	–
Hydraulic Utilization (%)	8.3	Typical operation is 2 hr/day
Projected Media Run Length to 10-µg/L As Breakthrough from Lead Vessel (BV)	65,000	1 BV = 28 ft^3=209 gal
Throughput to 10-µg/L As Breakthrough (gal)	13,600,000	–
Projected Media Life (month)	50	Based on 9,000 gpd water usage

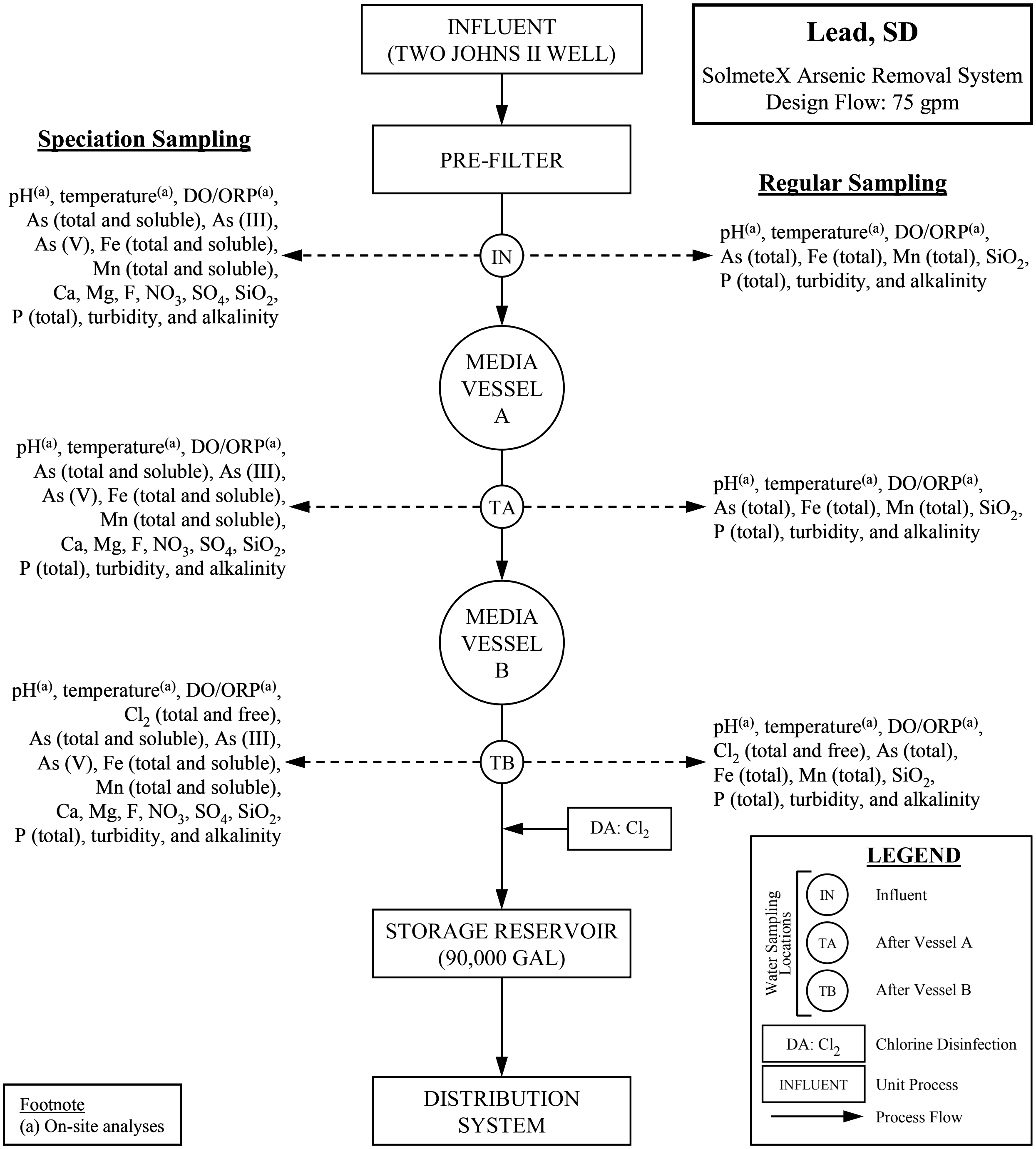


Figure 4-7. Process Flow Diagram and Sampling Locations for Lead, SD

Figure 4-8. SolmeteX Arsenic Removal System

The key process steps and major components of the arsenic removal system are discussed as follows:

- **Intake** – Raw water was pumped from the Two Johns II Well and fed to the treatment system via a 14,000-ft, 4-/6-in diameter PVC transmission line.
- **Pre-filter** – A 50-µm pre-filter was placed ahead of the SolmeteX system to remove any particulate from the well water (Figure 4-9).
- **Adsorption** – The arsenic removal system consisted of two 42-in × 72-in adsorption vessels, configured in series, each containing 28 ft^3 of media supported by 12-in garnet underbedding. The vessels were polyethylene construction, rated for 150 psi working pressure, and piped to a valve rack on a welded carbon steel frame. Based on a design flow rate of 75 gpm, the empty bed contact time (EBCT) was 2.8 min/vessel (or 5.6 min for both vessels) and the hydraulic loading rate was 7.8 gpm/ft^2. The design pressure drop across a clean resin bed was approximately 10 psi.

  All plumbing for the system was schedule 80 PVC. The skid-mounted system was pre-plumbed with the necessary isolation valves, check valves, sampling ports, and other features.
- **Filter Backwash** – For source water containing little or no iron, the media does not require backwashing during standard operation. For the initial media loading, the media was flushed to remove dust and fines generated during shipping. The first 1200-gal of wastewater generated was discharged to and hauled away by a septic truck. The remaining was discharged directly to the ground per the one-time dewatering permit issued by the State of South Dakota (Section 4.3.1).

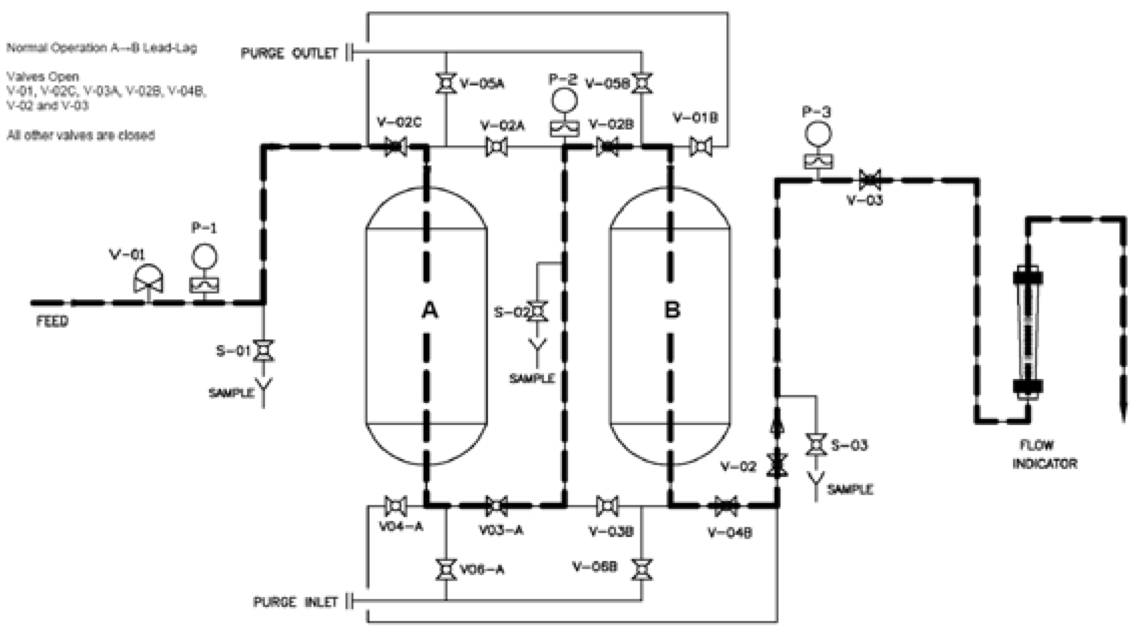
Figure 4-9. Pre-Filter Installed Upstream of SolmeteX System

- **Post-chlorination –** The chlorine addition system consisting of a pre-existing 15-gal polyethylene chemical day tank and a 3.0-gpd peristaltic metering pump was relocated to the treatment plant building for post-chlorination (see Figure 4-10). Chlorination was accomplished using a 12.5% NaOCl stock solution to maintain a target dosage of 1.25 mg/L (as Cl_2) and a target free chlorine residual level of 0.75 mg/L (as Cl_2) in the distribution system. The state of South Dakota required that the free chlorine residual level be maintained at >0.5 mg/L (as Cl_2) within the distribution system.

- **Media Regeneration/Rebedding –** SolmeteX initially recommended regenerating spent ArsenX^{np} media in the lead vessel (Vessel A) offsite when total arsenic levels following the lag vessel exceeded MCL. The system would operate with only the lag vessel (Vessel B) when the lead vessel was taken offline. SolmeteX claimed that ArsenX^{np} can be regenerated up to 10 times with the arsenic adsorptive capacity of a regenerated media reduced approximately 15% following each regeneration.

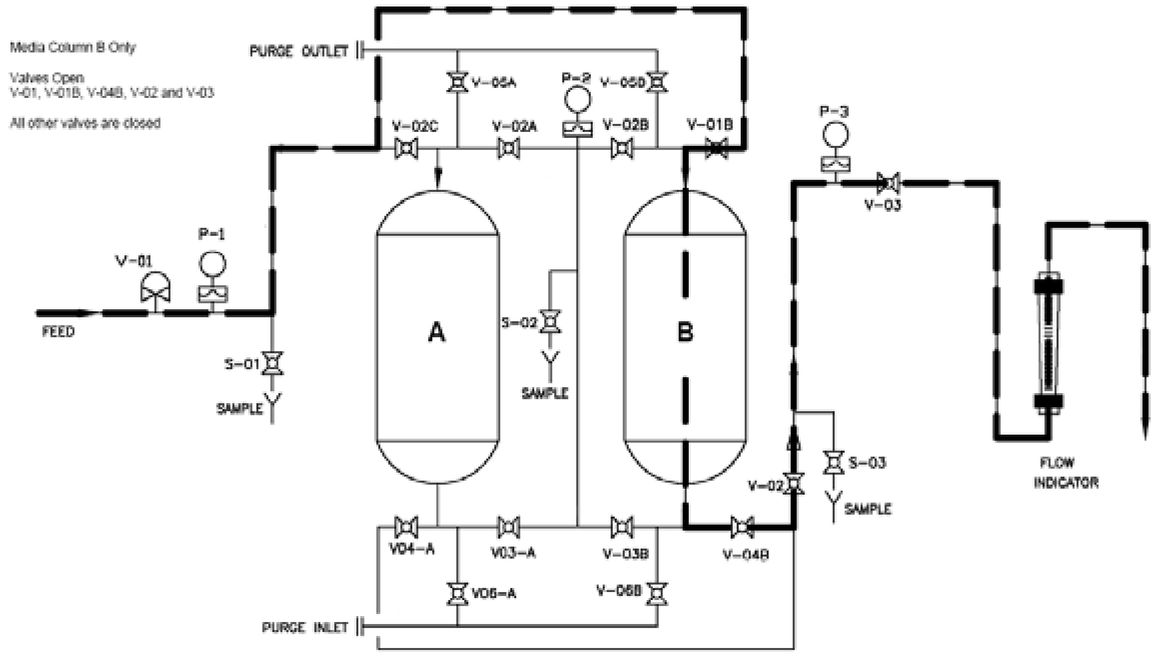
  Instead of regenerating the spent media, it was decided to rebed the lead vessel with LayneRT™, a new adsorptive media. Upon completion of media replacement, the newly rebedded lead vessel (Vessel A) was placed at the lag position with Vessel B containing partially exhausted ArsenX^{np} placed at the lead position. Figures 4-11 through 4-13 show the system flow path under different vessel configurations.

Figure 4-10. Chlorine Addition System



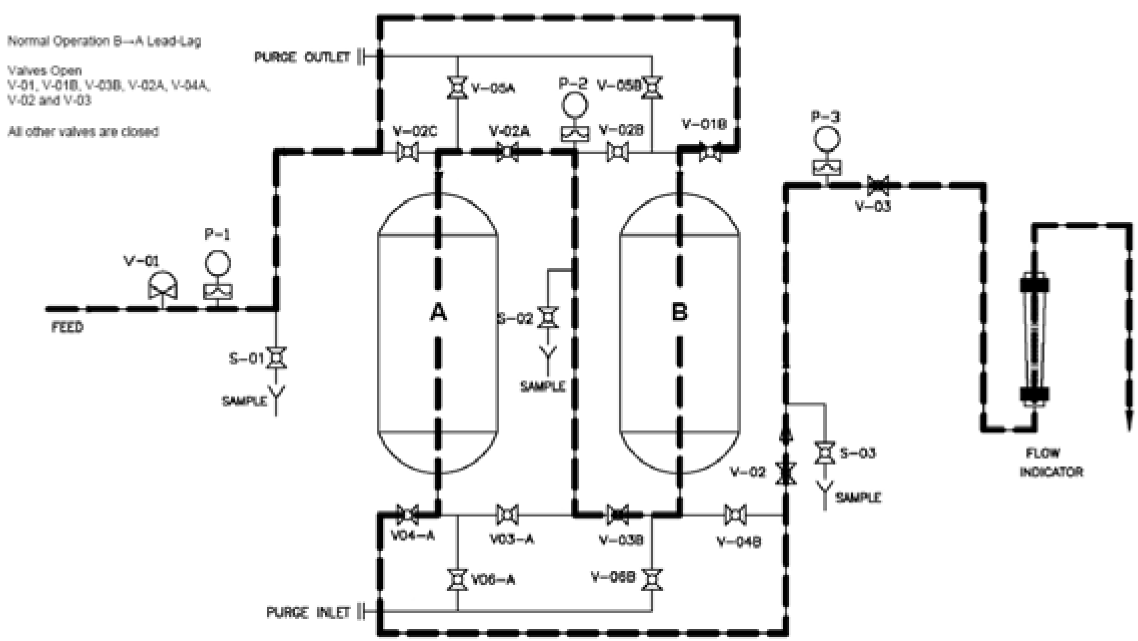
Source: SolmeteX™

Figure 4-11. System Flow Path - Vessel A in Lead Position and Vessel B in Lag Position



Source: SolmeteX™

Figure 4-12. System Flow Path - Vessel A Taken Offline During Proposed Offsite Media Regeneration



Source: SolmeteX™

Figure 4-13. System Flow Path - Vessel B in Lead Position and Rebedded/Regenerated Vessel A in Lag Position

4.3 System Installation

The installation of the treatment system was completed by SolmeteX on November 2, 2007. The following summarizes predemonstration activities, including permitting, building preparation, as well as system offloading, installation, shakedown, and startup.

4.3.1 Permitting. The system engineering package, prepared by SolmeteX and its subcontractor, Schrieir Engineering, included the following documents and drawings:

- A system design report
- A general arrangement and piping and instrumentation diagram (P&ID)
- Electrical and mechanical drawings and component specifications
- Building construction drawings detailing connections from the system to the tie-in points at the inlet and the entry point to town's distribution system

The engineering package was certified by a South Dakota Professional Engineer and submitted to D DENR for review and approval on September 13, 2007. A water supply construction permit was issued by SD DENR on September 14, 2007, and fabrication of the system began thereafter.

In addition to the treatment system construction permit, a one-time de-watering request was submitted in September 2007 and a permit was granted by SD DENR on September 17, 2007, to allow for one-time ground discharge of backwash wastewater during initial media loading.

4.3.2 Building Preparation. Because the existing treatment partition (Figure 4-4) was insufficient to house the SolmeteX arsenic removal system, the Terry Trojan Water District constructed a new treatment plant building (Figure 4-14) in 2006. Sitting on a 5-in thick concrete slab, the 20 ft × 40 ft × 14 ft structure had a 12 ft × 12 ft overhead door to enable ease of equipment placement and installation.

4.3.3 System Installation, Shakedown, and Startup. The treatment system was delivered to the site on October 30, 2007. SolmeteX performed the off-loading (Figure 4-15) and installation, including connections to the tie-in points. Because the treatment plant building was located at the top of a hill and the access road was not accessible to the delivering flatbed, a construction forklift was used to transport the equipment through the narrow and rutted access road to the treatment plant building.

To load media into the adsorption vessels, a scaffold was laid across the top of the system. The vessels were first half-filled with water. Vessel headers were then removed and 8 ft^3 of garnet was loaded into each vessel. To facilitate observation of the fill level in each vessel, light in the treatment plant building was turned off and an emergency light was shined over the opposite side of the vessel. The level of the garnet layer was about 2 in above the start of the bottom dome. Twenty eight ft^3 of $ArsenX^{np}$ was then loaded to each vessel and the vessels were filled with water to the level approximately 12 in below the start of the top dome. Figure 4-16 is a photograph of media loading.

Upon completion of media loading, 41 ounces of SaniSystem liquid sanitizer, consisting of 1 oz of sanitizer concentrate per gal of water, was added to each vessel to sanitize the vessel. The headers were replaced and the vessels and piping were filled with water. After 5 min, the liquid in the system was discharged to a 1200-gal septic truck at 10 to 20 gpm. Backwash purge continued with water passing through the system in all vessel configurations, followed by media rinsing. After the septic truck was full, media rinsing continued for two additional hours with wastewater discharged directly to the ground as permitted by SD DENR (Section 4.3.1). System sanitation was complete on November 2, 2007.

Figure 4-14. Treatment Plant Building at Terry Trojan Water District, SD

Figure 4-15. Lead Treatment System (*Under Tarp on Left*) and Offloading (*Right*)

Figure 4-16. Media Loading

Immediately after system installation, air bubbles were observed in the treatment system/piping. Elevated differential pressure of over 30 psi also was observed across the system. A teleconference among Battelle, SolmeteX, and Schreier Engineering was held on November 19, 2007, and a joint decision was made during the call to temporarily suspend system operation until the air bubble issue was resolved.

Upon investigation of the treatment system and transmission line by Schreier Engineering, the source of air bubbles was linked to a leak from the 8,060-ft transmission line between the booster station and the treatment plant. Because the treatment plant is located 415 ft above the booster station, water in the transmission line would retrieve to, at least, where the leak was, whenever the booster and well pumps were idle. Upon restart of the booster and well pumps, air in the transmission line would be pushed into the treatment system, thus causing the air bubble problem. According to the water static pressure measured at the level of booster station, the leak would be at a point approximately 6,990 ft away from the treatment plant (or 360 ft below the elevation of the treatment plant).

Instead of repairing the leak on the transmission line, Schreier Engineering proposed the following:

- Install a combination air release valve (Figure 4-17) on the system inlet piping to allow for release of air immediately after the well and booster pumps were triggered

Figure 4-17. Treatment System after Modification

- Install an air release valve (Figure 4-17) on top of each vessel to assist in purging air from the treatment system immediately after the well and booster pumps were triggered and during system operation
- Elevate the inlet piping to above the adsorption vessels so that when the well and booster pumps were shut down, water in the arsenic removal system would not be siphoned back into the transmission line.

SD DENR approved the proposed modifications submitted by Schreier Engineering and the modifications were completed by the firm's plumbing contractor on March 27, 2008. When operating the system at the design flowrate of 75 gpm, the system inlet pressure was reduced to 18 to 20 psi, compared to the 30 psi observed before the modifications. Air accumulating in the treatment system during the initial system shakedown in November 2007 was expelled from the lead vessel air release valve for 10 to 20 sec and from the lag vessel for approximately 5 min. Since the modifications, no air bubbles were observed in the treatment system. The system shakedown was therefore complete on March 31, 2008, and the demonstration study began on April 4, 2008.

Two Battelle staff members arrived at Lead, SD, on July 22, 2008, to inspect the treatment system and provide operator training, which included calibration and use of field water quality meters, collection and recording of operational data, collection of water samples, use of arsenic speciation kits (see Figure 4-18), and handling and shipping of collected samples.

4.4 System Operation

4.4.1 Operational Parameters. Operational data were collected during the period of April 4, 2008, through May 23, 2010, and are attached as Appendix A after tabulation. Table 4-5 summarizes key operational parameters. The performance evaluation study was divided into two study periods with Study Period I extending from April 4, 2008, through November 29, 2009, and Study Period II from November 30, 2009, through May 23, 2010. Study Period I evaluated the performance of ArsenX^{np}. Study Period II

Figure 4-18. Operator Training at Lead, SD

Table 4-5. Summary of SolmeteX System Operation

Parameter	Study Period I	Study Period II
Data Period	04/04/08–11/29/09	11/30/09–05/23/10
Adsorptive Media	Lead Vessel: Virgin ArsenX^{np} Lag Vessel: Virgin ArsenX^{np}	Lead Vessel: Partially Exhausted ArsenX^{np} Lag Vessel: Virgin LayneRT™
Total Operating Time (hr)	7,154[(a)]	1,787
Total Operating Days (day)	597	170
Daily Operating Time (hr/day)	2–24 (12.0)	2–24 (10.5)
Throughput to Distribution (gal)	27,978,780 (133,590 BV)	7,231,940 (34,530 BV)
Average Daily Use (gpd)	46,866	42,541
Calculated System Flowrate[(b)] (gpm)	23.6–112 (71.5)	48.9–136 (69.2)
Empty Bed Contact Time (min/vessel)	1.9–8.9 (2.9)	1.5–4.3 (3.0)
Hydraulic Loading to Each Vessel (gpm/ft^2)	2.5–11.7 (7.4)	5.1–14.2 (7.2)
Pressure Loss Across Each Vessel (psi)	Vessel A 4–20 (12) Vessel B 2–10 (6)	Vessel A 6–20 (13) Vessel B 3–7 (7)

1 BV = 28 ft^3 (media in one vessel) or 209.4 gal.

(a) Operational time from April 4 through May 25, 2008, estimated based on total number of operating hours and total number of operating days during remainder of Study Period I.

(b) Based on readings of totalizer at system outlet and hour meter at wellhead.

began after rebedding of the lead vessel with LayneRT™ and switching of the newly rebedded vessel to the lag position.

The system operating time was tracked by a well pump hour meter, which was installed on May 26, 2008, 52 days after commencement of the performance evaluation study. From May 26, 2008, through November 29, 2009, the treatment system operated for a total of 6,589.6 hr. Because the operating time was not recorded from April 4 through May 25, 2008, the operation time (564 hr) during this period was estimated by multiplying the average daily operating time (12 hr/day) during the remainder of Study Period I by the number of days (47 day) when the system was in operation. Therefore, the total system operating time during Study Period I (i.e., from April 4, 2008, through November 29, 2009) was 7,154 hr. The total operating time in Study Period II (from November 30, 2009 to May 23, 2010) was 1,787 hr. (Note that the system was still in operation when Study Period II ended.) The average daily operating time was 12.0 hr/day in Study Period I and 10.5 hr/day in Study Period II.

The total volume throughput was 27,978,780 gal, or 133,590 BV (1 BV = 28 ft^3 of media in one vessel) in Study Period I, and 7,231,940 gal, or 34,530 BV in Study Period II, based on a totalizer installed at the system outlet. Figure 4-19 plots amounts of daily water production, which averaged 46,866 gpd in Study Period I and 42,541 gpd in Study Period II. These amounts were approximately five times the daily demand of 9,000 gal originally provided by the District for the system design.

