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THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**ION EXCHANGE USED IN DRINKING WATER TREATMENT SYSTEMS**
APPLICATION:	**REMOVAL OF ARSENIC**
TECHNOLOGY NAME:	**BASIN WATER HIGH EFFICIENCY ION EXCHANGE TREATMENT SYSTEM**
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The U.S. Environmental Protection Agency (EPA) supports the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

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

NSF International (NSF) in cooperation with the EPA operates the Drinking Water Systems (DWS) Center, one of six technology areas under the ETV Program. The DWS Center recently evaluated the performance of an ion exchange (IX) system used in drinking water treatment applications. This verification statement provides a summary of the test results for the Basin Water High Efficiency Ion Exchange Treatment System (Basin Water System). MWH, an NSF-qualified field testing organization (FTO), performed the verification testing. The verification report contains a comprehensive description of the test.

ABSTRACT

Verification testing of the Basin Water System was conducted over a 54-day period between April 4, 2005, and May 28, 2005. The test was conducted at the Elsinore Valley Municipal Water District (EVMWD) Corydon Street Well in Lake Elsinore, California. The source water was a raw groundwater supply with chlorine added at 0.10-0.50 milligrams per liter (mg/L) as an oxidant to convert arsenite (As [III]) to arsenate (As [V]). Based on the manufacturer's recommendation, the system was operated during the Verification Test at 850 bed volumes before regeneration. The average total arsenic and vanadium (both naturally occurring) in the raw water were 15 micrograms per liter (µg/L) and 107 µg/L, respectively, during the Verification Test. The Basin Water System reduced the arsenic levels to below the detection limit (1.0 µg/L) in all 24-hour composite samples and all grab samples, with the exception of one grab sample with a level of 1.1 µg/L. The Basin Water System reduced the vanadium levels to below the detection limit (3.0 µg/L) in all 24-hour composite samples and all grab samples, with the exception of one grab sample with a vanadium level of 4.9 µg/L in the effluent water.

TECHNOLOGY DESCRIPTION

The following technology description was provided by the manufacturer and has not been verified.

The equipment tested in the ETV test was the Basin Water System. The system was a self contained, multi-bed, mobile unit. The Basin Water System utilized multiple IX vessels in a parallel mode of operation. The system contained two prefilters (5 micron, 30 inches in length) in parallel and six IX vessels. There were four vessels in service, at different stages of exhaustion, and two vessels out of service at any one time while the IX unit was in operation. The two vessels out of service were in the regeneration cycle with one vessel ready to return to service when the next vessel online was ready to go into regeneration cycle. The resin used in the vessels was a strong base anion (SBA) resin. Each vessel is 16 inches in diameter and contained 5 cubic feet (ft^3) of resin.

At all times the system was in operation, the Basin Water System utilized one of two treatment systems for the waste brine generated from the regeneration process: brine precipitation unit (BPU) and brine readsorption unit (BRA). The BPU utilized ferric chloride to coagulate the arsenic and vanadium and precipitate it out from the waste brine, while the BRA utilized an iron based adsorptive media to remove the arsenic and vanadium from the waste brine.

VERIFICATION TEST DESCRIPTION

Test Site

The test site selected for the verification testing of the Basin Water System was EVMWD's Corydon Street Well, located in Lake Elsinore, California. Drilled in 1983, the EVMWD's well off Corydon Street is one of many wells that supply potable water to consumers in a rural area of southern California.

The Corydon Street Well normally operates at 1.2-1.5 mg/L free chlorine, which could be potentially damaging to the IX resin. Therefore, a raw water line upstream of the well's chlorinate point was selected for the verification testing. Because As (III) is present in the water, low levels of chlorine (0.10-0.50 mg/L of total chlorine) were dosed between the raw water sampling location and the prefilters to the IX vessels to convert As (III) to As (V). This setup allowed the water entering the IX treatment system (influent water) to maintain low levels of the desired total chlorine residual. The feed water used during the verification testing had an average total chlorine residual of 0.30 mg/L.