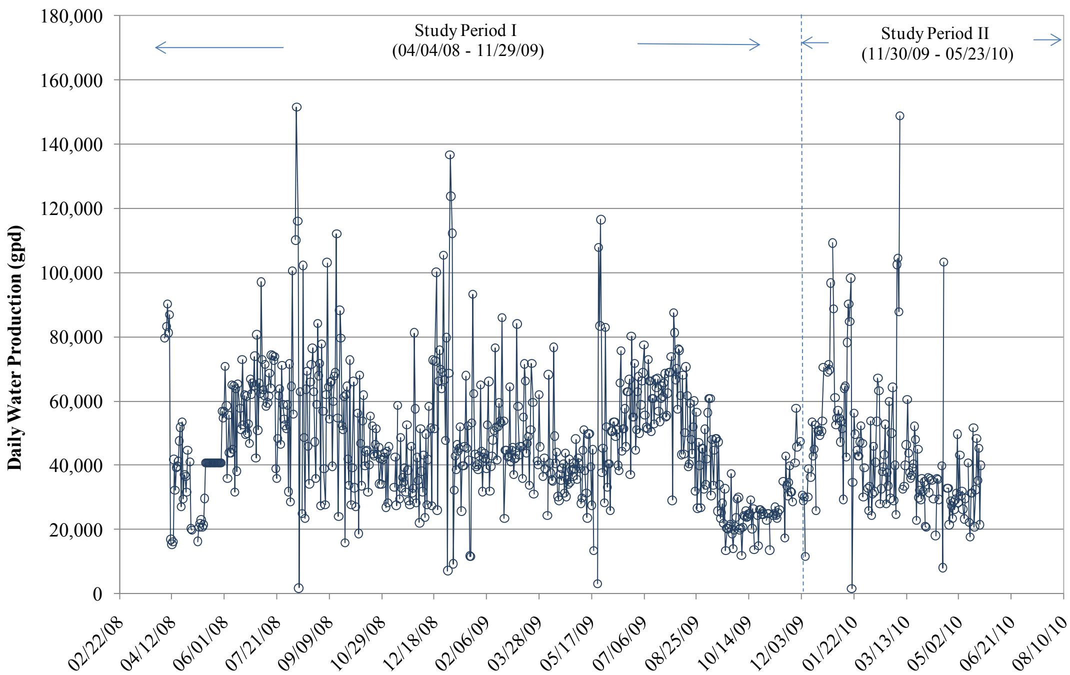


Figure 4-19. Treatment System Daily Water Production

To help identify the cause(s) of the discrepancy between the daily water production and daily water demand, the District provided Battelle its monthly water usage data, i.e., customers' water bills, from December 2007 through July 2008. As shown in Table 4-6, averaged daily water demands based on customers' water bills ranged from 10,143 to 19,204 gpd, which were about 1 to 2 times the amount (9,000 gpd) estimated by the District. Average daily water production volumes were 3 to 4 times those delivered to customers, indicating possible loss of water after the entry point.

Table 4-6. Comparison of Average Daily Water Demand and Average Daily Water Production

Month	Average Daily Water Demand Based on Customers Water Bills (gpd)	Average Daily Water Production Based on Totalizer at System Outlet (gpd)
Dec 2007	16,287	-[(a)]
Jan 2008	16,965	-[(a)]
Feb 2008	19,204	-[(a)]
Mar 2008	12,313	-[(a)]
Apr 2008	10,143	39,073
May 2008	11,558	40,584
June 2008	14,483	53,421
July 2008	19,106	62,162

(a) Demonstration study had not begun; no throughput data available.

During the 25-month performance evaluation study, four leaks at the water storage reservoir and in the distribution system were detected and repaired on July 20, 2008; October 19, 2008; March 7 through 9, 2010; and April 14 through 16, 2010. Nonetheless, no noticeable decrease in daily water demands was observed after the leaks were repaired. Average daily productions still ranged from 27,000 to 44,260 gpd.

Daily/incremental average flowrates were calculated based on daily/incremental throughputs recorded by the electromagnetic flow totalizer installed at the system outlet and wellhead hour meter readings. Instantaneous flowrates were tracked with a rotameter located at the system inlet. Figure 4-20 plots both calculated and instantaneous flowrates. Calculated daily/incremental flowrates ranged from 24 to 112 gpm and averaged 71.5 gpm in Study Period I, and ranged from 49 to 136 gpm and averaged 69.2 gpm in Study Period II (compared to the design value of 75 gpm [Table 4-4]). These average flowrates represented average EBCTs of 2.9 and 3.0 min (compared to the design value of 2.8 min) and average hydraulic loading rates of 7.4 and 7.2 gpm/ft^2 (compared to the design value of 7.8 gpm/ft^2).

Due to a leak from the transmission line between the booster station and the treatment plant, system flowrates decreased 29% starting on March 1, 2009, and continuing through May 19, 2009, as shown in Figure 4-20. The leakage was identified and fixed on May 19, 2009, and flowrates returned to the normal range. Average rotameter readings in Study Periods I and II were 73.8 and 76.7 gpm (on average), respectively, which were 3.2% and 9.8% higher than the corresponding calculated flowrates. Note that data collected between March 1 and May 19, 2009, when a leak occurred, were not included in the calculation of the average flowrates.

As shown in Figure 4-21, differential pressure (Δp) readings across Vessel A ranged from 4 to 20 psi and averaged 12 psi in Study Period I, and ranged from 6 to 20 psi and averaged 13 psi in Study Period II. Δp readings across Vessel B ranged from 2 to 10 psi and averaged 6 psi in Study Period I and ranged from 3 to 7 psi and averaged 7 psi in Study Period II. Δp readings across Vessel A were about twice those across Vessel B. The average Δp across Vessel A was about 20 to 30% higher than the design value of 10 psi, while the average differential pressure across Vessel B was about 30 to 40% lower than the design value.

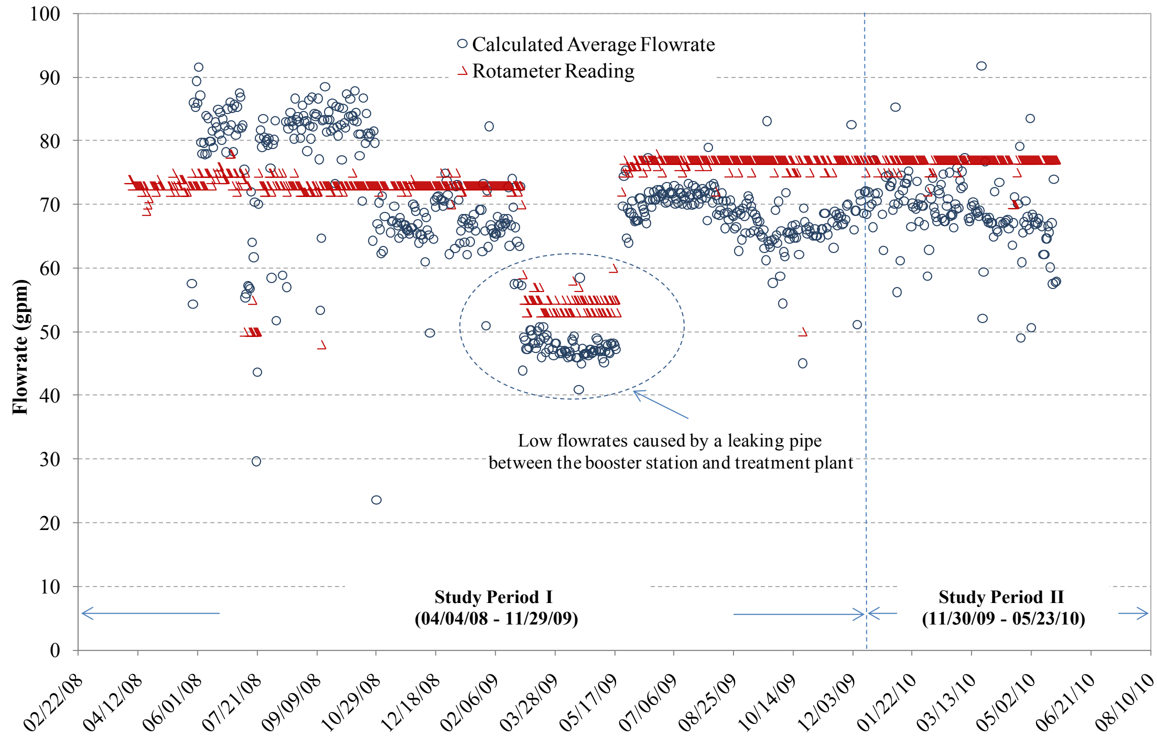


Figure 4-20. System Instantaneous and Calculated Flowrates

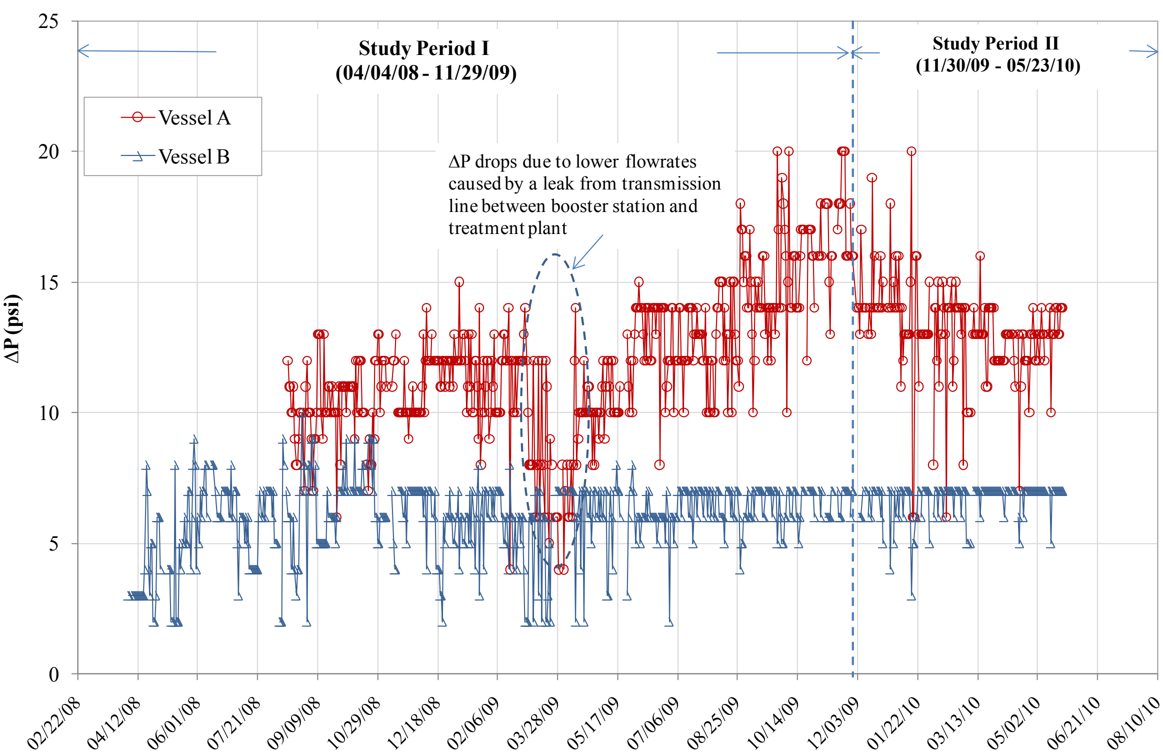


Figure 4-21. Operational Pressure Readings

Reduced Δp readings were observed between March and May 2009, due to lower system flowrates caused by a broken transmission line discussed above. Δp readings across Vessel B were rather steady throughout the entire performance evaluation study. However, Δp across Vessel A increased gradually after May 2009 to 16 to 20 psi before rebedding, likely due to accumulation of sediment or media fines in the lead vessel. Δp readings across Vessel A returned to the levels of 10 to 15 psi after rebedding.

4.4.2 Residual Management. Because backwashing was not required, no residuals were produced during routine system operation. One-time discharge of backwash wastewater was done during system startup as discussed in Section 4.3.1. During Vessel A rebedding, the vendor took back the spent ArsenX^{np} media with no charge (except for the freight).

4.4.3 Media Rebedding. To prepare for possible rebedding/regeneration, Battelle requested in August 2009 that SolmeteX produce a quote for media replacement with two options: (a) rebedding the lead vessel with LayneRT™ or (b) regenerating spent ArsenX^{np} on or offsite and rebedding the lead vessel with the regenerated ArsenX^{np}. Because the vendor had discontinued ArsenX^{np} media production, it recommended that LayneRT™ be used to replace ArsenX^{np}. Another reason for selecting this option was that the wastewater from media regeneration could not be discharged onsite and, therefore, regeneration had to be conducted offsite. Due to the logistic complexity of offsite regeneration, it was decided to replace the spent media with LayneRT™.

On November 17, 2009, after treating approximately 27,439,000 gal (or 131,000 BV) of water, arsenic concentrations were 70% of the influent concentration following the lead vessel and 58% of the arsenic MCL following the lag vessel. Although the media was not fully exhausted in November 2009, the District expressed its desire to move forward with lead vessel rebedding because it needed to complete all rebedding activities before the access road to the treatment building was closed due to snow cover.

The media replacement for the lead vessel was conducted on November 30, 2009, after the system had treated approximately 27,978,780 gal (or 133,590 BV) of water (based on the amount of media in one vessel). Before loading LayneRT™, freeboard heights in Vessel A were measured at 23.5 in from the media surface to the top flange and 62 in from the underbedding garnet surface to the top flange. Therefore, the bed depth was 38.5 in, which was about 3.5 in deeper than the design value of 35 in (Table 4-4).

Upon removal of the spent media, virgin LayneRT™ was loaded on top of the garnet underbedding at a target freeboard value of 23.5 in from the media surface to the top flange. Meanwhile, flow through the vessels was switched such that the lag vessel was placed in the lead position and the newly rebedded vessel was placed in the lag position. A BAC-T sample was taken after rebedding and the result was negative. Therefore, the system was put online without further sanitization.

4.4.4 System/Operation Reliability and Simplicity. In addition to the air bubble problem discussed in Section 4.3.3, the only O&M issues encountered were with the well pump controller due to a lightening strike and the leaky transmission line between the booster station and treatment plant. Both issues were solved in a timely manner and caused no more than one day of system downtime. The system O&M and operator skill requirements are discussed below in relation to post-treatment requirement, levels of system automation, operator skill requirements, preventive maintenance activities, and frequency of chemical/media handling and inventory requirements.

Pre- and Post-Treatment Requirements. No pre-treatment was required. The existing chlorination system was relocated to the treatment plant building for post-chlorination. The operator monitored chlorine tank levels to estimate consumption rates and residual chlorine levels using a Hach meter.

System Automation. Because of simple system operation (i.e., no periodic backwashing, no chemical addition, etc.), the adsorption system was operated manually. The operator manually opened or closed all hand valves to achieve an intended tank configuration and correct flow path. The operator monitored and adjusted the system flowrate and operating pressure, recorded log sheets, and took routine samples of raw water, treated water, and samples after each vessel.

Operator Skill Requirements. Skill requirements to operate the system demanded a higher level of awareness and attention than the previous system of only chlorination. The operator's knowledge of system limitations and typical operational parameters were keys to achieve system performance objectives. The operator was onsite typically seven times a week and spent approximately 60 min each time to perform visual inspections and record relevant system operating parameters on the Daily System Operation Log Sheets. The basis for the operator skills began with onsite training and a thorough review of the system operations manual; however, increased knowledge and invaluable system troubleshooting skills were gained through hands-on operational experience.

The State of South Dakota requires that all community and non-transient, non-community water systems have a certified water distribution operator. Any system that owns its own source and treats the water must also have a certified water treatment operator. The State categorizes treatment plants and systems into four classes, designated as Class I, II, III, or IV, according to complexity of operation. Class IV is the highest or most complex. The plant operator at Lead, SD, has Water Treatment Plant Class I and Water Distribution System Class I licenses.

Preventive Maintenance Activities. Preventive maintenance tasks included periodic checks of flow meters and pressure gauges, inspection of system piping, valves, and NaOCl injection pump. Typically, the operator performed these duties while onsite for routine activities.

Chemical/Media Handling and Inventory Requirements. NaOCl was used for post-chlorination. The operator ordered and handled the chemical as done prior to installation of the SolmeteX system.

4.5 System Performance

4.5.1 Treatment Plant Sampling. In Study Period I, treatment plant water samples were collected on 42 occasions (including three duplicate samples collected during three regular sampling events) with field speciation performed during nine of the 42 occasions at IN, TA, and TB sampling locations. Treatment plant water samples were collected on 13 occasions at IN, TA, and TB sampling locations in Study Period II. No duplicate sampling or speciation sampling was performed in Study Period II. Table 4-7 summarizes the analytical results of arsenic, iron, and manganese at the three sampling locations across the treatment train. Table 4-8 summarizes the results of other water quality parameters. Appendix B contains a complete set of analytical results throughout the performance evaluation study.

Arsenic. Total arsenic concentrations in source water ranged from 16.9 to 26.3 μg/L and averaged 22.2 μg/L in Study Period I; and ranged from 19.4 to 22.6 μg/L and averaged 21.0 μg/L in Study Period II. Based on the nine speciation sampling events taking place in Study Period I, soluble As(V) was the predominating species, ranging from 17.5 to 22.7 μg/L and averaging 20.4 μg/L. Trace levels of soluble As(III) also existed, with concentrations ranging from <0.1 to 1.1 μg/L and averaging 0.4 μg/L. Particulate arsenic concentrations were low as well, ranging from <0.1 to 1.8 μg/L and averaging 0.8 μg/L. Arsenic concentrations in source water measured during the performance evaluation study were consistent with those collected previously during source water sampling (Table 4-1).

Table 4-7. Summary of Analytical Results for Arsenic, Iron, and Manganese

Study Period	Parameter	Sampling Location[(a)]	Unit	Count	Concentration Minimum	Concentration Maximum	Concentration Average	Standard Deviation
I	As (total)	IN	µg/L	42	16.9	26.3	22.2	1.9
		TA		42	<0.1	21.9	-[(b)]	-[(b)]
		TB		42	<0.1	6.1	-[(b)]	-[(b)]
	As (soluble)	IN	µg/L	9	18.6	23.1	20.8	1.5
		TA		9	0.0	18.6	-[(b)]	-[(b)]
		TB		9	<0.1	2.2	-[(b)]	-[(b)]
	As (particulate)	IN	µg/L	9	<0.1	1.8	0.8	0.6
		TA		9	<0.1	0.4	-[(b)]	-[(b)]
		TB		9	<0.1	0.1	-[(b)]	-[(b)]
	As (III)	IN	µg/L	9	<0.1	1.1	0.4	0.3
		TA		9	<0.1	0.4	-[(b)]	-[(b)]
		TB		9	<0.1	1.0	-[(b)]	-[(b)]
	As (V)	IN	µg/L	9	17.5	22.7	20.4	1.7
		TA		9	<0.1	18.4	-[(b)]	-[(b)]
		TB		9	<0.1	2.0	-[(b)]	-[(b)]
	Fe (total)	IN	µg/L	32	<25	<25	<25	NA
		TA		32	<25	<25	<25	NA
		TB		32	<25	36.8	<25	NA
	Fe (soluble)	IN	µg/L	9	<25	<25	<25	NA
		TA		9	<25	<25	<25	NA
		TB		9	<25	37.5	<25	NA
	Mn (total)	IN	µg/L	32	<0.1	3.4	0.6	0.6
		TA		32	<0.1	3.3	0.6	0.7
		TB		32	0.2	3.5	1.1	0.9
	Mn(soluble)	IN	µg/L	9	0.2	0.9	0.3	0.2
		TA		9	0.2	0.8	0.5	0.3
		TB		9	0.3	1.6	0.8	0.5
II	As (total)	IN	µg/L	13	19.4	22.6	21.0	1.0
		TA[(c)]		13	0.3	2.5	-[(b)]	-[(b)]
		TB[(c)]		13	5.7	12.1	-[(b)]	-[(b)]

(a) See Figure 4-7 for sampling location.
(b) Not meaningful for concentrations related to breakthrough; see Figures 4-22 and 4-23 and Appendix B for results.
(c) Vessel positions switched after rebedding such that TA was after lag vessel and TB after lead vessel.
NA = Not Applicable
One-half of detection limit used for samples with concentrations less than detection limit for calculations.

Figures 4-22 and 4-23 present total arsenic breakthrough curves for Study Periods I and II. In Study Period I, total arsenic concentrations following the lead vessel reached 10 µg/L after treating approximately 70,310 BV of water (based on 28 ft^3 of media in the lead vessel), which was about 8% higher than the 65,000 BV of working capacity projected by the vendor (Table 4-4). Afterwards, total arsenic concentrations following the lead vessel continued to ramp higher and reached over 70% of influent concentrations by the end of Study Period I. By then, the system had treated 27,978,780 gal

Table 4-8. Summary of Water Quality Parameters

Study Period	Parameter	Sampling Location[(a)]	Unit	Count	Concentration Minimum	Concentration Maximum	Concentration Average	Standard Deviation
I	Alkalinity (as $CaCO_3$)	IN	mg/L	32	136	158	147	5.5
		TA		32	141	155	147	3.7
		TB		32	141	170	148	6.1
	Fluoride	IN	mg/L	9	0.4	0.8	0.7	0.1
		TA		9	0.7	0.8	0.8	0.0
		TB		9	0.7	0.8	0.8	0.0
	Sulfate	IN	mg/L	9	5.4	10.8	9.9	1.7
		TA		9	10.1	11.1	10.7	0.3
		TB		9	10.3	11.3	10.7	0.3
	Nitrate (as N)	IN	mg/L	9	0.2	0.5	0.4	0.1
		TA		9	0.5	0.5	0.5	0.0
		TB		9	0.5	0.6	0.5	0.0
	Total P (as P)	IN	µg/L	32	<10	18.0	6.0	3.0
		TA		32	<10	23.3	6.0	3.6
		TB		32	<10	<10	<10	NA
	Silica (as SiO_2)	IN	mg/L	32	14.5	18.4	16.4	1.0
		TA		32	14.6	17.9	16.4	1.0
		TB		32	14.7	19.6	16.6	1.3
	Turbidity	IN	NTU	32	<0.1	2.6	0.8	0.7
		TA		32	<0.1	2.9	0.6	0.8
		TB		32	<0.1	2.8	0.6	0.8
	pH	IN	S.U.	35	6.8	7.4	7.2	0.1
		TA		35	7.1	7.8	7.3	0.1
		TB		35	7.1	7.4	7.3	0.1
	Temperature	IN	°C	35	10.3	16.9	13.2	1.9
		TA		35	10.3	16.9	13.1	2.0
		TB		35	10.1	16.9	13.1	2.0
	DO	IN	mg/L	33	3.6	8.8	6.5	2.1
		TA		33	3.8	9.0	6.6	2.0
		TB		33	3.8	8.8	6.7	2.0
	ORP	IN	mV	35	304	472	421	41
		TA		35	309	489	412	41
		TB		35	295	493	410	45
	Free Chlorine (as Cl_2)	TB	mg/L	35	0.8	1.1	1.0	0.0
	Total Chlorine (as Cl_2)	TB	mg/L	35	0.8	1.1	1.0	0.1
	Total Hardness (as $CaCO_3$)	IN	mg/L	9	117	179	153	18
		TA		9	116	171	153	19
		TB		9	118	173	155	17
	Ca Hardness (as $CaCO_3$)	IN	mg/L	9	95.4	135	117	14
		TA		9	93.8	135	118	14
		TB		9	98.0	134	120	13
	Mg Hardness (as $CaCO_3$)	IN	mg/L	9	18.9	45.1	35.2	7.5
		TA		9	19.1	41.5	34.5	6.9
		TB		9	19.5	42.7	35.7	7.1

Table 4-8. Summary of Water Quality Parameters (Continued)

Study Period	Parameter	Sampling Location[(a)]	Unit	Count	Minimum	Maximum	Average	Standard Deviation
II[(b)]	pH	IN	S.U.	11	6.9	7.2	7.1	0.1
		TA		11	7.1	7.3	7.2	0.03
		TB		11	7.2	7.3	7.2	0.04
	Temperature	IN	°C	11	10.3	11.8	11.3	0.4
		TA		11	10.1	11.9	11.3	0.6
		TB		11	9.9	12.1	11.3	0.7
	DO	IN	mg/L	11	8.2	8.4	8.3	0.1
		TA		11	8.2	8.4	8.2	0.1
		TB		11	8.2	8.4	8.2	0.1
	ORP	IN	mV	11	418	440	432	6.4
		TA		11	352	621	440	65
		TB		11	316	435	420	35
	Free Chlorine (as Cl_2)	TB	mg/L	11	0.9	1.2	1.0	0.1
	Total Chlorine (as Cl_2)	TB	mg/L	11	1.0	1.2	1.0	0.1

(a) See Figure 4-7 for sampling location.
(b) Vessel positions switched after rebedding; sampling location TA was after lag vessel and TB after lead vessel.
NA = Not Applicable.
One-half of detection limit used for samples with concentrations less than detection limit for calculations.

(or 133,590 BV) of water. At this point, the arsenic concentration following the lag vessel, based on the water sample collected on November 17, 2009, was 5.8 µg/L, which was still below the 10-µg/L MCL. The system could have run longer and likely would have reached the 10 µg/L level after the two bed system (56 ft^3) had treated more than 70,000 BV of water.

The lead vessel was rebedded with LayneRT™ media (Section 4.4.3) at the end of Study Period I. After switching vessel positions, the vessel containing partially exhausted ArsenX^{np} (in the lead position) treated an additional 4,492,800 gal (or 21,340 BV) of water before arsenic concentrations in the vessel effluent reached 10 µg/L (see Figure 4-23). By the end of Study Period II, arsenic concentrations following the lead vessel were 11.7 µg/L (based on the sample collected on May 18, 2010) after treating an additional 7,051,380 gal (33,670 BV) of water. At this point, the concentration after the lag vessel was <1 µg/L.

According to the breakthrough curves obtained in Study Period I, after reaching 11 to 12 µg/L, the lead vessel could treat an additional 10,912,580 gal (52,104 BV) of water before the concentration in the vessel effluent would reach 70% of influent concentration. Assuming an average daily production rate of 42,541 gpd (Table 4-5), the system could operate for an additional 8 months after May 2010 before the lead vessel (Vessel B) would require rebedding.

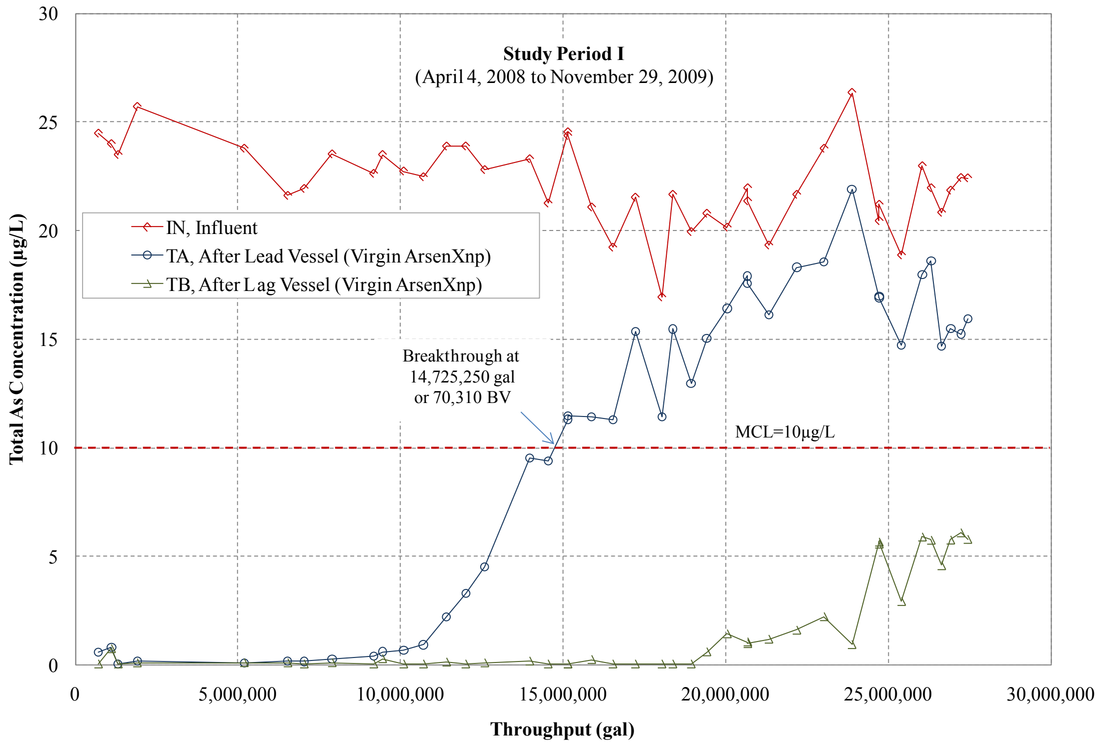


Figure 4-22. Total Arsenic Breakthrough Curves in Study Period I

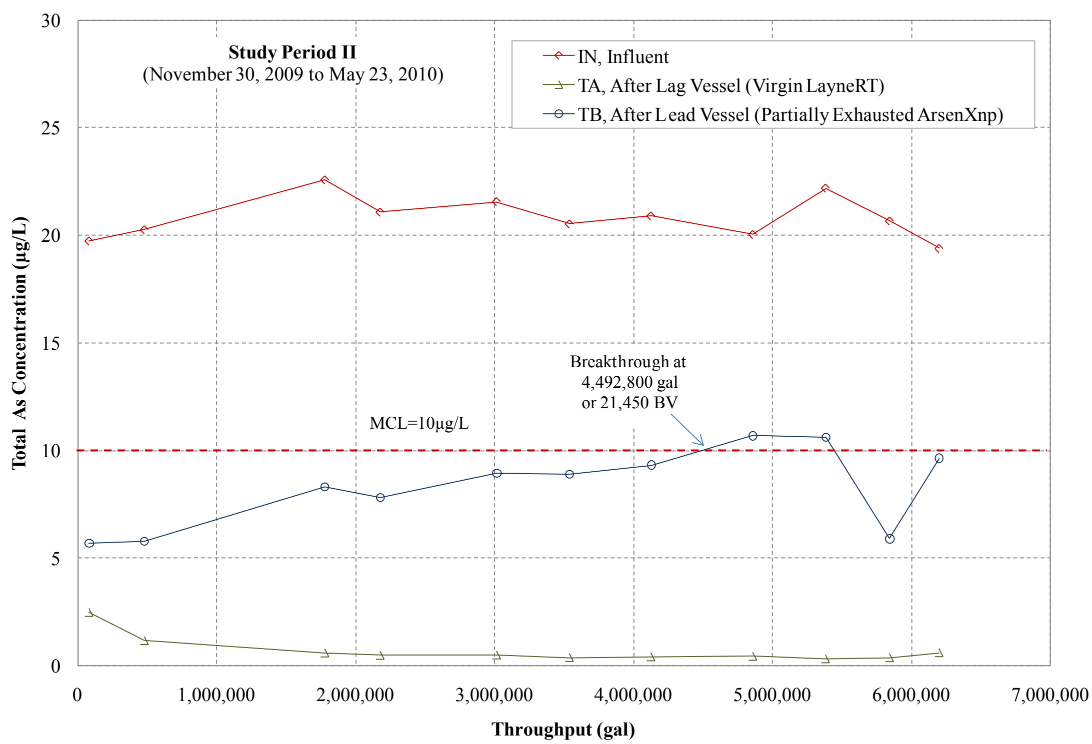


Figure 4-23. Total Arsenic Breakthrough Curves in Study Period II

Figure 4-24 contains three bar charts showing concentrations of total arsenic, particulate arsenic, soluble As(III), and soluble As(V) at the IN, TA, and TB sampling locations for each of the nine speciation sampling events in Study Period I. After treatment, soluble As(V) concentrations reduced to less than the MDL of 0.1 μg/L until 90,400 BV (1 BV = 28 ft^3). Afterwards, soluble As(V) started to break through the lag vessel and reached 2.0 μg/L at 110,000 BV, according to the result of the last speciation event on July 21, 2009. As(III) concentrations reduced only slightly from 0.4 μg/L (on average) in raw water to 0.3 μg/L (on average) after the lag vessel. The adsorption vessels filtered out some particulate arsenic, with the average concentration reduced from 0.8 μg/L in raw water to 0.1 μg/L after the treatment system.

Iron and Manganese. Total iron concentrations in source water and following the adsorption vessels were below the MDL of 25 μg/L (Table 4-7), except for the lag vessel sample collected on June 23, 2009, with total and soluble concentrations of 36.8 and 37.5 μg/L, respectively. Total manganese levels in source water also were low, ranging from <0.1 to 3.4 μg/L and averaging 0.6 μg/L. Total manganese concentrations in system effluent were at similar levels to those in source water, ranging from 0.2 to 3.5 μg/L and averaging 1.1 μg/L.

Competing Anions. Phosphate and silica, which might influence arsenic adsorption, were measured in Study Period I at IN, the TA, and TB sampling locations across the treatment train. Phosphorus concentrations were at or below 18 μg/L in source water and below the MDL of 10 μg/L in system effluent. Silica concentrations in source water ranged from 14.5 to 18.4 mg/L and averaged 16.4 mg/L. No silica reduction was observed after treatment, with concentrations averaged at 16.6 mg/L in the system effluent.

Other Water Quality Parameters. As shown in Table 4-8, alkalinity, reported as $CaCO_3$, ranged from 136 to 158 mg/L and averaged 147 mg/L in source water. As expected, alkalinity after the treatment system remained essentially unchanged at 148 mg/L (on average) after the lag vessel. Sulfate concentrations were consistently low, averaging 9.9 mg/L in source water and 10.7 mg/L after the lead and lag vessels. Fluoride and nitrate levels ranging from 0.4 to 0.8 mg/L and from 0.2 to 0.6 mg/L (as N), respectively, across the treatment train did not appear to have been affected by ArsenX^{np}.

Average pH values ranged from 7.2 to 7.3 in Study Period I and from 7.1 to 7.2 in Study Period II. Total hardness concentrations, reported as $CaCO_3$, ranged from 117 to 179 mg/L and averaged 153 mg/L in source water. Total hardness remained unchanged at 153 to 155 mg/L, on average, following Adsorption Vessels A and B. Average DO levels throughout the treatment train ranged from 6.5 to 6.7 mg/L in Study Period I, and from 8.2 to 8.3 mg/L in Study Period II. Average ORP readings throughout the treatment train ranged from 410 to 421 mV in Study Period I, and ranged from 420 to 440 mV in Study Period II. As expected, the mining tunnel water was rather oxidizing.

4.5.2 Spent Media Sampling. Three sets of spent media samples were collected from the top, middle, and bottom of the lead vessel (Vessel A) during media changeout on November 30, 2009. Table 4-9 presents the ICP-MS results. As shown in the table, arsenic loadings on the spent media were constant across the media bed, with 4.43, 4.39, and 4.53 mg/g of dry media measured at the top, middle, and bottom of the bed, respectively. The uniform arsenic loading across the media bed indicated that the media bed was close to complete exhaustion.

The adsorptive capacity also was calculated by dividing the arsenic mass represented by the area between the influent (IN) and the lead vessel effluent (TA) curves, as shown in Figure 4-22, by the amount of dry media in lead vessel. Assuming no media loss, the dry weight of the media, i.e., 601 lb/vessel, was calculated based on 1,414 lb of wet media (i.e., 28 ft^3 of media at an average bulk density of 50.5 lb/ft^3) and an average moisture content of 57.5% (Table 4-2). Using this approach, the theoretical arsenic

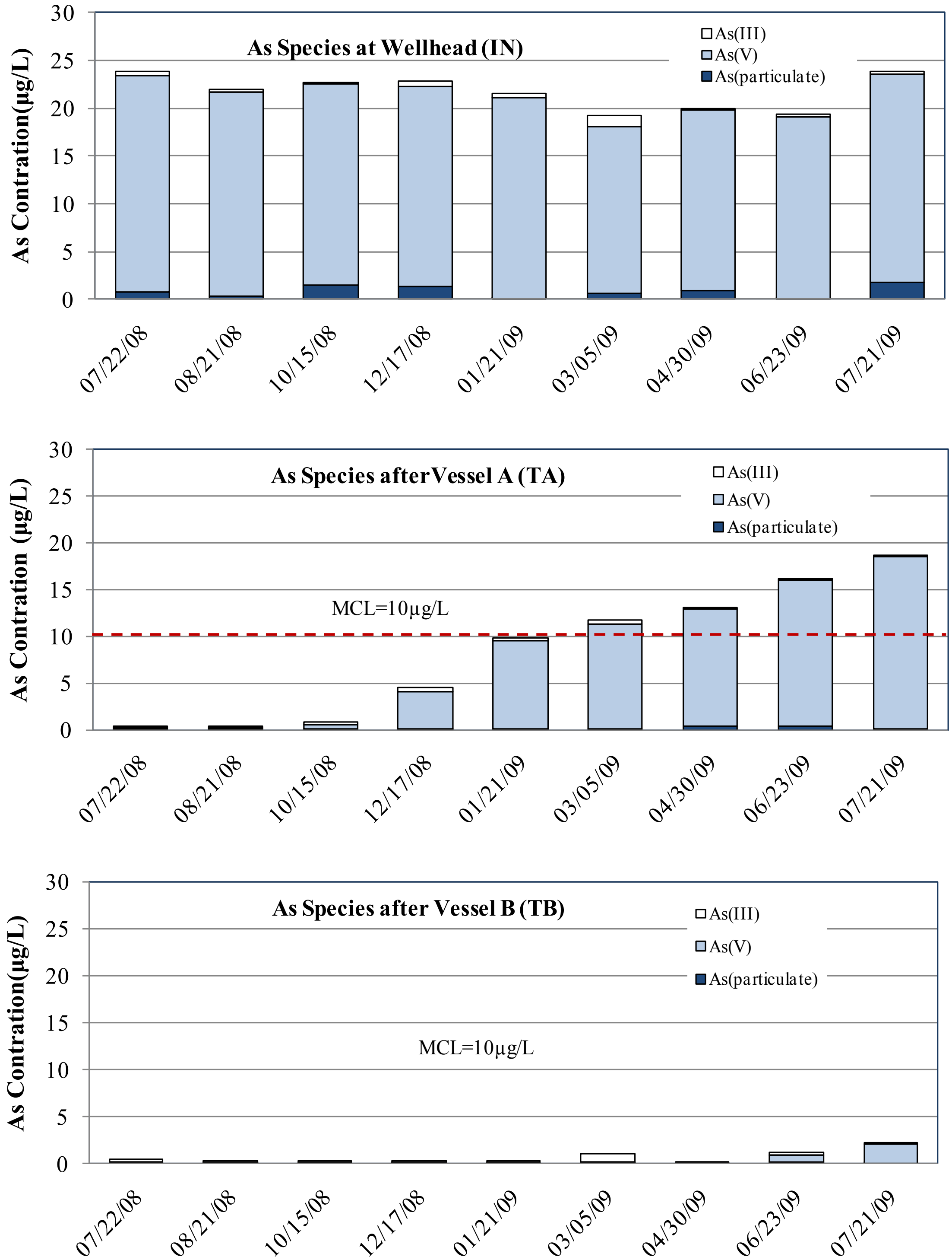


Figure 4-24. Arsenic Speciation Results in Study Period I

Table 4-9. Spent Media Total Metal Analysis

Analyte (µg/g)		Mg	P	Si	Ca	Fe	Mn	As	Ba
Vessel A Top	Run 1	536	772	3,211	2,381	223,134	3,663	4,536	31.4
	Run 2	499	746	3,359	2,387	207,605	3,838	4,316	35.6
	Avg.	*518*	*759*	*3,285*	*2,384*	*215,369*	*3,751*	*4,426*	*33.5*
Vessel A Middle	Run 1	544	754	3,502	2,510	20,368	3,151	4,342	27.6
	Run 2	572	797	4,732	2,422	222,570	3,695	4,432	36.3
	Avg.	*558*	*775*	*4,117*	*2,466*	*121,469*	*3,423*	*4,387*	*32.0*
Vessel A Bottom	Run 1	615	882	1,511	2,331	235,353	3,993	4,478	38.4
	Run 2	621	1,000	1,585	2,477	241,143	4,234	4,584	35.4
	Avg.	*618*	*941*	*1,548*	*2,404*	*238,248*	*4,113*	*4,531*	*36.9*

loadings on the media would be 5.50 mg/g of dry media. Therefore, ICP-MS analysis recovered approximately 80.8 % of arsenic.

4.5.3 Backwash Water Sampling. As recommended by the vendor, backwashing of the media was not conducted during the performance evaluation study.

4.5.4 Distribution System Water Sampling. Distribution system water samples were collected to determine if 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 system startup, baseline distribution system water samples were collected on October 31, 2007; December 19, 2007; and Februray 21, 2008. Since system startup, distribution system water sampling continued monthly at the same three locations until July 7, 2009. Table 4-10 presents the results. The stagnation times for the first draw samples ranged from 6.5 to 13.0 hr, which met the requirements of the EPA LCR sampling protocol (EPA, 2002).

Arsenic concentrations were reduced significantly from a pre-startup level of 22.5 µg/L (on average) to a post-startup level of 1.1 µg/L. Arsenic concentrations measured in the distribution system water were compared to those measured in the plant effluent. As shown in Figure 4-25, before 77,170 BV (16,163,800 gal) of throughput, arsenic concentrations in the distribution system water were higher than those in the plant effluent. Afterwards, arsenic concentrations decreased to levels similar to the plant effluent. These results suggest occurrence of some initial redissolution and/or resuspendsion of arsenic previously accumulated in the distribution system. After that, arsenic concentrations in the distribution system water essentially mirrored those of the plant effluent.

Iron concentrations measured in the distribution system were low both before and after system startup, with the majority of the samples measured at <25 µg/L. Manganese concentrations also were low both before (0.2 µg/L) and after (0.4 µg/L) system startup. Lead concentrations ranged from 0.1 to 3.0 µg/L after startup, with no sample exceeding the action level of 15 µg/L. Copper concentrations ranged from 1.9 to 143 µg/L after startup, with no sample exceeding the 1,300 µg/L action level. Compared to baseline samples, the average lead concentration reduced from 2.0 µg/L in baseline samples to 0.8 µg/L after startup; the average copper concentration reduced from 164 µg/L to 46.2 µg/L after startup.

Measured pH values ranged from 7.4 to 7.8 and averaged 7.5. Alkalinity levels ranged from 139 to 159 mg/L (as $CaCO_3$) and averaged 147 mg/L. The arsenic treatment system did not seem to affect pH and alkalinity levels in the distribution system.

Table 4-10. Distribution System Sampling Results

Sampling Event		DS1								DS2								DS3							
		21111 Barefoot Loop								21193 High Ridge								21163 Last Chance							
		LCR								LCR								LCR							
		1st Draw								1st Draw								1st Draw							
		Stagnation Time	pH	Alkalinity	As	Fe	Mn	Pb	Cu	Stagnation Time	pH	Alkalinity	As	Fe	Mn	Pb	Cu	Stagnation Time	pH	Alkalinity	As	Fe	Mn	Pb	Cu
No.	Date	hr	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	hr	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	hr	S.U.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BL1	10/31/07	7.0	7.6	157	21.7	<25	0.1	<0.1	85.4	7.3	7.5	147	12.1	<25	0.5	8.7	517	8.0	7.6	145	14.0	66.0	0.7	8.0	433
BL2	12/19/07	11.8	7.6	146	24.7	<25	0.3	0.2	94.0	13.0	7.8	148	23.2	<25	0.2	0.2	8.2	11.0	7.7	148	23.3	<25	0.3	0.6	24.5
BL3	02/21/08	8.0	7.5	151	28.6	<25	<0.1	0.2	101	10.0	7.5	151	27.7	<25	<0.1	<0.1	91.1	11.0	7.5	147	27.1	<25	<0.1	<0.1	117
1	08/11/08	8.0	7.5	146	3.8	<25	<0.1	1.6	130	9.5	7.5	148	1.5	<25	0.3	1.2	26.6	9.5	7.8	146	2.1	<25	0.5	1.0	63.0
2	09/04/08	10.3	7.5	142	3.8	<25	0.1	1.9	143	10.8	7.5	146	1.7	<25	1.2	0.8	61.3	9.8	7.5	146	1.3	<25	0.6	3.0	38.4
3	10/01/08	6.5	7.5	139	1.1	<25	0.6	1.8	31.6	6.3	7.6	141	1.4	<25	0.4	0.7	63.4	6.5	7.5	141	1.2	<25	0.4	0.1	31.2
4	10/30/08	NA	7.4	143	0.6	<25	0.2	0.6	18.5	NA	7.5	143	0.5	<25	0.5	1.1	41.3	NA	7.5	146	0.7	<25	0.2	<0.1	1.9
5	12/03/08	NA	7.5	152	0.3	<25	0.2	<0.1	10.6	NA	7.7	159	0.8	<25	0.4	1.1	98.4	NA	7.5	157	0.6	<25	<0.1	2.5	114
6	01/08/09	8.0	7.8	146	0.4	<25	0.1	<0.1	9.1	9.0	7.6	146	0.7	<25	0.4	0.7	119	9.5	7.5	144	1.4	<25	1.1	0.8	22.5
7	02/25/09	7.8	7.5	148	1.1	<25	0.6	0.2	33.1	8.0	7.4	148	1.4	<25	2.1	0.9	23.2	8.5	7.5	144	0.6	<25	0.1	<0.1	27.2
8	03/19/09	8.0	7.5	145	0.4	<25	0.1	0.5	66.3	8.0	7.4	149	<0.1	<25	<0.1	1.9	39.0	6.5	7.4	153	<0.1	<25	0.2	0.1	2.7
9	04/15/09	7.5	7.6	148	0.4	<25	<0.1	0.6	140	9.5	7.8	141	0.2	<25	0.1	<0.1	18.1	10.5	7.6	159	<0.1	<25	<0.1	1.5	33.0
10	05/13/09	11.5	7.8	145	0.7	<25	0.2	<0.1	10.3	11.0	7.6	145	0.5	<25	0.2	1.6	37.0	11.0	7.7	145	1.0	<25	0.4	1.3	138
11	06/11/09	10.5	7.4	150	1.3	<25	0.2	0.2	5.8	9.5	7.4	150	1.2	<25	0.2	0.2	5.7	10.0	7.5	152	1.2	<25	0.2	0.4	9.9
12	07/07/09	10.0	7.6	155	1.8	<25	0.2	<0.1	18.4	7.0	7.5	150	1.7	<25	0.2	0.2	15.0	10.5	7.5	148	1.7	<25	0.5	0.3	16.5

Lead action level = 15 µg/L; copper action level = 1.3 mg/L
BL = baseline sampling; NA = not available
The unit for alkalinity is mg/L as $CaCO_3$.

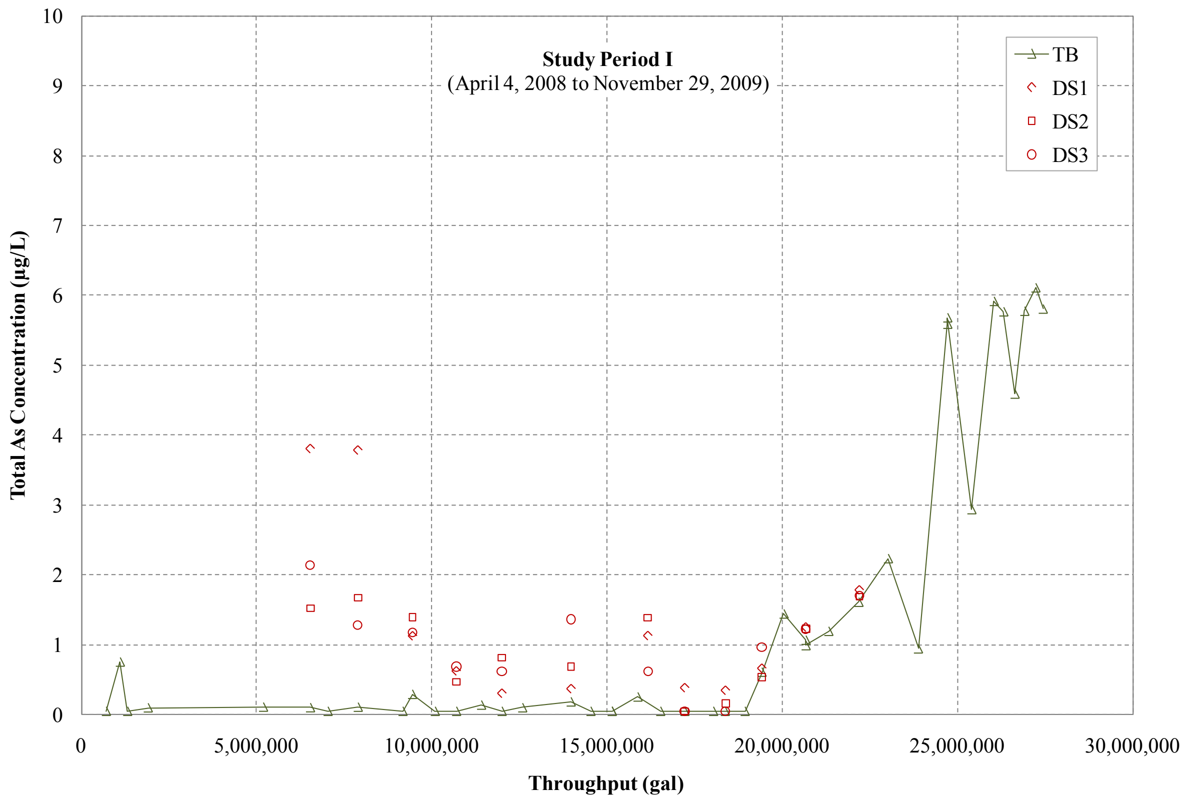


Figure 4-25. Arsenic Concentrations Measured in Distribution System Water

4.6 System Cost

System cost was evaluated based on the capital cost per gpm (or gpd) of the design capacity and the O&M cost per 1,000 gal of water treated. The capital cost includes the cost for equipment, site engineering, and installation. The O&M cost includes the cost for media replacement and disposal, electrical use, and labor.

4.6.1 Capital Cost. The capital investment for equipment, site engineering, and installation of the treatment system was $87,892 (see Table 4-11). The equipment cost was $60,678 (or 69% of the total capital investment), which included the cost for two adsorption vessels, system skid frame, 56 ft^3 of ArsenX^{np} media, prefilter, flowmeter, and shipping.

The engineering cost included the cost for the design work necessary to develop the final system layout and footprint within the building, design of the piping connections up to the water storage reservoir inlet pipe, and the design of the electrical connection and conduit plan. The engineering cost also included the cost for the submission of the plans and permit application to SD DENR. The site engineering cost was $14,214, or 16% of the total capital investment.

The installation cost included the equipment and labor to unload and install the skid-mounted unit, perform piping tie-ins and electrical work, load and backwash the media, perform system shakedown and startup, and conduct operator training. The installation cost was $13,000, or 15% of the total capital investment.

Table 4-11. Capital Investment Cost for Lead, SD System

Description	Quantity	Cost	% of Capital Investment Cost
Equipment Cost			
System Skid Frame	1	$17,625	–
Fiberglass Pressure Vessels	2	$8,125	–
Prefilter Assembly	1	$3,350	–
ArsenX^{np} Media (ft^3)	56	$23,800	–
Totalizer/flow meter	1	$1,778	–
Shipping	–	$6,000	–
Equipment Total	–	**$60,678**	**69**
Engineering Cost			
Vendor Labor	–	$14,214	–
Engineering Total	–	**$14,214**	**16**
Installation Cost			
Vendor Labor	–	$10,000	–
Subcontractor Labor	–	$1,000	–
Travel	–	$2,000	–
Installation Total	–	**$13,000**	**15**
Total Capital Investment	–	**$87,892**	**100**

The total capital cost of $87,892 was normalized to the system's rated capacity of 75 gpm (108,000 gpd), which resulted in $1,172/gpm of design capacity ($0.81/gpd). The capital cost also was converted to an annualized cost of $8,296/yr using a capital recovery factor (CRF) of 0.09439 based on a 7% interest rate and a 20-year return period. Assuming that the system operated 24 hours a day, 7 days a week at the system design flowrate of 75 gpm to produce 39,420,000 gal of water per year, the unit capital cost would be $0.21/1,000 gal. Because the system operated an average of 12 hr/day at approximately 71.5 gpm (based on the data in Study Period I, see Table 4-5), producing 18,790,000 gal of water annually, the unit capital cost increased to $0.44/1,000 gal at this reduced rate of use.

4.6.2 Operation and Maintenance Cost. The O&M cost included the cost for media replacement and disposal, electricity, and labor (Table 4-12). The media replacement and disposal cost was $9,693, including the cost for 28 ft^3 of LayneRT™ media and freight for shipping the virgin LayneRT™ media to the site and the spent ArsenX^{np} media to a SolmeteX location. Because the facility performed rebedding itself, the cost did not include labor and equipment for removing the spent media and loading the new media. To encourage the use of LayneRT™ for rebedding, the vendor offered a discounted price of $250/ft^3$, instead of its regular price of $480/ft^3$. Therefore, an adjusted cost of $16,133 (including the cost for 28 ft^3 of LayneRT™ at $480/ft^3$ and the freight as discussed above) was used to calculate the media replacement cost per 1,000 gal of water treated as a function of total throughput at 10-µg/L arsenic breakthrough from the lag vessel (Figure 4-26). Should additional cost for labor and equipment be included, the rebedding cost would be higher than $16,133.

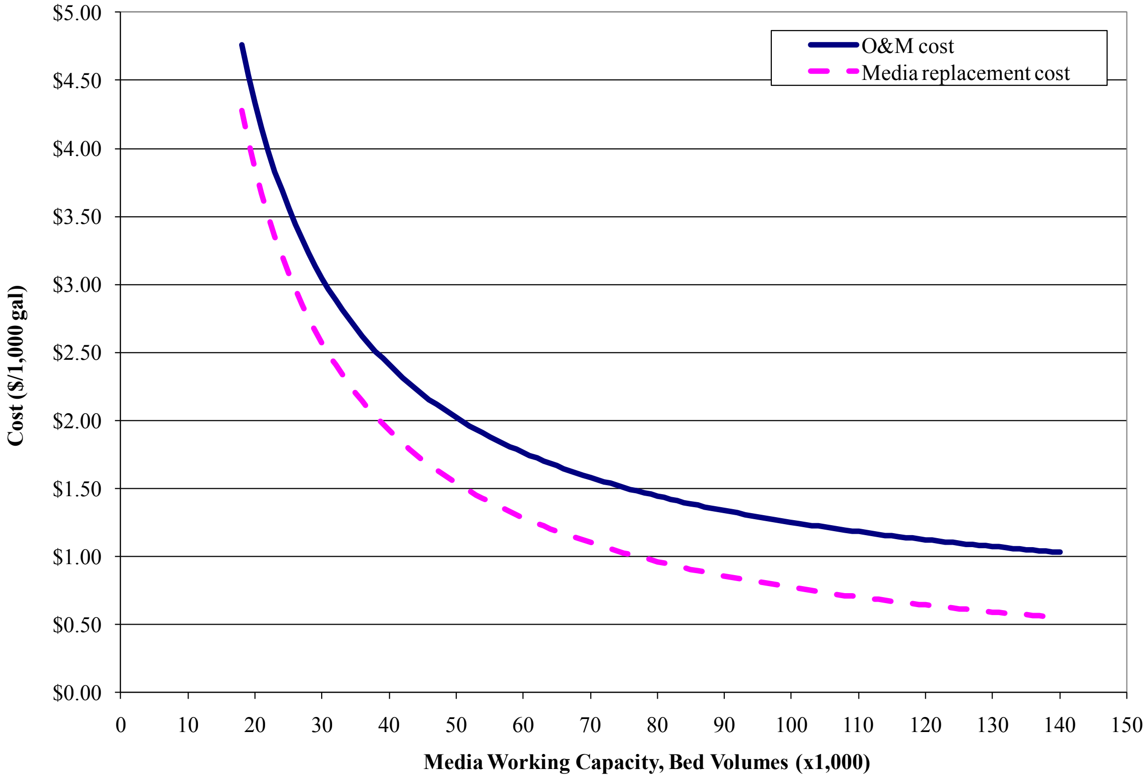
Comparison of electrical bills before and after system startup did not indicate any noticeable increase in power consumption. Therefore, electrical cost associated with system operation was assumed to be negligible.

The chemical cost associated with the operation of the treatment system included only post-chlorination. This treatment step was in use at the site prior to installation of the treatment system. Therefore, the incremental chemical cost for the treatment system was negligible.

Under normal operating conditions, routine labor activities to operate and maintain the system consumed an average of 1 hr/day. Therefore, the estimated labor cost was \$0.40/1,000 gal of water treated based on this time commitment and a labor rate of \$21/hr. This estimation assumes that maintenance and operational procedures were consistently performed through the completion of the system performance evaluation.

Table 4-12. Operation and Maintenance Cost for the Lead System

Cost Category	Value	Assumptions
Volume Processed (gal/year)	18,790,000	Based on 12 hr/day and 71.5 gpm flowrate
Media Replacement and Disposal		
Media Cost (\$)	7,000 or 13,440	28 ft^3 of LayneRT™ media at \$250/ft^3 (discounted price) or \$480/ft^3 (regular price)
Shipping (\$)	1,418	–
Freight of Spent Media to SolmeteX Facility (\$)	1,275	–
Subtotal (\$)	9,693 or 16,133	With a media cost of either \$7,000 or \$13,440
Media Replacement and Disposal Cost (\$/1000 gal)	See Figure 4-26	Based upon media run length at 10µg/L arsenic breakthrough
Electricity Consumption		
Power Use (\$/1,000 gal)	Negligible	–
Labor		
Average Weekly Labor (hr/wk)	7	1 hr/day; 7 day/wk
Total Labor Hours (hr/year)	364	–
Total Labor Cost (\$/year)	7,644	Labor rate=\$21/hr
Labor Cost (\$/1,000 gal)	0.40	–
Total O&M Cost/1,000 gal	See Figure 4-26	Based upon media run length at 10µg/L arsenic breakthrough



Note: One bed volume equals 28 ft^3 (209 gal)

Figure 4-26. Media Replacement and Operation and Maintenance Cost

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APPENDIX A

OPERATIONAL DATA

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure: System Inlet	System Pressure: After Prefilter	System Pressure: After Rotameter	System Pressure: Tank A Outlet	System Pressure: System Outlet	System Pressure: ΔP Tank A	System Pressure: ΔP Tank B	Totalizer to Distribution: System Totalizer[b]	Totalizer to Distribution: Cum. Flow	Totalizer to Distribution: Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
Study Period I															
1	Fri	04/04/08	NM	11	74	16	NM	NM	5	2	NA	3	450,943	NA	NA
	Sat	04/05/08	NM	11	74	16	NM	NM	5	2	NA	3	530,566	79,623	NA
2	Mon	04/07/08	NM	11	73	16	NM	NM	5	2	NA	3	697,152	246,209	NA
	Tues	04/08/08	NM	11	73	16	NM	NM	5	2	NA	3	787,412	336,469	NA
	Wed	04/09/08	NM	11	73	16	NM	NM	5	2	NA	3	868,703	417,760	NA
	Thur	04/10/08	NM	11	73	16	NM	NM	5	2	NA	3	955,531	504,588	NA
	Fri	04/11/08	NM	11	73	16	NM	NM	5	2	NA	3	972,404	521,461	NA
	Sat	04/12/08	NM	11	73	16	NM	NM	5	2	NA	3	987,800	536,857	NA
	Sun	04/13/08	NM	11	73	16	NM	NM	5	2	NA	3	1,003,943	553,000	NA
3	Mon	04/14/08	NM	11	73	16	NM	NM	5	2	NA	3	1,045,719	594,776	NA
	Tues	04/15/08	NM	11	72	16	NM	NM	5	2	NA	3	1,078,003	627,060	NA
	Wed	04/16/08	NM	11	73	16	NM	NM	5	2	NA	3	1,117,155	666,212	NA
	Thur	04/17/08	NM	11	73	16	NM	NM	5	2	NA	3	1,156,805	705,862	NA
	Fri	04/18/08	NM	11	72	18	NM	NM	7	3	NA	4	1,197,999	747,056	NA
	Sat	04/19/08	NM	11	69	32	NM	NM	16	8	NA	8	1,245,574	794,631	NA
	Sun	04/20/08	NM	11	70	25	NM	NM	12	5	NA	7	1,297,428	846,485	NA
4	Mon	04/21/08	NM	11	71	20	NM	NM	8	4	NA	4	1,323,854	872,911	NA
	Tues	04/22/08	NM	11	73	16	NM	NM	6	3	NA	3	1,377,283	926,340	NA
	Wed	04/23/08	NM	11	73	19	NM	NM	10	5	NA	5	1,406,836	955,893	NA
	Thur	04/24/08	NM	11	73	16	NM	NM	10	5	NA	5	1,443,849	992,906	NA
	Fri	04/25/08	NM	11	73	16	NM	NM	6	4	NA	2	1,480,288	1,029,345	NA
	Sat	04/26/08	NM	11	73	18	NM	NM	6	4	NA	2	1,511,968	1,061,025	NA
	Sun	04/27/08	NM	11	72	18	NM	NM	8	5	NA	3	1,556,732	1,105,789	NA
5	Mon	04/28/08	NM	11	74	16	NM	NM	8	2	NA	6	NM	1,105,789	NA
	Tue	04/29/08	NM	11	73	16	NM	NM	8	2	NA	6	1,597,741	1,146,798	NA
	Wed	04/30/08	NM	11	73	16	NM	NM	8	2	NA	6	1,618,019	1,167,076	NA
	Thu	05/01/08	NM	11	73	18	NM	NM	6	2	NA	4	1,637,874	1,186,931	NA
	Fri	05/02/08	System bypassed due to snow storm (05/02/08 to 05/06/08).												
	Sat	05/03/08													
	Sun	05/04/08													
6	Mon	05/05/08													
	Tue	05/06/08													
	Wed	05/07/08	NM	11	73	18	NM	NM	8	4	NA	4	1,658,575	1,207,632	NA
	Thu	05/08/08	NM	11	73	18	NM	NM	8	4	NA	4	1,679,314	1,228,371	NA
	Fri	05/09/08	NM	11	72	18	NM	NM	8	4	NA	4	1,701,297	1,250,354	NA
	Sat	05/10/08	NM	11	73	16	NM	NM	4	2	NA	2	1,724,244	1,273,301	NA
	Sun	05/11/08	NM	11	75	16	NM	NM	4	2	NA	2	1,745,029	1,294,086	NA

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[(a)]	Rotameter Flowrate	System Pressure: System Inlet	System Pressure: After Prefilter	System Pressure: After Rotameter	System Pressure: Tank A Outlet	System Pressure: System Outlet	System Pressure: ΔP Tank A	System Pressure: ΔP Tank B	Totalizer to Distribution: System Totalizer[(b)]	Totalizer to Distribution: Cum. Flow	Totalizer to Distribution: Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
7	Mon	05/12/08	NM	11	73	16	NM	NM	4	2	NA	2	1,766,068	1,315,125	NA
	Tue	05/13/08	NM	11	72	24	NM	NM	16	8	NA	8	1,795,783	1,344,840	NA
	Wed	05/14/08	NM	11	74	16	NM	NM	4	2	NA	2	1,818,567	1,385,593	NA
	Thu	05/15/08	NM	11	73	16	NM	NM	4	2	NA	2	2,915	1,426,345	NA
	Fri	05/16/08	NM	11	73	18	NM	NM	5	3	NA	2	11,376	1,467,098	NA
	Sat	05/17/08	NM	11	74	24	NM	NM	10	5	NA	5	12,268	1,507,851	NA
	Sun	05/18/08	NM	11	74	20	NM	NM	8	4	NA	4	16,432	1,548,604	NA
8	Mon	05/19/08	NM	11	74	20	NM	NM	10	5	NA	5	24,335	1,589,356	NA
	Tue	05/20/08	NM	11	72	20	NM	NM	10	5	NA	5	28,015	1,630,109	NA
	Wed	05/21/08	NM	11	72	26	NM	NM	13	7	NA	6	33,887	1,670,862	NA
	Thu	05/22/08	NM	11	73	24	NM	NM	10	5	NA	5	39,695	1,711,615	NA
	Fri	05/23/08	NM	11	72	24	NM	NM	10	5	NA	5	43,432	1,752,367	NA
	Sat	05/24/08	NM	11	73	26	NM	NM	14	7	NA	7	48,743	1,793,120	NA
	Sun	05/25/08	NM	11	73	26	NM	NM	14	7	NA	7	55,685	1,833,873	NA
9	Mon	05/26/08	49.4	11	73	20	NM	NM	8	4	NA	4	60,065	1,874,625	NA
	Tue	05/27/08	61.2	12	75	22	NM	NM	12	6	NA	6	66,159	1,915,378	58
	Wed	05/28/08	73.7	13	73	22	NM	NM	16	8	NA	8	72,681	1,956,131	54
	Thu	05/29/08	81.6	8	73	24	NM	NM	18	9	NA	9	36,301	1,996,884	86
	Fri	05/30/08	92.7	11	73	28	NM	NM	16	8	NA	8	93,079	2,053,662	85
	Sat	05/31/08	102.9	10	73	20	NM	NM	8	4	NA	4	147,784	2,108,367	89
	Sun	06/01/08	113.9	11	75	24	NM	NM	12	6	NA	6	204,452	2,165,035	86
10	Mon	06/02/08	126.8	13	75	22	NM	NM	10	5	NA	5	275,346	2,235,929	92
	Tue	06/03/08	138.0	11	73	28	NM	NM	14	7	NA	7	333,863	2,294,446	87
	Wed	06/04/08	145.5	8	73	25	NM	NM	12	6	NA	6	369,737	2,330,320	80
	Thu	06/05/08	157.4	12	73	28	NM	NM	14	7	NA	7	425,395	2,385,978	78
	Fri	06/06/08	166.6	9	73	26	NM	NM	14	7	NA	7	469,369	2,429,952	80
	Sat	06/07/08	176.0	9	75	26	NM	NM	16	8	NA	8	513,290	2,473,873	78
	Sun	06/08/08	188.9	13	75	26	NM	NM	16	8	NA	8	578,257	2,538,840	84
11	Mon	06/09/08	198.5	10	75	24	NM	NM	12	6	NA	6	623,175	2,583,758	78
	Tue	06/10/08	211.4	13	NM	NM	NM	NM	NM	NM	NA	NA	687,856	2,648,439	84
	Wed	06/11/08	218.0	7	NM	NM	NM	NM	NM	NM	NA	NA	719,487	2,680,070	80
	Thu	06/12/08	231.3	13	74	28	NM	NM	16	8	NA	8	783,240	2,743,823	80
	Fri	06/13/08	239.1	8	73	28	NM	NM	16	8	NA	8	821,378	2,781,961	81
	Sat	06/14/08	252.9	14	75	28	NM	NM	16	8	NA	8	886,710	2,847,293	79
12	Mon	06/16/08	276.1	12	74	27	NM	NM	14	7	NA	7	1,002,115	2,962,698	83
	Tue	06/17/08	286.5	10	75	23	NM	NM	12	6	NA	6	1,053,321	3,013,904	82
	Wed	06/18/08	300.8	14	76	24	NM	NM	12	6	NA	6	1,126,185	3,086,768	85
	Thu	06/19/08	311.6	11	76	24	NM	NM	12	6	NA	6	1,178,725	3,139,308	81
	Fri	06/20/08	323.8	12	75	24	NM	NM	12	6	NA	6	1,240,565	3,201,148	84
	Sat	06/21/08	334.1	10	75	28	NM	NM	14	7	NA	7	1,290,024	3,250,607	80
	Sun	06/22/08	346.4	12	74	28	NM	NM	14	7	NA	7	1,351,572	3,312,155	83

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
13	Mon	06/23/08	356.9	11	74	28	NM	NM	14	7	NA	7	1,401,599	3,362,182	NA
	Tue	06/24/08	367.6	11	74	27	NM	NM	13	6	NA	7	1,454,473	3,415,056	82
	Wed	06/25/08	377.6	10	75	27	NM	NM	13	6	NA	7	1,501,395	3,461,978	78
	Thu	06/26/08	390.7	13	75	27	NM	NM	14	7	NA	7	1,568,190	3,528,773	85
	Fri	06/27/08	403.4	13	75	28	NM	NM	14	8	NA	6	1,630,365	3,590,948	82
	Sat	06/28/08	416.1	13	78	28	NM	NM	14	8	NA	6	1,695,950	3,656,533	86
	Sun	06/29/08	429.2	13	78	22	NM	NM	14	6	NA	8	1,760,777	3,721,360	82
14	Mon	06/30/08	443.7	15	73	24	NM	NM	12	6	NA	6	1,834,770	3,795,353	85
	Tue	07/01/08	452.7	9	75	26	NM	NM	13	6	NA	7	1,877,045	3,837,628	78
	Wed	07/02/08	468.4	16	75	26	NM	NM	13	6	NA	7	1,957,706	3,918,289	86
	Thu	07/03/08	478.9	11	73	28	NM	NM	13	6	NA	7	2,008,640	3,969,223	81
	Fri	07/04/08	491.7	13	72	22	NM	NM	10	5	NA	5	2,074,147	4,034,730	85
	Sat	07/05/08	504.4	13	73	28	NM	NM	6	3	NA	3	2,136,513	4,097,096	82
	Sun	07/06/08	522.9	19	75	25	NM	NM	12	6	NA	6	2,233,615	4,194,198	87
15	Mon	07/07/08	536.9	14	75	24	NM	NM	11	5	NA	6	2,306,547	4,267,130	87
	Tue	07/08/08	549.8	13	74	27	NM	NM	13	7	NA	6	2,370,001	4,330,584	82
	Wed	07/09/08	562.3	13	74	27	NM	NM	13	7	NA	6	2,431,807	4,392,390	82
	Thu	07/10/08	578.1	16	50	21	NM	NM	10	5	NA	5	2,503,321	4,463,904	75
	Fri	07/11/08	595.7	18	75	24	NM	NM	11	5	NA	6	2,561,771	4,522,354	55
	Sat	07/12/08	613.4	18	73	26	NM	NM	10	5	NA	5	2,621,181	4,581,764	56
	Sun	07/13/08	631.3	18	73	27	NM	NM	13	7	NA	6	2,682,702	4,643,285	57
16	Mon	07/14/08	651.4	20	50	15	NM	NM	7	3	NA	4	2,751,444	4,712,027	57
	Tue	07/15/08	670.2	19	50	15	NM	NM	7	3	NA	4	2,815,474	4,776,057	57
	Wed	07/16/08	687.4	17	50	15	NM	NM	7	3	NA	4	2,889,730	4,850,313	72
	Thu	07/17/08	706.7	19	55	15	NM	NM	8	4	NA	4	2,963,925	4,924,508	64
	Fri	07/18/08	726.3	20	50	16	NM	NM	8	4	NA	4	3,036,473	4,997,056	62
	Sat	07/19/08	743.8	18	50	15	NM	NM	7	3	NA	4	3,110,292	5,070,875	70
	Sun	07/20/08	765.7	22	50	15	NM	NM	7	3	NA	4	3,149,210	5,109,793	30
17	Mon	07/21/08	779.4	14	50	15	NM	NM	7	3	NA	4	3,185,073	5,145,656	44
	Tue	07/22/08	790.9	12	75	24	NM	NM	12	6	NA	6	3,233,417	5,194,000	70
	Wed	07/23/08	803.7	13	73	28	NM	NM	14	7	NA	7	3,295,150	5,255,733	80
	Thu	07/24/08	816.7	13	73	27	NM	NM	13	7	NA	6	3,358,890	5,319,473	82
	Fri	07/25/08	826.5	10	73	25	NM	NM	12	6	NA	6	3,405,356	5,365,939	79
	Sat	07/26/08	840.7	14	73	28	NM	NM	14	7	NA	7	3,476,456	5,437,039	83
	Sun	07/27/08	852.9	12	72	25	NM	NM	12	6	NA	6	3,535,410	5,495,993	81
18	Mon	07/28/08	863.8	11	72	28	NM	NM	14	7	NA	7	3,587,627	5,548,210	80
	Tue	07/29/08	874.7	11	73	28	NM	NM	14	7	NA	7	3,640,049	5,600,632	80
	Wed	07/30/08	885.5	11	73	27	NM	NM	13	6	NA	7	3,691,447	5,652,030	79
	Thu	07/31/08	897.7	12	75	28	NM	NM	14	7	NA	7	3,750,222	5,710,805	80
	Fri	08/01/08	904.7	7	75	28	NM	NM	14	7	NA	7	3,782,008	5,742,591	76
	Sat	08/02/08	942.8	20	72	26	NM	NM	12	6	NA	6	3,853,562	5,814,145	58
	Sun	08/03/08	948.8	6	73	28	NM	NM	14	7	NA	7	3,882,156	5,842,739	79

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
19	Mon	08/04/08	962.8	13	75	18	NM	NM	9	4	NA	5	3,949,482	5,910,065	80
	Tue	08/05/08	977.9	20	73	18	NM	NM	9	4	NA	5	4,024,852	5,985,435	83
	Wed	08/06/08	995.9	18	73	16	NM	NM	8	3	NA	5	4,080,733	6,041,316	52
	Thu	08/07/08	Lighting striked the well pump controler on 8/7/08, the system was off.												
	Fri	08/08/08	1020.4	12	75	17	NM	NM	4	2	NA	2	4,301,030	6,261,613	NA
	Sat	08/09/08	1048.6	11	73	17	NM	NM	4	2	NA	2	4,452,535	6,413,118	NA
	Sun	08/10/08	1056.4	11	73	17	NM	NM	4	2	NA	2	4,568,553	6,529,136	NA
20	Mon	08/11/08	1056.9	11	75	28	NM	NM	18	9	NA	9	4,570,318	6,530,901	59
	Tue	08/12/08	1065.6	11	73	27	NM	NM	16	8	NA	8	4,633,330	6,593,913	NA
	Wed	08/13/08	System was offline to install a pressure gauge after the rotameter												
	Thu	08/14/08	1075.6	11	73	28	NM	NM	14	7	NA	7	4,683,140	6,643,723	83
	Fri	08/15/08	1095.5	11	72	25	24	24	12	6	12	6	4,785,418	6,746,001	57
	Sat	08/16/08	1105.4	11	73	26	25	24	13	7	11	6	4,834,092	6,794,675	82
	Sun	08/17/08	1110.1	11	73	26	25	24	13	7	11	6	4,857,495	6,818,078	83
21	Mon	08/18/08	1125.3	13	73	22	20	18	8	4	10	4	4,934,492	6,895,075	84
	Tue	08/19/08	1139.2	14	73	22	20	18	8	4	10	4	5,003,753	6,964,336	83
	Wed	08/20/08	1148.5	9	73	27	26	24	13	7	11	6	5,049,700	7,010,283	82
	Thu	08/21/08	1155.6	7	75	29	28	16	7	3	9	4	5,083,900	7,044,483	80
	Fri	08/22/08	1168.3	13	73	23	22	15	7	4	8	3	5,149,907	7,110,490	87
	Sat	08/23/08	1183.2	14	73	22	21	16	8	4	8	4	5,224,392	7,184,975	83
	Sun	08/24/08	1198.4	15	73	27	26	17	8	4	9	4	5,300,845	7,261,428	84
22	Mon	08/25/08	1210.5	13	73	27	26	24	14	7	10	7	5,361,060	7,321,643	83
	Tue	08/26/08	1220.3	10	72	27	26	24	14	7	10	7	5,408,335	7,368,918	80
	Wed	08/27/08	1227.6	7	72	29	26	27	26	16	NA	10	5,444,144	7,404,727	82
	Thu	08/28/08	1239.1	11	72	27	26	25	15	7	10	8	5,503,192	7,463,775	86
	Fri	08/29/08	1255.8	17	72	26	25	23	16	8	7	8	5,587,294	7,547,877	84
	Sat	08/30/08	1270.0	14	72	27	26	25	14	7	11	7	5,658,017	7,618,600	83
	Sun	08/31/08	1284.4	14	73	23	22	22	10	8	12	2	5,729,809	7,690,392	83
23	Mon	09/01/08	1290.0	6	73	29	28	26	16	8	10	8	5,756,131	7,716,714	78
	Tue	09/02/08	1305.0	15	72	29	28	26	16	8	10	8	5,833,854	7,794,437	86
	Wed	09/03/08	1316.5	11	72	26	25	24	14	7	10	7	5,890,681	7,851,264	82
	Thu	09/04/08	1324.6	8	72	28	27	25	16	7	9	9	5,929,712	7,890,295	80
	Fri	09/05/08	1329.9	5	73	27	26	24	17	8	7	9	5,957,337	7,917,920	87
	Sat	09/06/08	1343.0	13	73	28	26	25	16	9	9	7	6,021,900	7,982,483	82
	Sun	09/07/08	1363.4	20	72	28	27	25	16	8	9	8	6,125,041	8,085,624	84
24	Mon	09/08/08	1375.7	13	73	24	23	21	11	6	10	5	6,186,888	8,147,471	84
	Tue	09/09/08	1386.5	11	72	28	26	25	12	7	13	5	6,241,387	8,201,970	84
	Wed	09/10/08	1399.2	13	72	28	26	25	12	7	13	5	6,307,404	8,267,987	87
	Thu	09/11/08	1413.5	14	73	27	25	24	11	6	13	5	6,373,515	8,334,098	77
	Fri	09/12/08	1425.9	12	73	22	21	20	10	5	10	5	6,413,199	8,373,782	53
	Sat	09/13/08	1442.0	15	48	21	20	19	10	5	9	5	6,475,642	8,436,225	65
	Sun	09/14/08	1455.6	14	73	28	26	25	12	7	13	5	6,543,467	8,504,050	83

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
	Mon	09/15/08	1468.8	14	73	24	26	21	11	6	10	5	6,609,464	8,570,047	83
	Tue	09/16/08	1489.9	21	73	24	23	22	12	7	10	5	6,721,539	8,682,122	89
	Wed	09/17/08	1501.1	11	73	27	25	24	14	7	10	7	6,776,191	8,736,774	81
25	Thu	09/18/08	1505.9	5	73	26	25	24	13	7	11	6	6,800,196	8,760,779	83
	Fri	09/19/08	1523.3	17	73	26	25	24	13	7	11	6	6,888,419	8,849,002	85
	Sat	09/20/08	1539.9	16	72	25	24	22	12	6	10	6	6,971,355	8,931,938	83
	Sun	09/21/08	1550.6	11	72	26	25	24	13	7	11	6	7,023,685	8,984,268	82
	Mon	09/22/08	1560.1	10	73	26	25	23	13	7	10	6	7,072,619	9,033,202	86
	Tue	09/23/08	1572.6	12	73	26	25	23	13	7	10	6	7,134,063	9,094,646	82
	Wed	09/24/08	1576.2	4	73	23	21	20	10	5	10	5	7,149,897	9,110,480	73
26	Thu	09/25/08	1588.3	12	73	24	23	18	12	6	6	6	7,211,874	9,172,457	85
	Fri	09/26/08	1601.4	13	73	26	23	23	13	6	10	7	7,276,458	9,237,041	82
	Sat	09/27/08	1610.4	9	72	28	27	25	14	7	11	7	7,320,076	9,280,659	81
	Sun	09/28/08	1617.0	7	73	24	23	21	13	6	8	7	7,353,836	9,314,419	85
	Mon	09/29/08	1631.1	15	73	28	27	25	14	7	11	7	7,423,605	9,384,188	82
	Tue	09/30/08	1637.1	6	73	28	27	26	15	7	11	8	7,451,319	9,411,902	77
	Wed	10/01/08	1644.8	8	72	26	25	24	13	6	11	7	7,490,612	9,451,195	85
27	Thu	10/02/08	1658.1	13	73	28	27	25	14	7	11	7	7,556,709	9,517,292	83
	Fri	10/03/08	1664.8	7	73	28	27	26	16	7	10	9	7,589,695	9,550,278	82
	Sat	10/04/08	1670.2	5	73	27	26	25	14	7	11	7	7,618,005	9,578,588	87
	Sun	10/05/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NM	NA
	Mon	10/06/08	1692.1	11	73	28	27	25	14	7	11	7	7,728,055	9,688,638	84
	Tue	10/07/08	1695.7	4	73	27	26	25	14	7	11	7	7,746,756	9,707,339	87
	Wed	10/08/08	1709.2	13	73	28	26	25	14	7	11	7	7,814,795	9,775,378	84
28	Thu	10/09/08	1718.5	9	75	28	27	25	14	7	11	7	7,861,585	9,822,168	84
	Fri	10/10/08	1727.5	7	73	28	27	25	16	7	9	9	7,906,457	9,867,040	83
	Sat	10/11/08	1734.3	10	73	26	26	25	13	6	12	7	7,942,303	9,902,886	88
	Sun	10/12/08	1746.5	12	73	27	26	24	14	7	10	7	8,004,129	9,964,712	84
	Mon	10/13/08	1754.5	8	73	28	27	26	14	7	12	7	8,043,939	10,004,522	83
	Tue	10/14/08	1763.6	9	73	27	26	26	14	7	12	7	8,088,197	10,048,780	81
	Wed	10/15/08	1773.2	10	73	27	26	25	13	6	12	7	8,132,891	10,093,474	78
29	Thu	10/16/08	1779.7	6	73	28	27	26	16	8	10	8	8,164,479	10,125,062	81
	Fri	10/17/08	1789.2	9	73	28	27	26	16	8	10	8	8,204,655	10,165,238	70
	Sat	10/18/08	1800.3	11	73	27	26	25	15	8	10	7	8,262,384	10,222,967	87
	Sun	10/19/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	8,262,384	NA	NA
	Mon	10/20/08	1810.9	11	73	28	28	24	16	8	8	8	8,312,538	10,273,121	80
	Tue	10/21/08	1819.5	9	73	28	26	24	17	8	7	9	8,356,018	10,316,601	84
	Wed	10/22/08	1828.3	9	73	27	25	25	16	7	9	9	8,398,851	10,359,434	81
30	Thu	10/23/08	1837.9	10	73	27	26	24	16	7	8	9	8,445,286	10,405,869	81
	Fri	10/24/08	1852.4	11	73	28	27	24	16	8	8	8	8,515,860	10,476,443	81
	Sat	10/25/08	1856.7	6	73	28	26	24	14	7	10	7	8,544,813	10,505,396	112
	Sun	10/26/08	1868.5	12	73	28	26	25	16	7	9	9	8,590,337	10,550,920	64

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

						System Pressure							Totalizer to Distribution		
Week No.	Day	Date	Pump Hours	Daily OP Time[(a)]	Rotameter Flowrate	System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[(b)]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
	Mon	10/27/08	1875.2	7	73	26	25	24	12	6	12	6	8,623,114	10,583,697	82
	Tue	10/28/08	1884.0	9	73	26	24	24	12	6	12	6	8,665,169	10,625,752	80
	Wed[(c)]	10/29/08	1917.6	24	73	26	25	24	11	6	13	5	8,712,745	10,673,328	24
31	Thu	10/30/08	1923.9	10	73	28	25	24	11	6	13	5	8,738,054	10,698,637	67
	Fri	10/31/08	1934.0	10	72	27	26	22	12	6	10	6	8,780,648	10,741,231	70
	Sat	11/01/08	1945.5	11	73	28	27	24	13	7	11	6	8,826,225	10,786,808	66
	Sun	11/02/08	1952.7	7	73	26	25	24	12	6	12	6	8,853,129	10,813,712	62
	Mon	11/03/08	1962.6	10	73	26	25	24	12	6	12	6	8,895,512	10,856,095	71
	Tue	11/04/08	1970.1	7	73	26	25	24	12	6	12	6	8,923,719	10,884,302	63
	Wed	11/05/08	1981.3	11	73	26	25	24	13	7	11	6	8,969,492	10,930,075	68
32	Thu	11/06/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Fri	11/07/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	11/08/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sun	11/09/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Mon	11/10/08	2026.9	8	73	27	26	24	13	6	11	7	9,148,836	11,109,419	66
	Tue	11/11/08	2037.9	11	73	27	26	24	12	7	12	5	9,193,209	11,153,792	67
	Wed	11/12/08	2044.7	7	73	26	25	20	8	4	12	4	9,220,705	11,181,288	67
33	Thu	11/13/08	2058.7	14	73	26	25	20	7	3	13	4	9,279,276	11,239,859	70
	Fri	11/14/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	11/15/08	2071.8	7	73	27	26	24	14	7	10	7	9,331,992	11,292,575	67
	Sun	11/16/08	2085.0	12	73	27	26	24	14	7	10	7	9,384,717	11,345,300	67
	Mon	11/17/08	2094.5	8	73	27	26	24	14	7	10	7	9,421,574	11,382,157	65
	Tue	11/18/08	2103.0	9	73	27	26	24	14	7	10	7	9,456,191	11,416,774	68
	Wed	11/19/08	2111.6	9	72	26	25	22	12	6	10	6	9,490,808	11,451,391	67
34	Thu	11/20/08	2121.6	10	73	28	27	24	12	6	12	6	9,530,030	11,490,613	65
	Fri	11/21/08	2129.8	8	73	27	26	24	14	7	10	7	9,562,912	11,523,495	67
	Sat	11/22/08	2138.0	13	73	25	24	20	10	5	10	5	9,595,794	11,556,377	67
	Sun	11/23/08	2147.7	10	73	27	26	24	14	7	10	7	9,634,250	11,594,833	66
	Mon	11/24/08	2157.4	7	72	27	26	22	13	6	9	7	9,672,701	11,633,284	66
	Tue	11/25/08	2164.4	7	73	28	27	24	14	7	10	7	9,700,324	11,660,907	66
	Wed	11/26/08	2176.1	12	73	28	27	24	14	7	10	7	9,746,149	11,706,732	65
35	Thu	11/27/08	2184.0	8	74	29	28	26	15	8	11	7	9,777,579	11,738,162	66
	Fri	11/28/08	2191.9	8	73	28	27	24	14	7	10	7	9,808,999	11,769,582	66
	Sat	11/29/08	2205.6	19	73	27	26	24	14	7	10	7	9,866,543	11,827,126	70
	Sun	11/30/08	2219.4	14	73	27	26	24	14	7	10	7	9,924,168	11,884,751	70
	Mon	12/01/08	2228.5	7	73	27	26	24	14	7	10	7	9,961,804	11,922,387	69
	Tue	12/02/08	2239.3	11	73	27	26	24	14	7	10	7	10,004,198	11,964,781	65
	Wed	12/03/08	2248.1	9	73	27	26	24	14	7	10	7	10,039,534	12,000,117	67
36	Thu	12/04/08	2254.1	6	73	27	26	24	14	7	10	7	10,062,560	12,023,143	64
	Fri	12/05/08	2266.7	13	73	28	27	25	14	7	11	7	10,111,892	12,072,475	65
	Sat	12/06/08	2273.2	10	73	28	27	25	12	6	13	6	10,137,311	12,097,894	65
	Sun	12/07/08	2281.4	8	73	27	26	24	14	7	10	7	10,169,079	12,129,662	65

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
37	Mon	12/08/08	2295.8	10	73	28	27	26	14	7	12	7	10,228,452	12,189,035	69
	Tue	12/09/08	2302.3	7	73	25	24	22	8	4	14	4	10,252,220	12,212,803	61
	Wed	12/10/08	2314.5	12	73	28	27	26	14	7	12	7	10,301,960	12,262,543	68
	Thu	12/11/08	2321.2	7	73	28	27	26	14	7	12	7	10,328,468	12,289,051	66
	Fri	12/12/08	2331.9	11	73	28	27	26	14	7	12	7	10,370,303	12,330,886	65
	Sat	12/13/08	2344.9	20	73	28	27	26	13	7	13	6	10,409,162	12,369,745	50
	Sun	12/14/08	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
38	Mon	12/15/08	2357.9	5	73	27	26	24	12	6	12	6	10,531,444	12,492,027	NA
	Tue	12/16/08	2365.0	7	73	28	27	26	14	7	12	7	10,558,934	12,519,517	65
	Wed	12/17/08	2382.2	17	73	23	20	20	8	4	12	4	10,631,758	12,592,341	71
	Thu	12/18/08	2394.5	12	73	23	21	20	8	4	12	4	10,683,047	12,643,630	69
	Fri	12/19/08	2411.5	17	73	24	21	20	8	4	12	4	10,755,548	12,716,131	71
	Sat	12/20/08	2427.1	23	73	23	20	18	7	4	11	3	10,822,316	12,782,899	71
	Sun	12/21/08	2444.0	17	73	23	20	18	7	4	11	3	10,848,390	12,808,973	NA
39	Mon	12/22/08	2464.8	16	75	20	18	16	4	2	12	2	10,936,770	12,897,353	71
	Tue	12/23/08	2482.7	18	73	27	26	24	12	6	12	6	11,012,630	12,973,213	71
	Wed	12/24/08	2498.7	17	73	26	24	21	10	5	11	5	11,079,540	13,040,123	70
	Thu	12/25/08	2514.4	15	73	27	26	24	12	6	12	6	11,146,006	13,106,589	71
	Fri	12/26/08	2529.1	15	73	27	26	24	12	6	12	6	11,212,033	13,172,616	75
	Sat	12/27/08	2544.0	24	73	27	26	24	12	6	12	6	11,277,869	13,238,452	74
	Sun	12/28/08	2559.5	16	75	28	27	25	14	7	11	7	11,344,337	13,304,920	71
40	Mon	12/29/08	2577.6	13	73	27	26	24	12	6	12	6	11,411,874	13,372,457	62
	Tue	12/30/08	2595.8	19	73	27	26	24	12	6	12	6	11,488,320	13,448,903	70
	Wed	12/31/08	2612.9	17	70	25	24	21	10	5	11	5	11,495,501	13,456,084	NA
	Thu	01/01/09	2629.4	16	73	26	25	23	10	5	13	5	11,567,038	13,527,621	NA
	Fri	01/02/09	2647.1	18	73	27	26	24	12	6	12	6	11,703,770	13,664,353	NA
	Sat	01/03/09	2666.2	23	73	27	26	24	12	6	12	6	11,775,999	13,736,582	63
	Sun	01/04/09	2691.9	12	75	28	27	26	14	7	12	7	11,888,229	13,848,812	73
41	Mon	01/05/09	2694.9	2	73	25	24	22	7	3	15	4	11,901,380	13,861,963	73
	Tue	01/06/09	2702.5	8	73	27	26	24	12	6	12	6	11,933,620	13,894,203	71
	Wed	01/07/09	2713.2	11	73	27	26	24	12	6	12	6	11,974,650	13,935,233	64
	Thu	01/08/09	2723.0	10	72	26	25	23	10	5	13	5	12,013,339	13,973,922	66
	Fri	01/09/09	2734.5	12	72	26	25	23	10	5	13	5	12,059,751	14,020,334	67
	Sat	01/10/09	2745.9	11	73	26	25	24	12	6	12	6	12,106,078	14,066,661	68
	Sun	01/11/09	2757.7	12	73	27	24	22	12	6	10	6	12,151,375	14,111,958	64
42	Mon	01/12/09	2770.5	13	73	27	25	23	12	6	11	6	12,203,348	14,163,931	68
	Tue	01/13/09	2777.4	7	73	27	26	23	10	5	13	5	12,229,070	14,189,653	62
	Wed	01/14/09	2787.3	10	73	28	27	25	14	7	11	7	12,268,865	14,229,448	67
	Thu	01/15/09	2797.3	10	73	27	26	23	10	5	13	5	12,308,661	14,269,244	66
	Fri	01/16/09	2809.2	12	73	28	26	24	14	7	10	7	12,354,440	14,315,023	64
	Sat	01/17/09	2820.4	17	73	28	26	22	12	6	10	6	12,399,721	14,360,304	67
	Sun	01/18/09	2831.7	11	73	24	22	20	8	4	12	4	12,445,003	14,405,586	67

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure: System Inlet	System Pressure: After Prefilter	System Pressure: After Rotameter	System Pressure: Tank A Outlet	System Pressure: System Outlet	ΔP Tank A	ΔP Tank B	Totalizer to Distribution: System Totalizer[b]	Totalizer to Distribution: Cum. Flow	Totalizer to Distribution: Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
43	Mon	01/19/09	2848.7	13	73	27	25	24	12	6	12	6	12,514,777	14,475,360	68
	Tue	01/20/09	2859.2	11	73	28	27	25	14	7	11	7	12,556,247	14,516,830	66
	Wed	01/21/09	2874.0	15	73	28	27	25	16	8	9	8	12,567,959	14,528,542	NA
	Thu	01/22/09	2888.8	15	73	26	25	20	6	3	14	3	12,579,621	14,540,204	NA
	Fri	01/23/09	2913.1	24	73	26	24	20	12	6	8	6	12,632,901	14,593,484	NA
	Sat	01/24/09	2928.1	22	73	28	27	24	14	7	10	7	12,695,110	14,655,693	69
	Sun	01/25/09	2943.1	15	73	24	22	20	8	4	12	4	12,757,320	14,717,903	69
44	Mon	01/26/09	2958.1	12	73	28	27	24	14	7	10	7	12,813,595	14,774,178	63
	Tue	01/27/09	2967.1	9	73	28	27	25	14	7	11	7	12,853,155	14,813,738	73
	Wed	01/28/09	2977.7	10	73	26	24	24	12	6	12	6	12,895,005	14,855,588	66
	Thu	01/29/09	2990.4	13	73	26	25	24	12	6	12	6	12,933,766	14,894,349	51
	Fri	01/30/09	3000.3	10	72	27	25	23	14	7	9	7	12,976,646	14,937,229	72
	Sat	01/31/09	3011.7	17	73	28	25	24	14	7	10	7	13,019,960	14,980,543	63
	Sun	02/01/09	3020.3	9	73	28	24	24	12	6	12	6	13,062,407	15,022,990	82
45	Mon	02/02/09	3030.9	8	73	28	26	25	14	7	11	7	13,104,827	15,065,410	67
	Tue	02/03/09	3041.6	11	73	28	27	25	12	6	13	6	13,147,247	15,107,830	66
	Wed	02/04/09	3052.7	11	73	28	25	24	14	7	10	7	13,190,862	15,151,445	65
	Thu	02/05/09	3063.9	11	73	28	26	24	14	7	10	7	13,234,477	15,195,060	65
	Fri	02/06/09	3073.4	10	73	28	26	24	14	7	10	7	13,271,726	15,232,309	65
	Sat	02/07/09	3082.9	13	73	28	25	24	14	7	10	7	13,308,975	15,269,558	65
	Sun	02/08/09	3099.1	16	73	28	25	24	14	7	10	7	13,375,106	15,335,689	68
46	Mon	02/09/09	3109.4	8	73	28	26	24	12	6	12	6	13,416,253	15,376,836	67
	Tue	02/10/09	3119.9	10	73	28	26	24	12	6	12	6	13,457,550	15,418,133	66
	Wed	02/11/09	3130.1	11	73	27	25	23	10	5	13	5	13,498,549	15,459,132	67
	Thu	02/12/09	3142.6	12	73	27	25	23	10	5	13	5	13,548,451	15,509,034	67
	Fri	02/13/09	3155.1	13	73	28	26	24	12	6	12	6	13,599,268	15,559,851	68
	Sat	02/14/09	3167.8	19	73	28	26	24	12	6	12	6	13,650,277	15,610,860	67
	Sun	02/15/09	3180.7	13	73	25	24	22	8	4	14	4	13,702,160	15,662,743	67
47	Mon	02/16/09	3194.4	10	73	26	24	20	16	8	4	8	13,757,809	15,718,392	68
	Tue	02/17/09	3206.3	12	73	28	25	24	12	6	12	6	13,809,711	15,770,294	73
	Wed	02/18/09	3221.9	16	73	28	25	24	12	6	12	6	13,869,094	15,829,677	63
	Thu	02/19/09	3235.3	13	72	23	20	18	8	4	10	4	13,922,713	15,883,296	67
	Fri	02/20/09	3247.3	12	72	24	22	20	10	5	10	5	13,976,000	15,936,583	74
	Sat	02/21/09	3260.2	21	73	28	25	24	12	6	12	6	14,029,785	15,990,368	69
	Sun	02/22/09	3275.8	16	73	23	20	18	8	4	10	4	14,083,570	16,044,153	57
48	Mon	02/23/09	3283.9	6	73	28	25	24	12	6	12	6	14,115,830	16,076,413	66
	Tue	02/24/09	3295.5	12	73	28	25	24	12	6	12	6	14,160,450	16,121,033	64
	Wed	02/25/09	3307.9	13	72	26	24	22	10	5	12	5	14,203,242	16,163,825	58
	Thu	02/26/09	3319.1	11	73	28	25	24	12	6	12	6	14,245,829	16,206,412	63
	Fri	02/27/09	3328.9	10	73	28	25	24	12	6	12	6	14,288,621	16,249,204	73
	Sat	02/28/09	3341.4	19	70	24	22	20	7	3	13	4	14,331,515	16,292,098	57
	Sun	03/01/09	3357.7	16	59	25	23	22	8	6	14	2	14,374,410	16,334,993	44

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
49	Mon	03/02/09	3377.9	15	55	16	14	16	4	2	12	2	14,433,970	16,394,553	49
	Tue	03/03/09	3393.5	16	55	18	14	14	4	2	10	2	14,479,490	16,440,073	49
	Wed	03/04/09	3406.6	13	53	23	21	20	12	6	8	6	14,516,670	16,477,253	47
	Thu	03/05/09	3421.4	15	53	25	23	20	12	6	8	6	14,558,540	16,519,123	47
	Fri	03/06/09	3436.2	15	55	24	22	20	12	6	8	6	14,600,760	16,561,343	48
	Sat	03/07/09	3454.8	20	55	24	22	20	12	6	8	6	14,656,785	16,617,368	50
	Sun	03/08/09	3473.4	19	55	25	23	16	4	2	12	2	14,712,810	16,673,393	50
50	Mon	03/09/09	3493.4	15	55	24	21	20	14	7	6	7	14,772,125	16,732,708	49
	Tue	03/10/09	3509.3	16	57	24	21	20	14	7	6	7	14,818,065	16,778,648	48
	Wed	03/11/09	3525.2	16	57	24	20	22	14	7	8	7	14,864,006	16,824,589	48
	Thu	03/12/09	3537.8	13	55	23	21	18	6	3	12	3	14,899,849	16,860,432	47
	Fri	03/13/09	3555.3	18	55	24	20	20	14	7	6	7	14,952,512	16,913,095	50
	Sat	03/14/09	3572.8	21	55	16	14	20	12	6	8	6	15,003,175	16,963,758	48
	Sun	03/15/09	3594.6	22	57	24	12	16	4	2	12	2	15,069,445	17,030,028	51
51	Mon	03/16/09	3614.6	15	53	24	21	20	12	6	8	6	15,127,950	17,088,533	49
	Tue	03/17/09	3631.6	17	53	24	21	18	12	6	6	6	15,174,865	17,135,448	46
	Wed	03/18/09	3647.0	16	53	28	25	16	4	2	12	2	15,221,780	17,182,363	51
	Thu	03/19/09	3658.5	12	53	24	21	15	4	2	11	2	15,255,623	17,216,206	49
	Fri	03/20/09	3676.7	18	53	18	15	12	6	3	6	3	15,306,625	17,267,208	47
	Sat	03/21/09	3693.8	24	55	20	18	15	10	5	5	5	15,357,410	17,317,993	49
	Sun	03/22/09	3714.2	20	55	17	14	13	4	2	9	2	15,417,025	17,377,608	49
52	Mon	03/23/09	3728.8	11	53	26	23	20	12	6	8	6	15,458,438	17,419,021	47
	Tue	03/24/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Wed	03/25/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Thu	03/26/09	3772.7	15	53	26	23	20	14	7	6	7	15,582,680	17,543,263	47
	Fri	03/27/09	3787.2	15	53	24	22	20	14	7	6	7	15,622,919	17,583,502	46
	Sat	03/28/09	3802.4	21	55	25	22	20	14	7	6	7	15,666,819	17,627,402	48
	Sun	03/29/09	3817.6	16	53	23	20	18	14	7	4	7	15,710,720	17,671,303	48
53	Mon	03/30/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Tue	03/31/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Wed	04/01/09	3861.2	13	53	27	25	22	14	7	8	7	15,832,430	17,793,013	47
	Thu	04/02/09	3875.6	15	53	24	21	18	14	7	4	7	15,873,000	17,833,583	47
	Fri	04/03/09	3890.1	14	55	25	23	21	14	7	7	7	15,913,570	17,874,153	47
	Sat	04/04/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sun	04/05/09	3905.2	9	53	25	22	20	12	-	8		15,956,186	17,916,769	47
54	Mon	04/06/09	3935.5	24	53	25	22	20	14	7	6	7	16,041,420	18,002,003	47
	Tue	04/07/09	3949.4	15	55	25	23	20	14	7	6	7	16,080,315	18,040,898	47
	Wed	04/08/09	3963.0	14	53	24	24	22	14	7	8	7	16,117,850	18,078,433	46
	Thu	04/09/09	3975.6	13	53	25	25	20	14	7	6	7	16,153,267	18,113,850	47
	Fri	04/10/09	3988.3	13	53	24	24	22	14	7	8	7	16,188,415	18,148,998	46
	Sat	04/11/09	4005.8	18	55	25	25	24	12	6	12	6	16,239,587	18,200,170	49
	Sun	04/12/09	4023.4	17	58	24	24	18	4	2	14	2	16,290,760	18,251,343	48

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
55	Mon	04/13/09	4041.7	14	55	22	22	20	12	6	8	6	16,344,950	18,305,533	49
	Tue	04/14/09	4056.5	15	55	24	24	21	12	6	9	6	16,387,160	18,347,743	48
	Wed	04/15/09	4067.5	11	53	25	25	24	14	7	10	7	16,417,470	18,378,053	46
	Thu	04/16/09	4078.5	11	55	20	20	18	8	4	10	4	16,447,780	18,408,363	46
	Fri	04/17/09	4093.6	15	57	26	26	24	14	7	10	7	16,484,790	18,445,373	41
	Sat	04/18/09	4100.3	10	55	26	26	24	14	7	10	7	16,508,286	18,468,869	58
	Sun	04/19/09	4114.8	14	55	26	26	16	4	2	12	2	16,547,350	18,507,933	45
56	Mon	04/20/09	4133.2	14	55	25	25	24	14	7	10	7	16,599,590	18,560,173	47
	Tue	04/21/09	4144.9	11	53	26	26	24	14	7	10	7	16,632,160	18,592,743	46
	Wed	04/22/09	4160.6	16	55	24	24	23	12	6	11	6	16,675,910	18,636,493	46
	Thu	04/23/09	4171.0	11	53	25	25	23	12	6	11	6	16,704,960	18,665,543	47
	Fri	04/24/09	4183.7	13	53	26	26	24	14	7	10	7	16,740,400	18,700,983	47
	Sat	04/25/09	4192.4	12	55	21	21	20	10	5	10	5	16,764,530	18,725,113	46
	Sun	04/26/09	4207.8	15	55	22	22	20	12	6	8	6	16,808,107	18,768,690	47
57	Mon	04/27/09	4223.2	12	53	26	26	24	14	7	10	7	16,851,685	18,812,268	47
	Tue	04/28/09	4237.5	14	53	25	25	22	14	7	8	7	16,891,715	18,852,298	47
	Wed	04/29/09	4250.5	13	55	25	25	22	12	6	10	6	16,928,135	18,888,718	47
	Thu	04/30/09	4264.3	14	55	25	25	22	12	6	10	6	16,967,047	18,927,630	47
	Fri	05/01/09	4278.1	14	53	25	25	23	14	7	9	7	17,005,960	18,966,543	47
	Sat	05/02/09	4289.7	16	55	25	25	22	12	6	10	6	17,040,084	19,000,667	49
	Sun	05/03/09	4301.4	12	53	26	26	24	14	7	10	7	17,074,209	19,034,792	49
58	Mon	05/04/09	4321.4	15	53	25	25	23	12	6	11	6	17,130,497	19,091,080	47
	Tue	05/05/09	4335.7	14	55	26	26	24	12	6	12	6	17,171,058	19,131,641	47
	Wed	05/06/09	4350.1	14	53	24	24	23	14	7	9	7	17,211,620	19,172,203	47
	Thu	05/07/09	4359.9	10	53	26	26	25	14	7	11	7	17,238,570	19,199,153	46
	Fri	05/08/09	4370.9	11	55	20	20	18	6	3	12	3	17,268,392	19,228,975	45
	Sat	05/09/09	4381.5	16	55	19	19	18	6	3	12	3	17,298,215	19,258,798	47
	Sun	05/10/09	4399.2	18	53	25	25	23	12	6	11	6	17,349,232	19,309,815	48
59	Mon	05/11/09	4417.0	13	53	25	25	24	14	7	10	7	17,400,250	19,360,833	48
	Tue	05/12/09	4428.2	11	55	26	26	24	12	6	12	6	17,431,626	19,392,209	47
	Wed	05/13/09	4437.0	8	55	22	22	20	8	4	12	4	17,456,252	19,416,835	47
	Thu	05/14/09	4454.2	17	53	25	25	24	14	7	10	7	17,505,998	19,466,581	48
	Fri	05/15/09	4471.5	17	55	25	25	24	14	7	10	7	17,555,795	19,516,378	48
	Sat	05/16/09	4480.6	14	60	28	28	26	16	8	10	8	17,582,095	19,542,678	48
	Sun	05/17/09	4489.8	10	55	25	25	24	14	7	10	7	17,608,446	19,569,029	48
60	Mon	05/18/09	4511.6	16	55	26	26	24	14	7	10	7	17,670,172	19,630,755	47
	Tue	05/19/09	4532.9	21	53	25	25	23	12	6	11	6	17,683,563	19,644,146	NA
	Wed	05/20/09	4556.4	23	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Thu	05/21/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Fri	05/22/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	05/23/09	4628.9	3.50	72	38	38	36	36	2			17,695,695	19,656,278	NA
	Sun	05/24/09	4645.0	24	75	27	27	25	25	4			17,763,070	19,723,653	70

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
	Mon	05/25/09	4670.7	19	77	22	22	18	5	2	13	3	17,877,735	19,838,318	74
	Tue	05/26/09	4696.5	22	75	26	26	24	13	7	11	6	17,994,250	19,954,833	75
	Wed	05/27/09	4706.2	10	76	26	26	24	14	7	10	7	18,031,920	19,992,503	65
61	Thu	05/28/09	4717.1	11	76	28	28	26	14	7	12	7	18,077,247	20,037,830	69
	Fri	05/29/09	4724.8	7	75	28	28	24	14	6	10	8	18,106,785	20,067,368	64
	Sat	05/30/09	4737.4	20	76	28	28	26	14	7	12	7	18,158,672	20,119,255	69
	Sun	05/31/09	4750.0	13	76	28	28	26	13	7	13	6	18,210,560	20,171,143	69
	Mon	06/01/09	4760.8	8	76	26	26	24	10	5	14	5	18,256,234	20,216,817	70
	Tue	06/02/09	4770.7	10	77	28	28	26	12	6	14	6	18,296,618	20,257,201	68
	Wed	06/03/09	4780.7	10	77	28	28	26	12	6	14	6	18,337,003	20,297,586	67
62	Thu	06/04/09	4787.1	6	76	30	30	28	13	7	15	6	18,362,903	20,323,486	67
	Fri	06/05/09	4799.6	13	76	26	26	24	10	5	14	5	18,413,484	20,374,067	67
	Sat	06/06/09	4812.1	13	77	29	29	27	13	7	14	6	18,464,065	20,424,648	67
	Sun	06/07/09	4824.7	13	77	28	28	25	12	6	13	6	18,517,660	20,478,243	71
	Mon	06/08/09	4837.3	13	77	28	28	24	12	6	12	6	18,571,255	20,531,838	71
	Tue	06/09/09	4849.0	12	77	28	28	26	12	6	14	6	18,620,247	20,580,830	70
	Wed	06/10/09	4860.8	12	75	29	29	26	14	7	12	7	18,669,240	20,629,823	69
63	Thu	06/11/09	4870.5	10	77	28	28	26	12	6	14	6	18,709,261	20,669,844	69
	Fri	06/12/09	4880.3	9	77	28	28	26	12	5	14	7	18,749,282	20,709,865	68
	Sat	06/13/09	4896.6	16	76	26	26	24	12	6	12	6	18,814,858	20,775,441	67
	Sun	06/14/09	4912.9	16	77	26	26	24	12	6	12	6	18,890,435	20,851,018	77
	Mon	06/15/09	4923.2	10	77	28	28	26	12	6	14	6	18,934,858	20,895,441	72
	Tue	06/16/09	4935.3	12	77	28	28	26	12	6	14	6	18,986,157	20,946,740	71
	Wed	06/17/09	4947.6	12	77	28	28	26	12	6	14	6	19,037,456	20,998,039	70
64	Thu	06/18/09	4961.2	14	77	29	29	25	12	6	13	6	19,095,096	21,055,679	71
	Fri	06/19/09	4971.8	11	77	26	26	24	10	5	14	5	19,140,880	21,101,463	72
	Sat	06/20/09	4986.6	15	77	28	28	26	12	6	14	6	19,203,697	21,164,280	71
	Sun	06/21/09	5001.4	15	78	25	25	20	12	6	8	6	19,266,515	21,227,098	71
	Mon	06/22/09	5016.8	15	76	28	28	26	12	6	14	6	19,333,270	21,293,853	72
	Tue	06/23/09	5025.5	9	77	28	28	26	12	6	14	6	19,370,395	21,330,978	71
	Wed	06/24/09	5044.0	19	77	28	28	26	12	6	14	6	19,450,555	21,411,138	72
65	Thu	06/25/09	5056.8	13	77	28	28	26	12	6	14	6	19,505,602	21,466,185	72
	Fri	06/26/09	5069.6	13	75	24	24	20	10	5	10	5	19,560,650	21,521,233	72
	Sat	06/27/09	5086.3	17	77	27	27	25	14	7	11	7	19,632,385	21,592,968	72
	Sun	06/28/09	5096.8	11	77	28	28	24	12	6	12	6	19,677,036	21,637,619	71
	Mon	06/29/09	5107.4	12	77	24	24	20	8	6	12	2	19,721,687	21,682,270	70
	Tue	06/30/09	5123.6	14	77	28	28	24	12	6	12	6	19,792,412	21,752,995	73
	Wed	07/01/09	5139.6	16	77	28	28	26	12	6	14	6	19,860,015	21,820,598	70
66	Thu	07/02/09	5148.8	12	77	28	28	26	12	6	14	6	19,899,616	21,860,199	72
	Fri	07/03/09	5164.7	14	77	26	26	20	10	5	10	5	19,968,295	21,928,878	72
	Sat	07/04/09	5180.7	15	77	26	26	24	12	6	12	6	20,037,242	21,997,825	72
	Sun	07/05/09	5196.7	16	77	27	27	24	12	6	12	6	20,106,033	22,066,616	72

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[(a)]	Rotameter Flowrate	System Pressure: System Inlet	System Pressure: After Prefilter	System Pressure: After Rotameter	System Pressure: Tank A Outlet	System Pressure: System Outlet	System Pressure: ΔP Tank A	System Pressure: ΔP Tank B	Totalizer to Distribution: System Totalizer[(b)]	Totalizer to Distribution: Cum. Flow	Totalizer to Distribution: Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
67	Mon	07/06/09	5212.2	18	77	28	28	26	14	7	12	7	20,173,889	22,134,472	73
	Tue	07/07/09	5227.1	13	77	29	29	28	14	7	14	7	20,236,478	22,197,061	70
	Wed	07/08/09	5239.3	12	77	29	29	28	14	7	14	7	20,288,338	22,248,921	71
	Thu	07/09/09	5251.5	12	77	27	27	24	12	6	12	6	20,339,699	22,300,282	70
	Fri	07/10/09	5268.3	17	76	29	29	26	14	7	12	7	20,412,641	22,373,224	72
	Sat	07/11/09	5283.7	15	77	28	28	24	14	7	10	7	20,478,900	22,439,483	72
	Sun	07/12/09	5299.1	15	77	29	29	26	14	7	12	7	20,545,160	22,505,743	72
68	Mon	07/13/09	5310.6	12	75	29	29	26	14	7	12	7	20,593,482	22,554,065	70
	Tue	07/14/09	5324.8	14	77	29	29	26	14	7	12	7	20,654,190	22,614,773	71
	Wed	07/15/09	5339.1	14	76	29	29	26	12	6	14	6	20,714,968	22,675,551	71
	Thu	07/16/09	5351.4	12	76	29	29	26	12	6	14	6	20,767,957	22,728,540	72
	Fri	07/17/09	5368.0	16	77	29	29	28	14	7	14	7	20,837,498	22,798,081	70
	Sat	07/18/09	5382.6	15	77	29	29	28	14	7	14	7	20,901,664	22,862,247	73
	Sun	07/19/09	5398.3	16	77	26	26	22	10	5	12	5	20,968,641	22,929,224	71
69	Mon	07/20/09	5411.0	13	77	29	29	27	14	7	13	7	21,023,137	22,983,720	72
	Tue	07/21/09	5423.8	13	77	29	29	27	14	7	13	7	21,076,754	23,037,337	70
	Wed	07/22/09	5437.7	14	77	28	28	26	12	6	14	6	21,137,626	23,098,209	73
	Thu	07/23/09	5453.1	15	77	29	29	27	14	7	13	7	21,202,379	23,162,962	70
	Fri	07/24/09	5467.8	14	77	29	29	27	14	7	13	7	21,266,339	23,226,922	73
	Sat	07/25/09	5483.1	15	77	29	29	27	14	7	13	7	21,332,009	23,292,592	72
	Sun	07/26/09	5498.4	16	77	29	29	27	14	7	13	7	21,397,680	23,358,263	72
70	Mon	07/27/09	5511.5	13	76	28	28	24	12	6	12	6	21,452,763	23,413,346	70
	Tue	07/28/09	5524.4	13	77	29	29	26	14	7	12	7	21,508,222	23,468,805	72
	Wed	07/29/09	5539.1	15	77	30	30	28	14	7	14	7	21,570,695	23,531,278	71
	Thu	07/30/09	5555.0	16	77	28	28	24	14	7	10	7	21,639,767	23,600,350	72
	Fri	07/31/09	5571.0	16	77	28	28	24	12	6	12	6	21,708,840	23,669,423	72
	Sat	08/01/09	5582.4	17	77	28	28	24	14	7	10	7	21,758,124	23,718,707	72
	Sun	08/02/09	5591.5	7	77	28	28	24	14	7	10	7	21,796,907	23,757,490	71
71	Mon	08/03/09	5613.1	22	76	28	28	24	12	6	12	6	21,884,348	23,844,931	67
	Tue	08/04/09	5626.7	17	77	28	28	26	14	7	12	7	21,948,715	23,909,298	79
	Wed	08/05/09	5644.8	16	27	26	26	22	12	6	10	6	22,026,580	23,987,163	72
	Thu	08/06/09	5658.8	16	77	26	26	22	12	6	10	6	22,087,881	24,048,464	73
	Fri	08/07/09	5674.1	14	77	29	29	27	14	7	13	7	22,152,403	24,112,986	70
	Sat	08/08/09	5692.2	17	77	32	32	28	14	7	14	7	22,231,850	24,192,433	73
	Sun	08/09/09	5710.3	17	77	32	32	28	14	7	14	7	22,310,798	24,271,381	73
72	Mon	08/10/09	5723.5	14	72	29	29	27	12	6	15	6	22,367,334	24,327,917	71
	Tue	08/11/09	5734.5	11	77	29	29	27	12	6	15	6	22,412,509	24,373,092	68
	Wed	08/12/09	5749.9	16	77	29	29	27	12	6	15	6	22,477,806	24,438,389	71
	Thu	08/13/09	5760.5	11	77	28	28	24	12	6	12	6	22,521,194	24,481,777	68
	Fri	08/14/09	5772.6	12	77	28	28	24	10	5	14	5	22,571,350	24,531,933	69
	Sat	08/15/09	5789.7	16	77	29	29	26	14	7	12	7	22,644,958	24,605,541	72
	Sun	08/16/09	5805.2	15	77	29	29	27	14	7	13	7	22,710,541	24,671,124	71

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[(a)]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[(b)]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
73	Mon	08/17/09	5814.2	10	77	28	28	24	14	7	10	7	22,747,585	24,708,168	69
	Tue	08/18/09	5824.4	10	77	30	30	27	14	7	13	7	22,788,098	24,748,681	66
	Wed	08/19/09	5838.4	14	77	29	29	27	12	6	15	6	22,847,335	24,807,918	71
	Thu	08/20/09	5848.1	12	77	28	28	24	14	7	10	7	22,887,337	24,847,920	69
	Fri	08/21/09	5860.2	11	75	30	30	27	12	6	15	6	22,936,380	24,896,963	68
	Sat	08/22/09	5873.5	12	77	30	30	27	12	6	15	6	22,992,731	24,953,314	71
	Sun	08/23/09	5888.5	14	77	30	30	27	14	7	13	7	23,055,285	25,015,868	70
74	Mon	08/24/09	5895.0	8	77	28	28	26	14	7	12	7	23,081,903	25,042,486	68
	Tue	08/25/09	5910.0	14	77	28	28	26	14	7	12	7	23,143,215	25,103,798	68
	Wed	08/26/09	5916.7	7	77	27	27	25	14	8	11	6	23,169,817	25,130,400	66
	Thu	08/27/09	5929.0	12	77	28	28	26	8	4	18	4	23,218,831	25,179,414	66
	Fri	08/28/09	5938.3	10	77	29	29	27	10	5	17	5	23,257,172	25,217,755	69
	Sat	08/29/09	5945.4	7	75	29	29	27	10	5	17	5	23,283,871	25,244,454	63
	Sun	08/30/09	5956.3	11	77	30	30	27	12	6	15	6	23,329,064	25,289,647	69
75	Mon	08/31/09	5967.3	11	77	30	30	28	12	6	16	6	23,374,257	25,334,840	68
	Tue	09/01/09	5975.7	8	77	30	30	28	12	6	16	6	23,406,740	25,367,323	64
	Wed	09/02/09	5988.0	12	77	32	32	28	14	7	14	7	23,457,977	25,418,560	69
	Thu	09/03/09	5996.3	8	77	29	29	26	12	6	14	6	23,491,909	25,452,492	68
	Fri	09/04/09	6007.0	11	77	32	32	29	12	6	17	6	23,533,925	25,494,508	65
	Sat	09/05/09	6020.4	13	77	30	30	27	12	6	15	6	23,590,274	25,550,857	70
	Sun	09/06/09	6034.6	14	77	29	29	27	14	7	13	7	23,651,021	25,611,604	71
76	Mon	09/07/09	6048.9	14	77	28	28	24	14	7	10	7	23,711,768	25,672,351	71
	Tue	09/08/09	6056.7	8	77	26	26	24	12	6	12	6	23,742,399	25,702,982	65
	Wed	09/09/09	6068.2	12	75	32	32	29	14	7	15	7	23,790,460	25,751,043	70
	Thu	09/10/09	6076.4	8	77	30	30	28	14	7	14	7	23,824,315	25,784,898	69
	Fri	09/11/09	6087.7	11	77	32	32	29	14	7	15	7	23,868,936	25,829,519	66
	Sat	09/12/09	6099.5	12	77	30	30	28	14	7	14	7	23,917,360	25,877,943	68
	Sun	09/13/09	6111.4	12	77	30	30	28	14	7	14	7	23,965,785	25,926,368	68
77	Mon	09/14/09	6117.5	6	77	32	32	28	14	7	14	7	23,990,394	25,950,977	67
	Tue	09/15/09	6129.0	12	77	32	32	28	12	6	16	6	24,035,729	25,996,312	66
	Wed	09/16/09	6138.1	8	77	32	32	28	12	6	16	6	24,072,447	26,033,030	67
	Thu	09/17/09	6144.1	6	77	30	30	27	14	7	13	7	24,095,894	26,056,477	65
	Fri	09/18/09	6150.6	7	77	32	32	28	14	7	14	7	24,121,202	26,081,785	65
	Sat	09/19/09	6157.7	7	77	30	30	26	14	7	12	7	24,149,306	26,109,889	66
	Sun	09/20/09	6163.5	6	77	32	32	28	14	7	14	7	24,171,250	26,131,833	63
78	Mon	09/21/09	6172.4	9	77	34	34	28	14	7	14	7	24,203,925	26,164,508	61
	Tue	09/22/09	6175.1	3	77	32	32	26	14	7	12	7	24,217,381	26,177,964	83
	Wed	09/23/09	6180.4	5	77	30	30	26	12	6	14	6	24,237,794	26,198,377	64
	Thu	09/24/09	6185.7	5	77	30	30	28	14	7	14	7	24,258,049	26,218,632	64
	Fri	09/25/09	6191.2	6	77	30	30	27	14	7	13	7	24,278,913	26,239,496	63
	Sat	09/26/09	6196.8	6	77	34	34	28	14	7	14	7	24,300,518	26,261,101	64
	Sun	09/27/09	6207.6	11	77	35	35	30	10	5	20	5	24,337,874	26,298,457	58

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
79	Mon	09/28/09	6212.1	5	75	35	35	29	12	6	17	6	24,355,284	26,315,867	64
	Tue	09/29/09	6215.5	3	77	35	35	28	14	7	14	7	24,369,370	26,329,953	69
	Wed	09/30/09	6220.9	5	77	31	31	26	12	6	14	6	24,390,490	26,351,073	65
	Thu	10/01/09	6226.4	6	77	35	35	29	10	5	19	5	24,411,578	26,372,161	64
	Fri	10/02/09	6232.0	6	77	35	35	28	10	5	18	5	24,435,245	26,395,828	70
	Sat	10/03/09	6240.4	8	77	35	35	29	12	6	17	6	24,464,813	26,425,396	59
	Sun	10/04/09	6248.0	8	77	34	34	28	12	6	16	6	24,494,819	26,455,402	66
80	Mon	10/05/09	6254.1	6	77	28	28	24	14	7	10	7	24,514,726	26,475,309	54
	Tue	10/06/09	6259.3	5	77	35	35	29	14	7	15	7	24,534,224	26,494,807	62
	Wed	10/07/09	6262.8	3	77	35	35	34	14	7	20	7	24,547,188	26,507,771	62
	Thu	10/08/09	6267.4	5	75	30	30	26	12	6	14	6	24,567,001	26,527,584	72
	Fri	10/09/09	6273.6	6	75	30	30	26	12	6	14	6	24,591,368	26,551,951	66
	Sat	10/10/09	6279.7	6	77	35	35	30	14	7	16	7	24,615,389	26,575,972	66
	Sun	10/11/09	6286.1	7	77	35	35	30	14	7	16	7	24,640,160	26,600,743	65
81	Mon	10/12/09	6292.4	6	77	35	35	30	14	7	16	7	24,664,886	26,625,469	65
	Tue	10/13/09	6298.7	6	75	30	30	26	12	6	14	6	24,690,053	26,650,636	67
	Wed	10/14/09	6304.8	6	75	30	30	26	12	6	14	6	24,713,968	26,674,551	65
	Thu	10/15/09	6311.2	6	75	28	28	24	10	5	14	5	24,738,785	26,699,368	65
	Fri	10/16/09	6318.5	7	77	32	32	28	12	6	16	6	24,768,045	26,728,628	67
	Sat	10/17/09	6323.5	5	75	35	35	31	14	7	17	7	24,787,478	26,748,061	65
	Sun	10/18/09	6330.2	7	77	35	35	31	14	7	17	7	24,813,995	26,774,578	66
82	Mon	10/19/09	6333.9	4	77	35	35	31	14	7	17	7	24,827,785	26,788,368	62
	Tue	10/20/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Wed	10/21/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Thu	10/22/09	6361.0	9	50	30	30	26	14	7	12	7	24,900,930	26,861,513	45
	Fri	10/23/09	6364.6	4	77	35	35	31	14	7	17	7	24,915,910	26,876,493	69
	Sat	10/24/09	6371.1	6	77	35	35	31	14	7	17	7	24,942,123	26,902,706	67
	Sun	10/25/09	6377.7	7	77	35	35	31	14	7	17	7	24,968,288	26,928,871	66
83	Mon	10/26/09	6384.3	6	77	35	35	30	14	7	16	7	24,994,153	26,954,736	65
	Tue	10/27/09	6390.7	6	77	35	35	30	14	7	16	7	25,019,685	26,980,268	66
	Wed	10/28/09	6397.0	6	75	30	30	26	12	6	14	6	25,044,525	27,005,108	66
	Thu	10/29/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Fri	10/30/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	10/31/09	6414.6	6	77	35	34	30	14	7	16	7	25,113,131	27,073,714	65
	Sun	11/01/09	6420.9	6	77	35	34	30	14	7	16	7	25,138,105	27,098,688	66
84	Mon	11/02/09	6427.3	6	77	35	35	30	12	6	18	6	25,163,080	27,123,663	65
	Tue	11/03/09	6430.5	3	77	35	35	30	14	7	16	7	25,175,567	27,136,150	65
	Wed	11/04/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Thu	11/05/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Fri	11/06/09	6449.3	6	77	35	35	30	12	6	18	6	25,248,594	27,209,177	65
	Sat	11/07/09	6456.1	6	77	35	35	30	12	6	18	6	25,275,552	27,236,135	66
	Sun	11/08/09	6462.9	7	77	35	35	30	12	6	18	6	25,302,510	27,263,093	66

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure: System Inlet	System Pressure: After Prefilter	System Pressure: After Rotameter	System Pressure: Tank A Outlet	System Pressure: System Outlet	System Pressure: ΔP Tank A	System Pressure: ΔP Tank B	Totalizer to Distribution: System Totalizer[b]	Totalizer to Distribution: Cum. Flow	Totalizer to Distribution: Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
85	Mon	11/09/09	6468.6	6	75	30	30	27	12	6	15	6	25,325,945	27,286,528	69
	Tue	11/10/09	6474.3	6	75	30	29	25	12	6	13	6	25,349,381	27,309,964	69
	Wed	11/11/09	6480.9	6	77	35	35	30	14	7	16	7	25,375,618	27,336,201	66
	Thu	11/12/09	6487.6	7	77	35	35	30	14	7	16	7	25,401,856	27,362,439	65
	Fri	11/13/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	11/14/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sun	11/15/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
86	Mon	11/16/09	6522.3	9	75	37	36	31	14	7	17	7	25,541,743	27,502,326	67
	Tue	11/17/09	6526.9	5	77	35	33	30	12	6	18	6	25,559,165	27,519,748	63
	Wed	11/18/09	6537.3	10	77	35	35	30	12	6	18	6	25,602,095	27,562,678	69
	Thu	11/19/09	6545.5	8	77	35	35	30	12	6	18	6	25,635,701	27,596,284	68
	Fri	11/20/09	6552.5	8	77	37	37	34	14	7	20	7	25,663,700	27,624,283	67
	Sat	11/21/09	6561.7	8	77	37	37	34	14	7	20	7	25,701,161	27,661,744	68
	Sun	11/22/09	6571.4	10	77	37	37	34	14	7	20	7	25,741,065	27,701,648	69
87	Mon	11/23/09	6579.2	8	77	35	33	30	14	7	16	7	25,772,902	27,733,485	68
	Tue	11/24/09	6587.1	8	77	34	32	30	14	7	16	7	25,804,550	27,765,133	67
	Wed	11/25/09	6594.2	7	77	34	32	30	14	7	16	7	25,833,082	27,793,665	67
	Thu	11/26/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Fri	11/27/09	6614.3	10	77	34	32	30	12	6	18	6	25,914,620	27,875,203	68
	Sat	11/28/09	6628.1	14	77	35	33	30	14	7	16	7	25,972,402	27,932,985	70
	Sun	11/29/09	6639.0	11	77	35	33	30	14	7	16	7	26,018,201	27,978,784	70
Study Period II															
88	Mon	11/30/09	6649.2	10	77	35	33	30	14	7	16	7	26,061,777	28,022,360	71
	Tue	12/01/09	6653.5	4	77	27	25	20	6	6	14		26,073,037	28,033,620	44
	Wed	12/02/09	6663.1	10	77	27	25	20	6	6	14		26,120,565	47,528	83
	Thu	12/03/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Fri	12/04/09	6678.3	8	77	30	30	26	12	6	14	6	26,180,704	107,667	66
	Sat	12/05/09	6685.6	7	77	30	29	25	12	6	13	6	26,210,905	137,868	69
	Sun	12/06/09	6692.9	7	77	34	33	29	12	6	17	6	26,241,107	168,070	69
89	Mon	12/07/09	6696.7	4	77	35	33	28	14	7	14	7	26,252,750	179,713	51
	Tue	12/08/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Wed	12/09/09	6710.4	7	77	35	33	28	14	7	14	7	26,311,560	238,523	72
	Thu	12/10/09	6720.0	9	77	35	33	28	14	7	14	7	26,352,157	279,120	70
	Fri	12/11/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	12/12/09	6737.3	9	77	33	32	25	12	6	13	6	26,423,375	350,338	69
	Sun	12/13/09	6750.2	12	77	35	33	28	14	7	14	7	26,479,040	406,003	72

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[(a)]	Rotameter Flowrate	System Pressure: System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	Totalizer to Distribution: System Totalizer[(b)]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
90	Mon	12/14/09	6760.1	10	75	30	28	25	12	6	13	6	26,521,828	448,791	72
	Tue	12/15/09	6770.6	11	77	35	35	33	14	7	19	7	26,564,915	491,878	68
	Wed	12/16/09	6782.8	12	77	35	33	28	14	7	14	7	26,617,539	544,502	72
	Thu	12/17/09	6789.5	6	77	37	35	30	14	7	16	7	26,645,516	572,479	70
	Fri	12/18/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	12/19/09	6813.1	12	77	35	33	28	14	7	14	7	26,744,606	671,569	70
	Sun	12/20/09	6825.9	13	77	35	33	28	14	7	14	7	26,795,573	722,536	66
91	Mon	12/21/09	6836.6	11	77	35	33	28	14	7	14	7	26,845,003	771,966	77
	Tue	12/22/09	6847.4	12	77	35	32	28	12	6	16	6	26,891,433	818,396	72
	Wed	12/23/09	6860.1	13	77	35	32	28	14	7	14	7	26,945,143	872,106	70
	Thu	12/24/09	6876.5	16	75	30	27	25	10	5	15	5	27,015,744	942,707	72
	Fri	12/25/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	12/26/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sun	12/27/09	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
92	Mon	12/28/09	6945.3	17	77	35	33	28	14	7	14	7	27,298,154	1,225,117	68
	Tue	12/29/09	6963.5	19	75	35	33	28	14	7	14	7	27,366,651	1,293,614	63
	Wed	12/30/09	6972.4	9	77	37	35	26	8	4	18	4	27,439,356	1,366,319	136
	Thu	12/31/09	6992.3	22	77	35	33	28	14	7	14	7	27,528,109	1,455,072	74
	Fri	01/01/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	01/02/10	7032.0	19	75	30	27	25	10	5	15	5	27,705,616	1,632,579	75
	Sun	01/03/10	7052.3	20	77	35	33	28	14	7	14	7	27,794,370	1,721,333	73
93	Mon	01/04/10	7065.7	14	77	35	33	28	12	6	16	6	27,852,875	1,779,838	73
	Tue	01/05/10	7078.1	12	77	35	33	28	14	7	14	7	27,907,565	1,834,528	74
	Wed	01/06/10	7091.3	13	75	35	33	28	12	6	16	6	27,962,255	1,889,218	69
	Thu	01/07/10	7104.3	14	77	35	33	28	14	7	14	7	28,016,886	1,943,849	70
	Fri	01/08/10	7115.0	11	77	32	28	25	14	7	11	7	28,071,635	1,998,598	85
	Sat	01/09/10	7129.6	14	77	35	33	28	14	7	14	7	28,120,865	2,047,828	56
	Sun	01/10/10	7141.3	13	75	30	27	24	12	6	12	6	28,170,095	2,097,058	70
94	Mon	01/11/10	7153.8	12	77	35	33	27	14	7	13	7	28,223,684	2,150,647	71
	Tue	01/12/10	7161.8	8	77	35	3	27	14	7	13	7	28,253,035	2,179,998	61
	Wed	01/13/10	7176.1	14	77	35	33	27	14	7	13	7	28,316,974	2,243,937	75
	Thu	01/14/10	7190.4	15	77	35	33	27	14	7	13	7	28,378,913	2,305,876	72
	Fri	01/15/10	7200.9	10	77	35	33	27	14	7	13	7	28,423,349	2,350,312	71
	Sat	01/16/10	7218.7	18	77	33	31	27	12	6	15	6	28,501,583	2,428,546	73
	Sun	01/17/10	7240.1	21	77	32	30	25	5	2	20	3	28,595,671	2,522,634	73
95	Mon	01/18/10	7258.4	19	77	25	23	16	10	5	6	5	28,676,921	2,603,884	74
	Tue	01/19/10	7281.1	22	77	25	23	16	10	5	6	5	28,779,336	2,706,299	75
	Wed	01/20/10	7281.1		77	35	33	28	12	6	16	6	28,780,780	2,707,743	NA
	Thu	01/21/10	7289.8	9	77	35	33	28	12	6	16	6	28,815,476	2,742,439	66
	Fri	01/22/10	7302.6	13	77	35	33	27	14	7	13	7	28,869,330	2,796,293	70
	Sat	01/23/10	7315.5	12	77	32	30	25	14	7	11	7	28,923,164	2,850,127	70
	Sun	01/24/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[(a)]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[(b)]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
96	Mon	01/25/10	7336.1	11	77	32	28	25	12	6	13	6	29,008,785	2,935,748	69
	Tue	01/26/10	7345.8	10	77	35	32	27	14	7	13	7	29,051,594	2,978,557	74
	Wed	01/27/10	7356.0	10	77	35	32	27	14	7	13	7	29,094,404	3,021,367	70
	Thu	01/28/10	7368.2	12	77	35	32	27	14	7	13	7	29,143,619	3,070,582	67
	Fri	01/29/10	7380.5	12	77	35	32	27	14	7	13	7	29,195,971	3,122,934	71
	Sat	01/30/10	7391.2	11	77	35	32	27	14	7	13	7	29,240,779	3,167,742	70
	Sun	01/31/10	7399.0	7	77	35	32	27	14	7	13	7	29,273,382	3,200,345	70
97	Mon	02/01/10	7408.4	10	77	32	27	25	10	5	15	5	29,310,994	3,237,957	67
	Tue	02/02/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Wed	02/03/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Thu	02/04/10	7436.7	9	72	28	25	20	12	6	8	6	29,410,651	3,337,614	59
	Fri	02/05/10	7443.3	7	75	35	32	28	14	7	14	7	29,435,537	3,362,500	63
	Sat	02/06/10	7451.0	8	75	35	32	28	14	7	14	7	29,469,015	3,395,978	72
	Sun	02/07/10	7463.1	13	77	32	28	26	14	7	12	7	29,520,493	3,447,456	71
98	Mon	02/08/10	7468.6	6	75	32	30	27	12	6	15	6	29,544,925	3,471,888	74
	Tue	02/09/10	7476.4	7	77	35	32	25	14	7	11	7	29,577,453	3,504,416	70
	Wed	02/10/10	7484.3	11	77	35	32	27	14	7	13	7	29,609,982	3,536,945	69
	Thu	02/11/10	7492.1	8	77	35	32	27	14	7	13	7	29,641,805	3,568,768	68
	Fri	02/12/10	7505.2	10	77	32	30	27	12	6	15	6	29,694,701	3,621,664	67
	Sat	02/13/10	7518.1	12	77	35	32	28	14	7	14	7	29,750,603	3,677,566	72
	Sun	02/14/10	7531.1	16	77	35	31	27	14	7	13	7	29,806,506	3,733,469	72
99	Mon	02/15/10	7547.3	14	77	28	24	20	14	7	6	7	29,877,589	3,804,552	73
	Tue	02/16/10	7554.2	7	77	35	32	28	14	7	14	7	29,905,654	3,832,617	68
	Wed	02/17/10	7561.8	7	77	35	32	28	14	7	14	7	29,939,719	3,866,682	75
	Thu	02/18/10	7571.2	9	77	35	32	28	14	7	14	7	29,977,700	3,904,663	67
	Fri	02/19/10	7580.6	10	77	35	33	29	14	7	15	7	30,015,681	3,942,644	67
	Sat	02/20/10	7590.1	10	77	35	33	25	14	7	11	7	30,055,432	3,982,395	70
	Sun	02/21/10	7602.5	12	77	30	26	24	12	6	12	6	30,108,129	4,035,092	71
100	Mon	02/22/10	7609.5	6	77	35	32	28	14	7	14	7	30,139,622	4,066,585	75
	Tue	02/23/10	7617.2	9	77	35	32	29	14	7	15	7	30,171,115	4,098,078	68
	Wed	02/24/10	7625.4	8	77	35	32	28	14	7	14	7	30,204,768	4,131,731	68
	Thu	02/25/10	7633.3	15	77	35	32	28	14	7	14	7	30,237,165	4,164,128	68
	Fri	02/26/10	7644.5	7	77	35	32	28	14	7	14	7	30,281,702	4,208,665	66
	Sat	02/27/10	7655.4	12	77	32	28	25	12	6	13	6	30,327,527	4,254,490	70
	Sun	02/28/10	7674.1	15	77	35	32	28	14	7	14	7	30,405,219	4,332,182	69
101	Mon	03/01/10	7680.5	6	75	30	26	22	14	7	8	7	30,434,281	4,361,244	76
	Tue	03/02/10	7689.3	10	77	35	32	28	14	7	14	7	30,470,937	4,397,900	69
	Wed	03/03/10	7694.4	6	77	35	32	28	14	7	14	7	30,493,508	4,420,471	74
	Thu	03/04/10	7718.5	24	77	25	22	20	10	5	10	5	30,598,195	4,525,158	72
	Fri	03/05/10	7741.2	23	77	25	22	20	10	5	10	5	30,700,515	4,627,478	75
	Sat	03/06/10	7763.0	20	77	38	32	28	125	6	NA	NA	30,795,672	4,722,635	73
	Sun	03/07/10	7787.1	NA	77	25	22	20	10	5	10	5	30,907,311	4,834,274	77

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure							Totalizer to Distribution		
						System Inlet	After Prefilter	After Rotameter	Tank A Outlet	System Outlet	ΔP Tank A	ΔP Tank B	System Totalizer[b]	Cum. Flow	Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
102	Mon	03/08/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Tue	03/09/10	7828.3	18	77	35	32	27	14	7	13	7	30,907,358	4,834,321	NA
	Wed	03/10/10	7836.3	8	77	35	32	28	14	7	14	7	30,939,900	4,866,863	68
	Thu	03/11/10	7844.6	8	77	35	32	27	14	7	13	7	30,973,415	4,900,378	67
	Fri	03/12/10	7853.6	10	77	35	32	27	14	7	13	7	31,010,040	4,937,003	68
	Sat	03/13/10	7864.7	11	77	35	32	27	14	7	13	7	31,056,443	4,983,406	70
	Sun	03/14/10	7879.0	14	77	35	32	27	14	7	13	7	31,116,840	5,043,803	70
103	Mon	03/15/10	7889.9	10	77	34	30	28	12	6	16	6	31,162,502	5,089,465	70
	Tue	03/16/10	7899.4	9	77	35	33	27	14	7	13	7	31,201,781	5,128,744	69
	Wed	03/17/10	7908.7	9	77	35	33	27	14	7	13	7	31,240,046	5,167,009	69
	Thu	03/18/10	7917.8	9	77	35	33	27	14	7	13	7	31,277,628	5,204,591	69
	Fri	03/19/10	7927.0	10	77	35	33	28	14	7	14	7	31,315,210	5,242,173	68
	Sat	03/20/10	7936.8	10	77	35	32	25	14	7	11	7	31,355,749	5,282,712	69
	Sun	03/21/10	7945.1	9	77	35	32	25	14	7	11	7	31,401,399	5,328,362	92
104	Mon	03/22/10	7957.9	15	77	35	32	28	14	7	14	7	31,441,351	5,368,314	52
	Tue	03/23/10	7964.3	6	77	35	32	28	14	7	14	7	31,464,151	5,391,114	59
	Wed	03/24/10	7974.1	10	77	35	32	28	14	7	14	7	31,509,255	5,436,218	77
	Thu	03/25/10	7982.4	7	77	35	32	28	14	7	14	7	31,543,032	5,469,995	68
	Fri	03/26/10	7990.7	8	77	35	32	28	14	7	14	7	31,576,682	5,503,645	68
	Sat	03/27/10	7998.6	7	77	35	30	26	14	7	12	7	31,608,515	5,535,478	67
	Sun	03/28/10	8006.7	9	77	35	30	26	14	7	12	7	31,641,471	5,568,434	68
105	Mon	03/29/10	8015.3	8	77	35	30	26	14	7	12	7	31,676,071	5,603,034	67
	Tue	03/30/10	8024.3	9	77	35	30	26	14	7	12	7	31,712,336	5,639,299	67
	Wed	03/31/10	8029.5	5	77	35	30	26	14	7	12	7	31,732,573	5,659,536	65
	Thu	04/01/10	8033.9	5	77	35	30	26	14	7	12	7	31,751,567	5,678,530	72
	Fri	04/02/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	04/03/10	8052.2	18	77	35	30	26	14	7	12	7	31,824,027	5,750,990	66
	Sun	04/04/10	8060.2	8	77	32	27	24	12	6	12	6	31,855,562	5,782,525	66
106	Mon	04/05/10	8068.3	8	77	35	30	27	14	7	13	7	31,891,268	5,818,231	73
	Tue	04/06/10	8076.7	9	77	35	30	27	14	7	13	7	31,925,138	5,852,101	67
	Wed	04/07/10	-	NA	77	35	30	27	14	7	13	7	-	-	NA
	Thu	04/08/10	8091.7	15	77	35	30	27	14	7	13	7	31,985,342	5,912,305	67
	Fri	04/09/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Sat	04/10/10	8100.5	9	77	35	30	27	14	7	13	7	32,020,786	5,947,749	67
	Sun	04/11/10	8109.4	9	77	35	30	27	14	7	13	7	32,056,781	5,983,744	67
107	Mon	04/12/10	8118.2	9	77	35	30	26	14	7	12	7	32,092,461	6,019,424	68
	Tue	04/13/10	8125.6	7	77	35	30	25	14	7	11	7	32,121,843	6,048,806	66
	Wed	04/14/10	System offline to repair leak in												
	Thu	04/15/10													
	Fri	04/16/10	8136.5	10	70	35	30	25	12	6	13	6	32,163,381	6,090,344	64
	Sat	04/17/10	8138.6	2	70	30	25	17	10	5	7	5	32,171,824	6,098,787	67
	Sun	04/18/10	8159.8	24	70	35	30	25	14	7	11	7	32,262,272	6,189,235	71

Table A-1. EPA Demonstration Project at Lead, SD – Daily Operational Log Sheet (Continued)

Week No.	Day	Date	Pump Hours	Daily OP Time[a]	Rotameter Flowrate	System Pressure: System Inlet	System Pressure: After Prefilter	System Pressure: After Rotameter	System Pressure: Tank A Outlet	System Pressure: System Outlet	System Pressure: ΔP Tank A	System Pressure: ΔP Tank B	Totalizer to Distribution: System Totalizer[b]	Totalizer to Distribution: Cum. Flow	Totalizer to Distribution: Avg Flowrate
			hr	hr/day	gpm	psig	psig	psig	psig	psig	psi	psi	gal	gal	gpm
108	Mon	04/19/10													
	Tue	04/20/10						System offline to repair leak in							
	Wed	04/21/10	8168.2	8	77	35	30	26	14	7	12	7	32,294,099	6,221,062	70
	Thu	04/22/10	8175.4	7	77	35	30	26	14	7	12	7	32,328,270	6,255,233	79
	Fri	04/23/10	8181.2	7	77	35	30	26	14	7	12	7	32,345,297	6,272,260	49
	Sat	04/24/10	8189.1	8	77	35	30	26	14	7	12	7	32,374,163	6,301,126	61
	Sun	04/25/10	8196.1	7	77	35	30	24	14	7	10	7	32,401,655	6,328,618	65
109	Mon	04/26/10	8203.1	6	77	34	30	27	14	7	13	7	32,429,878	6,356,841	67
	Tue	04/27/10	8209.6	7	77	35	30	27	14	7	13	7	32,457,362	6,384,325	70
	Wed	04/28/10	8216.4	7	77	35	30	28	14	7	14	7	32,484,579	6,411,542	67
	Thu	04/29/10	8223.6	7	77	35	30	27	14	7	13	7	32,513,965	6,440,928	68
	Fri	04/30/10	8231.5	8	77	35	30	26	14	7	12	7	32,545,276	6,472,239	66
	Sat	05/01/10	8240.6	10	77	35	30	26	14	7	12	7	32,590,840	6,517,803	83
	Sun	05/02/10	8249.9	9	77	35	30	27	14	7	13	7	32,619,084	6,546,047	51
110	Mon	05/03/10	8259.1	11	77	35	30	26	14	7	12	7	32,656,821	6,583,784	68
	Tue	05/04/10	8266.9	7	77	35	30	27	14	7	13	7	32,688,591	6,615,554	68
	Wed	05/05/10	8274.2	8	77	35	30	28	14	7	14	7	32,717,844	6,644,807	67
	Thu	05/06/10	8281.0	7	77	35	30	27	14	7	13	7	32,745,263	6,672,226	67
	Fri	05/07/10	8288.0	6	77	35	30	27	14	7	13	7	32,773,412	6,700,375	67
	Sat	05/08/10	8295.3	7	77	35	30	26	14	7	12	7	32,803,053	6,730,016	68
	Sun	05/09/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
111	Mon	05/10/10	NM	NA	NM	NM	NM	NM	NM	NM	NA	NA	NM	NA	NA
	Tue	05/11/10	8324.2	10	77	35	30	27	14	7	13	7	32,918,413	6,845,376	67
	Wed	05/12/10	8329.9	6	77	35	30	28	14	7	14	7	32,939,651	6,866,614	62
	Thu	05/13/10	8335.6	5	77	30	24	20	10	5	10	5	32,960,889	6,887,852	62
	Fri	05/14/10	8343.7	8	77	35	30	27	14	7	13	7	32,992,274	6,919,237	65
	Sat	05/15/10	8351.8	8	77	35	30	27	14	7	13	7	33,023,660	6,950,623	65
	Sun	05/16/10	8362.6	13	77	35	30	27	14	7	13	7	33,066,790	6,993,753	67
112	Mon	05/17/10	8369.0	5	77	35	30	28	14	7	14	7	33,091,978	7,018,941	66
	Tue	05/18/10	8378.0	9	77	35	30	28	14	7	14	7	33,124,421	7,051,384	60
	Wed	05/19/10	8385.5	12	77	35	30	27	14	7	13	7	33,154,586	7,081,549	67
	Thu	05/20/10	8400.0	10	77	35	30	27	14	7	13	7	33,204,571	7,131,534	57
	Fri	05/21/10	8410.2	10	77	35	30	28	14	7	14	7	33,249,812	7,176,775	74
	Sat	05/22/10	8414.6	6	77	35	30	28	14	7	14	7	33,265,038	7,192,001	58
	Sun	05/23/10	8426.1	12	77	35	30	28	14	7	14	7	33,304,981	7,231,944	58

NM = not measure, NA = Not available

Tank A and B have 28 ft3 of media each.

(a)Hour meter readings were not recorded prior to 05/26/08, daily opearation time was estimated based on the average value in the following month.

(b) The totalizer was located on the outlet piping of the skid mounted treatment system

(c) K-factor of the flow meter was reset, when tried to recaliabrate the flow meter to close the gap between the throughput and the actual water usage rate.

APPENDIX B

ANALYTICAL DATA

Table B-1. Analytical Results from Long Term Sampling, Lead, SD

Sampling Date		04/17/08			04/28/08			05/12/08			05/27/08			07/22/08			08/11/08		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	3.4		-	5.3		-	6.3		-	9.1		-	24.8		-	31.2	
Alkalinity (as $CaCO_3$)	mg/L	150 -	148 -	146 -	145 -	143 -	141 -	144 -	151 -	149 -	143 -	143 -	147 -	149 -	144 -	147 -	148 -	146 -	151 -
Fluoride	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.8	0.8	0.8	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	10.4	10.5	10.6	-	-	-
Nitrate (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0.5	0.5	-	-	-
Total P (as P)	µg/L	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	13.6 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -
Silica (as SiO_2)	mg/L	14.9 -	14.7 -	14.7 -	14.5 -	14.6 -	14.7 -	15.9 -	15.8 -	15.7 -	17.1 -	17.4 -	17.3 -	16.2 -	16.4 -	16.3 -	16.7 -	16.5 -	19.5 -
Turbidity	NTU	1.0 -	2.9 -	0.9 -	0.8 -	1.1 -	0.9 -	1.3 -	1.2 -	0.7 -	0.2 -	0.2 -	0.1 -	0.1 -	<0.1 -	<0.1 -	0.3 -	<0.1 -	<0.1 -
pH	S.U.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.1	7.1	7.1	7.2	7.2	7.4
Temperature	°C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12.7	12.3	12.7	16.8	16.9	16.9
DO	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.6	3.9	4.0	3.7	3.9	3.8
ORP	mV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	472	489	493	458	445	446
Free Chlorine (as Cl_2)	mg/L	-	NA	NA	-	NA	NA	-	NA	NA	-	NA	NA	-	-	0.9	-	-	0.9
Total Chlorine (as Cl_2)	mg/L	-	NA	NA	-	NA	NA	-	NA	NA	-	NA	NA	-	-	0.8	-	-	0.9
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	133	128	141	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	95.4	93.8	103	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	37.8	34.2	38.5	-	-	-
As (total)	µg/L	24.5 -	0.6 -	<0.1 -	24.0 -	0.8 -	0.8 -	23.5 -	<0.1 -	<0.1 -	25.7 -	0.2 -	0.1 -	23.8 -	0.1 -	0.1 -	21.6 -	0.2 -	0.1 -
As (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	23.1	0.0	0.1	-	-	-
As (particulate)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.7	<0.1	<0.1	-	-	-
As (III)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.4	0.3	0.4	-	-	-
As (V)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	22.7	<0.1	<0.1	-	-	-
Fe (total)	µg/L	<25 -	99 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -
Fe (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	<25	<25	<25	-	-	-
Mn (total)	µg/L	0.9 -	3.3 -	2.4 -	0.5 -	1.2 -	2.2 -	0.7 -	2.0 -	2.7 -	0.6 -	1.4 -	2.2 -	1.0 -	0.9 -	1.6 -	0.5 -	0.4 -	1.9 -
Mn (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	0.2	0.8	1.5	-	-	-

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		08/21/08			09/04/08			9/25/2008			10/01/08			10/15/08			10/30/08		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	33.6		-	37.7		-	43.8		-	45.1		-	48.2		-	51.1	
Alkalinity (as $CaCO_3$)	mg/L	145 -	145 -	143 -	146 -	144 -	146 -	143 -	146 -	146 -	143 -	141 -	141 -	139 -	143 -	143 -	143 -	146 -	146 -
Fluoride	mg/L	0.8	0.8	0.7	-	-	-	-	-	-	-	-	-	0.7	0.7	0.8	-	-	-
Sulfate	mg/L	10.7	11.1	10.7	-	-	-	-	-	-	-	-	-	10.8	10.9	10.8	-	-	-
Nitrate (as N)	mg/L	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	0.5	0.5	0.5	-	-	-
Total P (as P)	µg/L	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	10.6 -	<10 -	<10 -
Silica (as SiO_2)	mg/L	16.9 -	17.1 -	17.3 -	17.1 -	17.1 -	16.7 -	16.6 -	16.7 -	16.3 -	16.0 -	16.1 -	15.9 -	14.5 -	15.3 -	14.7 -	16.6 -	16.9 -	16.9 -
Turbidity	NTU	0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	<0.1 -	0.3 -	<0.1 -	<0.1 -	0.2 -	<0.1 -	<0.1 -
pH	S.U.	7.1	7.4	7.3	7.2	7.4	7.4	7.1	7.2	7.4	7.2	7.2	7.4	6.8	7.2	7.2	6.9	7.2	7.3
Temperature	°C	16.0	16.3	16.4	16.9	16.7	16.5	16.7	16.8	16.7	16.1	16.2	16.2	13.3	13.4	13.1	14.4	13.3	13.9
DO	mg/L	3.7	3.9	3.8	3.7	3.9	3.8	3.6	3.9	3.8	5.0	5.0	5.0	6.0	5.9	5.8	6.0	5.9	5.8
ORP	mV	459	452	445	457	457	449	471	445	445	470	441	445	461	368	357	461	371	361
Free Chlorine (as Cl_2)	mg/L	-	-	0.8	-	-	0.9	-	-	0.9	-	-	1.0	-	-	1.0	-	-	1.0
Total Chlorine (as Cl_2)	mg/L	-	-	0.8	-	-	0.8	-	-	0.8	-	-	0.9	-	-	0.9	-	-	1.0
Total Hardness (as $CaCO_3$)	mg/L	161	165	163	-	-	-	-	-	-	-	-	-	153	151	150	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	125	129	128	-	-	-	-	-	-	-	-	-	115	116	113	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	35.4	36.6	35.6	-	-	-	-	-	-	-	-	-	37.4	34.8	36.4	-	-	-
As (total)	µg/L	21.9 -	0.2 -	<0.1 -	23.5 -	0.3 -	0.1 -	22.6 -	0.4 -	<0.1 -	23.5 -	0.6 -	0.3 -	22.7 -	0.7 -	<0.1 -	22.5 -	0.9 -	<0.1 -
As (soluble)	µg/L	21.5	0.1	<0.1	-	-	-	-	-	-	-	-	-	21.3	0.7	<0.1	-	-	-
As (particulate)	µg/L	0.4	<0.1	<0.1	-	-	-	-	-	-	-	-	-	1.5	<0.1	<0.1	-	-	-
As (III)	µg/L	0.3	0.2	0.2	-	-	-	-	-	-	-	-	-	0.2	0.2	0.2	-	-	-
As (V)	µg/L	21.3	<0.1	<0.1	-	-	-	-	-	-	-	-	-	21.0	0.5	<0.1	-	-	-
Fe (total)	µg/L	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -
Fe (soluble)	µg/L	<25	<25	<25	-	-	-	-	-	-	-	-	-	<25	<25	<25	-	-	-
Mn (total)	µg/L	0.4 -	0.6 -	0.9 -	0.3 -	0.5 -	1.0 -	0.7 -	0.5 -	0.7 -	0.3 -	0.5 -	0.7 -	0.3 -	0.5 -	1.1 -	1.0 -	0.5 -	0.8 -
Mn (soluble)	µg/L	0.4	0.6	0.9	-	-	-	-	-	-	-	-	-	0.2	0.5	1.3	-	-	-

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		11/18/08			12/03/08			12/17/08			01/08/09			01/21/09			02/04/09		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	54.5		-	57.3		-	60.1		-	66.7		-	69.4		-	72.3	
Alkalinity (as $CaCO_3$)	mg/L	136	143	143	150	152	152	147	147	145	142	144	144	138	146	146	143	148	150
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	148	148	150
Fluoride	mg/L	-	-	-	-	-	-	0.8	0.8	0.8	-	-	-	0.8	0.8	0.8	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	10.2	10.5	10.4	-	-	-	10.6	10.6	10.7	-	-	-
Nitrate (as N)	mg/L	-	-	-	-	-	-	0.5	0.5	0.5	-	-	-	0.5	0.5	0.5	-	-	-
Total P (as P)	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	18.0	23.3	<10	<10	<10	<10	<10	<10	<10
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<10	<10	<10
Silica (as SiO_2)	mg/L	16.5	16.4	16.6	16.5	16.1	16.5	15.0	14.9	15.0	15.0	14.7	15.7	15.7	15.3	15.9	16.5	17.1	17.0
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16.7	16.7	16.8
Turbidity	NTU	0.3	<0.1	<0.1	1.6	0.1	0.2	2.1	2.5	2.8	0.1	0.1	<0.1	0.2	0.1	<0.1	2.2	<0.1	0.5
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	0.4	0.8
pH	S.U.	7.1	7.2	7.4	7.1	7.2	7.3	7.2	7.3	7.3	7.2	7.3	7.3	7.3	7.3	7.2	7.3	7.3	7.3
Temperature	°C	16.7	16.8	16.4	16.6	16.4	16.3	10.3	10.3	10.4	12.3	11.4	11.9	14.7	14.5	14.7	13.6	13.5	13.7
DO	mg/L	3.6	3.9	3.8	3.6	3.8	3.8	3.9	5.1	4.1	3.9	4.8	4.0	5.1	5.4	8.0	5.2	5.3	6.9
ORP	mV	471	445	445	472	446	446	353	355	372	368	355	360	443	448	446	449	452	450
Free Chlorine (as Cl_2)	mg/L	-		1.0	-	-	0.9	-		0.9	-	-	1.0	-	-	1.0	-	-	0.9
Total Chlorine (as Cl_2)	mg/L	-		0.9	-	-	0.9	-		0.9	-	-	0.9	-	-	0.9	-	-	0.9
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	161	162	165	-	-	-	154	159	163	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	124	125	128	-	-	-	113	119	120	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	36.5	37.1	37.5	-	-	-	40.8	40.9	42.7	-	-	-
As (total)	µg/L	23.9	2.2	0.1	23.9	3.3	<0.1	22.8	4.5	0.1	23.3	9.5	0.2	21.3	9.4	<0.1	24.5	11.3	<0.1
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.4	11.5	<0.1
As (soluble)	µg/L	-	-	-	-	-	-	21.4	4.4	0.1	-	-	-	21.5	9.7	<0.1	-	-	-
As (particulate)	µg/L	-	-	-	-	-	-	1.4	0.1	<0.1	-	-	-	<0.1	<0.1	<0.1	-	-	-
As (III)	µg/L	-	-	-	-	-	-	0.6	0.4	0.2	-	-	-	0.4	0.3	0.2	-	-	-
As (V)	µg/L	-	-	-	-	-	-	20.8	4.0	<0.1	-	-	-	21.1	9.5	<0.1	-	-	-
Fe (total)	µg/L	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<25	<25	<25
Fe (soluble)	µg/L	-	-	-	-	-	-	<25	<25	<25	-	-	-	<25	<25	<25	-	-	-
Mn (total)	µg/L	0.7	0.2	0.9	0.4	<0.1	0.5	3.4	1.9	2.7	0.4	0.1	0.3	0.3	0.3	0.5	0.4	0.4	1.4
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	0.4	1.5
Mn (soluble)	µg/L	-	-	-	-	-	-	0.9	0.7	1.0	-	-	-	0.2	0.2	0.4	-	-	-

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		02/19/09			03/05/09			03/19/09			04/07/09			04/15/09			04/30/09		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	75.8		-	78.9		-	82.2		-	86.1		-	87.7		-	90.4	
Alkalinity (as $CaCO_3$)	mg/L	156 -	153 -	156 -	150 -	148 -	154 -	147 -	151 -	149 -	158 -	155 -	160 -	157 -	141 -	141 -	140 -	142 -	142 -
Fluoride	mg/L	-	-	-	0.8	0.8	0.8	-	-	-	-	-	-	-	-	-	0.7	0.8	0.8
Sulfate	mg/L	-	-	-	10.8	11	11.3	-	-	-	-	-	-	-	-	-	9.2	10.1	10.3
Nitrate (as N)	mg/L	-	-	-	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	0.4	0.5	0.6
Total P (as P)	µg/L	<10 -	<10 -	<10 -	<10 -	11.9 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	10.8 -	12.2 -	<10 -
Silica (as SiO_2)	mg/L	15.0 -	15.3 -	15.4 -	16.7 -	16.7 -	16.4 -	16.0 -	16.1 -	16.2 -	14.6 -	14.7 -	14.7 -	17.6 -	17.9 -	17.4 -	18.4 -	17.8 -	19.6 -
Turbidity	NTU	1.2 -	2.4 -	2.8 -	0.2 -	0.1 -	0.3 -	1.0 -	0.5 -	0.8 -	0.8 -	0.5 -	0.3 -	0.6 -	0.6 -	0.6 -	1.6 -	1.8 -	0.8 -
pH	S.U.	7.3	7.8	7.3	7.3	7.3	7.4	7.4	7.3	7.4	7.3	7.3	7.2	7.3	7.4	7.3	7.4	7.4	7.3
Temperature	°C	13.4	13.9	13.3	12.9	12.8	12.8	12.4	11.9	11.9	11.3	11.0	10.9	12.6	12.4	12.0	11.5	11.3	11.4
DO	mg/L	5.2	5.3	5.8	5.7	7.8	6.8	7.8	7.7	7.8	8.7	7.1	7.9	8.4	8.0	7.9	8.6	8.6	8.4
ORP	mV	441	440	444	304	309	326	418	411	411	419	405	408	418	412	403	418	412	410
Free Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.0	-	-	0.9	-	-	1.0	-	-	0.9	-	-	1.0
Total Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	117	116	118	-	-	-	-	-	-	-	-	-	154	159	162
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	97.6	96.8	98.0	-	-	-	-	-	-	-	-	-	117	121	123
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	18.9	19.1	19.5	-	-	-	-	-	-	-	-	-	36.2	37.5	38.2
As (total)	µg/L	21.1 -	11.4 -	0.3 -	19.2 -	11.3 -	<0.1 -	21.5 -	15.4 -	<0.1 -	16.9 -	11.4 -	<0.1 -	21.7 -	15.5 -	<0.1 -	19.9 -	13.0 -	<0.1 -
As (soluble)	µg/L	-	-	-	18.6	11.6	0.1	-	-	-	-	-	-	-	-	-	19.0	12.7	<0.1
As (particulate)	µg/L	-	-	-	0.7	<0.1	<0.1	-	-	-	-	-	-	-	-	-	1.0	0.3	<0.1
As (III)	µg/L	-	-	-	1.1	0.4	1.0	-	-	-	-	-	-	-	-	-	<0.1	<0.1	<0.1
As (V)	µg/L	-	-	-	17.5	11.3	<0.1	-	-	-	-	-	-	-	-	-	18.9	12.6	<0.1
Fe (total)	µg/L	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -
Fe (soluble)	µg/L	-	-	-	<25	<25	<25	-	-	-	-	-	-	-	-	-	<25	<25	<25
Mn (total)	µg/L	0.3 -	0.3 -	0.7 -	0.6 -	0.2 -	0.4 -	0.4 -	0.1 -	0.2 -	0.5 -	<0.1 -	0.2 -	0.4 -	0.1 -	0.3 -	0.8 -	0.3 -	0.6 -
Mn (soluble)	µg/L	-	-	-	0.3	0.2	0.4	-	-	-	-	-	-	-	-	-	0.3	0.2	0.3

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		05/13/09			05/28/09			06/11/09			06/23/09			07/07/09			07/21/09		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	92.7		-	95.7		-	98.7		-	102		-	106		-	110	
Alkalinity (as $CaCO_3$)	mg/L	149 -	147 -	147 -	148 -	148 -	148 -	152 152	152 152	152 150	148 -	146 -	144 -	153 -	148 -	155 -	156 -	144 -	170 -
Fluoride	mg/L	-	-	-	-	-	-	-	-	-	0.8	0.8	0.8	-	-	-	0.4	0.8	0.8
Sulfate	mg/L	-	-	-	-	-	-	-	-	-	10.6	10.7	10.7	-	-	-	5.38	10.6	10.5
Nitrate (as N)	mg/L	-	-	-	-	-	-	-	-	-	0.5	0.5	0.5	-	-	-	0.21	0.45	0.46
Total P (as P)	µg/L	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 <10	<10 <10	<10 <10	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -	<10 -
Silica (as SiO_2)	mg/L	17.5 -	17.9 -	18.1 -	16.8 -	17.2 -	17.6 -	17.1 16.8	17.0 16.9	16.7 16.8	16.7 -	16.6 -	16.6 -	17.1 -	17.1 -	17.1 -	18.3 -	17.3 -	19.3 -
Turbidity	NTU	0.2 -	0.1 -	0.3 -	1.0 -	0.6 -	2.1 -	1.4 1.4	1.4 0.6	1.0 1.3	1.6 -	0.6 -	0.6 -	0.3 -	0.5 -	0.2 -	2.6 -	1.2 -	1.6 -
pH	S.U.	7.4	7.4	7.3	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.4	7.3	7.3	7.2
Temperature	°C	11.9	12.1	11.8	12.1	12.4	12.3	11.9	11.7	11.5	11.7	11.7	11.6	12.7	12.8	13.0	12.9	12.9	13.1
DO	mg/L	8.7	8.8	8.7	8.8	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.6	-(a)	-(a)	-(a)	-(a)	-(a)	-(a)
ORP	mV	420	419	418	419	419	418	420	420	420	421	420	420	441	461	476	443	475	484
Free Chlorine (as Cl_2)	mg/L	-	-	0.9	-	-	0.9	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0
Total Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	164	164	164	-	-	-	179	171	173
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	135	135	134	-	-	-	134	130	130
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	29	29	30	-	-	-	45	41	43
As (total)	µg/L	20.8 -	15.0 -	0.6 -	20.2 -	16.4 -	1.4 -	22.0 21.4	17.9 17.6	1.1 1.0	19.3 -	16.1 -	1.2 -	21.7 -	18.3 -	1.6 -	23.8 -	18.6 -	2.2 -
As (soluble)	µg/L	-	-	-	-	-	-	-	-	-	19.2	15.8	1.1	-	-	-	22.0	18.6	2.2
As (particulate)	µg/L	-	-	-	-	-	-	-	-	-	<0.1	0.4	0.1	-	-	-	1.8	<0.1	<0.1
As (III)	µg/L	-	-	-	-	-	-	-	-	-	0.3	0.1	0.3	-	-	-	0.2	0.2	0.2
As (V)	µg/L	-	-	-	-	-	-	-	-	-	19.0	15.7	0.8	-	-	-	21.8	18.4	2.0
Fe (total)	µg/L	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 <25	<25 <25	<25 <25	<25 -	<25 -	36.8 -	<25 -	<25 -	<25 -	<25 -	<25 -	<25 -
Fe (soluble)	µg/L	-	-	-	-	-	-	-	-	-	<25	<25	37.5	-	-	-	<25	<25	<25
Mn (total)	µg/L	0.6 -	0.3 -	1.2 -	0.4 -	1.7 -	3.5 -	0.5 0.5	0.2 0.2	0.4 0.4	0.7 -	0.6 -	1.8 -	<0.1 -	<0.1 -	0.2 -	0.3 -	0.5 -	0.5 -
Mn (soluble)	µg/L	-	-	-	-	-	-	-	-	-	0.4	0.7	1.6	-	-	-	0.2	0.2	0.3

(a) Data were not available due to a mistake in measurement

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		08/04/09			08/18/09			09/02/09			09/17/09			09/29/09			10/13/09		
Sampling Location / Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	114		-	118		-	121		-	124		-	126		-	127	
Alkalinity (as $CaCO_3$)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fluoride	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total P (as P)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Silica (as SiO_2)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Turbidity	NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
pH	S.U.	7.3	7.3	7.3	7.2	7.2	7.2	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Temperature	°C	12.8	12.7	12.6	13.0	12.9	12.7	11.8	11.7	11.7	11.9	12.1	12.0	11.7	11.9	11.9	11.9	11.7	11.8
DO	mg/L	8.5	8.5	8.4	8.1	8.1	8.7	8.7	8.7	8.8	8.5	9.0	8.5	8.5	8.5	8.5	8.5	8.4	8.4
ORP	mV	395	387	375	363	337	295	374	378	386	391	392	411	381	380	378	371	379	378
Free Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.1
Total Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.1	-	-	1.1
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (total)	µg/L	26.3 -	21.9 -	0.9 -	20.5 21.2	17.0 16.9	5.6 5.7	18.9 -	14.7 -	2.9 -	23.0 -	18.0 -	5.9 -	22.0 -	18.6 -	5.8 -	20.8 -	14.7 -	4.6 -
As (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (particulate)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (III)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (V)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe (total)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fe (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn (total)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Mn (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		10/27/09			11/10/09			11/17/09			12/3/09[a]			12/15/09			01/04/10		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	128		-	130		-	131		-	0.4		-	2.3		-	8.5	
Alkalinity (as $CaCO_3$)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fluoride	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total P (as P)	μg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Silica (as SiO_2)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Turbidity	NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
pH	S.U.	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	6.9	7.2	7.3	NA	NA	NA	7.0	7.2	7.2
Temperature	°C	12.1	12.2	12.1	10.9	10.7	10.6	10.7	10.5	10.1	10.3	10.1	9.9	NA	NA	NA	11.5	10.9	11.1
DO	mg/L	8.4	6.3	8.3	8.4	8.4	8.3	8.4	8.4	8.3	8.4	8.4	8.4	NA	NA	NA	8.4	8.3	8.3
ORP	mV	382	385	385	422	400	354	418	402	380	418	352	316	NA	NA	NA	432	427	425
Free Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	0.9	-	-	0.9	-	-	1.0	-	-	NA	-	-	1.0
Total Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.0	-	-	1.0	-	-	1.0	-	-	NA	-	-	1.0
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (total)	μg/L	21.9 -	15.5 -	5.8 -	22.4 -	15.2 -	6.1 -	22.4 -	15.9 -	5.8 -	19.7 -	2.5 -	5.7 -	20.3 -	1.2 -	5.8 -	22.6 -	0.6 -	8.3 -
As (soluble)	μg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (particulate)	μg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (III)	μg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (V)	μg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe (total)	μg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fe (soluble)	μg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn (total)	μg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Mn (soluble)	μg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(a) Vessel A was placed in the lag position after rebedding on 12/02/09.

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		01/12/10			01/27/10			02/10/10			02/24/10			03/10/10			03/23/10		
Sampling Location / Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	10.4		-	14.4		-	16.9		-	19.7		-	23.2		-	25.7	
Alkalinity (as $CaCO_3$)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fluoride	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total P (as P)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Silica (as SiO_2)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Turbidity	NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
pH	S.U.	7.0	7.1	7.3	7.1	7.3	7.2	NA	NA	NA	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Temperature	°C	11.1	11.0	10.5	10.9	10.7	10.6	NA	NA	NA	11.7	11.8	11.8	11.5	11.7	11.6	11.8	11.9	12.1
DO	mg/L	8.2	8.3	8.3	8.2	8.2	8.3	NA	NA	NA	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
ORP	mV	439	423.1	431.7	438	429.3	430.7	NA	NA	NA	437	435.1	435.1	440	431.6	434	432	433	434
Free Chlorine (as Cl_2)	mg/L	-	-	1.1	-	-	1.0	-	-	NA	-	-	0.9	-	-	1.0	-	-	1.1
Total Chlorine (as Cl_2)	mg/L	-	-	1.1	-	-	1.0	-	-	NA	-	-	1.0	-	-	1.0	-	-	1.1
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (total)	µg/L	21.1 -	0.5 -	7.8 -	21.6 -	0.5 -	8.9 -	20.5 -	0.4 -	8.9 -	20.9 -	0.4 -	9.3 -	20.0 -	0.4 -	10.7 -	22.2 -	0.3 -	10.6 -
As (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (particulate)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (III)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As (V)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe (total)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fe (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn (total)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Mn (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B-1. Analytical Results from Long Term Sampling, Lead, SD (Continued)

Sampling Date		04/06/10			04/20/10			05/04/10			05/18/10		
Sampling Location Parameter	Unit	IN	TA	TB	IN	TA	TB	IN	TA	TB	IN	TA	TB
Bed Volume	10^3	-	27.9		-	29.6		-	31.6		-	33.7	
Alkalinity (as $CaCO_3$)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fluoride	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Sulfate	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Total P (as P)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Silica (as SiO_2)	mg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Turbidity	NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
pH	S.U.	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Temperature	°C	11.7	11.8	11.8	11.6	11.5	11.7	11.3	11.3	11.1	11.4	11.5	11.7
DO	mg/L	8.3	8.2	8.2	8.3	8.2	8.3	8.3	8.3	8.3	8.4	8.3	8.3
ORP	mV	428	435	435	431	429	428	429	621	420	429	426	426
Free Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.2	-	-	1.1	-	-	1.0
Total Chlorine (as Cl_2)	mg/L	-	-	1.0	-	-	1.2	-	-	1.1	-	-	1.0
Total Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Ca Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Mg Hardness (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
As (total)	µg/L	20.7 -	0.4 -	5.9 -	19.4 -	0.6 -	9.6 -	22.4 -	0.3 -	12.1 -	21.2 -	0.5 -	11.7 -
As (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
As (particulate)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
As (III)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
As (V)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
Fe (total)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fe (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
Mn (total)	µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Mn (soluble)	µg/L	-	-	-	-	-	-	-	-	-	-	-	-