Over the 54 days on-site at the Corydon Street Well, the system was in operation for 48 days: 29 days for Initial Plant Characterization, five days in operation during data review, and 14 days for the Verification

Test. There were three plant shutdowns (April 7, May 12, and May 14, 2005) accounting for the balance of the testing period. Each shutdown was associated with construction in the area and was not a direct result of the Basin Water System.

Methods and Procedures

Water quality was monitored from three water streams: raw water, chlorinated and filtered raw water (influent), and treated water (effluent). Measurements of free and total chlorine, pH, temperature, and conductivity were collected on-site through grab samples, using equipment set up inside the mobile Basin Water System at the EVMWD Corydon Street Well. MWH Laboratories in Monrovia, California, were also sent samples to analyze for the following: arsenic (total [24-hour composite and grab samples] and dissolved and As [III] grab samples); vanadium (24-hour composite and grab samples); and calcium, chloride, hardness, alkalinity, total dissolved solids (TDS), total suspended solids (TSS), manganese, iron, magnesium, dissolved silica, fluoride, sulfate, and nitrate (24-hour composite samples). Grab samples were also collected for N-nitrosodimethylamine (NDMA), as requested by the utility. Previous research suggests that in some IX resins, NDMA could form when a water plant uses chloramines. All laboratory samples were delivered the same day as collection in coolers filled with ice. They were analyzed using either *Standard Methods for the Examination of Water and Wastewater, 20th edition* or EPA-approved methods. Complete descriptions of the verification test, results, and quality assurance/quality control (QA/QC) procedures are included in the verification report.

VERIFICATION OF PERFORMANCE

System Operation

The Basin Water System used multiple IX vessels operating in parallel to remove arsenic and vanadium from the water. The IX resin beds were staggered such that all beds online were operated at different, but evenly spaced points on their respective breakthrough curves. When a vessel reached the selected absorption limit set point (the point at which the bed would no longer provide beneficial target ion removal), the bed was removed from service for regeneration. The IX resin was regenerated using a sodium chloride (brine) solution. Following regeneration, the IX resin was then rinsed using effluent water from the treatment process prior to returning to service, to maintain the desired number of beds in service. As part of the waste minimization features of the Basin Water System, cleaner portions of the rinse water were recovered to the salt tank to make up the next batch of brine for the next regeneration cycle. The entire regeneration, rinsing, and exhaustion process was automatically performed by the programmable logic controller (PLC). Regeneration of the IX vessels was performed while the Basin Water System was online and did not interrupt the production of treated water. Individual IX vessels were regenerated and rinsed while the remaining vessels were online producing treated water.

The computer automation of the exhaustion, regeneration, rinse, and waste treatment using both BPU and BRA cycles required minimal human attention, and therefore made the system easy to operate. Automated alarms (system pressure, raw water flow rate, brine flow rate, brine tank level, etc.) further enhanced the system to alert the operator of any problems or changes in operating conditions outside the system's set points, as determined by the manufacturer. However, not all alarms worked flawlessly. Occasionally alarms (such as low and high-level tank alerts) would go off, and the appropriate actions would not automatically occur. In addition, inline sensors (pH and conductivity) could not be removed for calibration without the treatment system being taken off-line.

When changes in onsite conditions triggered a system shutdown, the IX and waste treatment systems would automatically go through shutdown procedures and wait in standby mode until the system pressure and raw water flow rates resumed to the preset points. This automatic system start-up had the option for manual override, but due to the remote nature of the test site, the system was operated in automatic mode.

All alarm and operating conditions were logged by the PLC for the operator to review upon returning to the test site.

Water Quality Results

The raw water at the test site had average total arsenic and vanadium levels of 15 µg/L and 107 µg/L, respectively. From the statistical analysis of the daily, 24-hour composite data presented in the following table, the Basin Water System consistently removed the raw water arsenic and vanadium to non-detectable levels of <1.0 µg/L and <3.0 µg/L, respectively.

Table VS-1: 24-Hour Composite Raw, Influent, and Effluent Water Verification Test Total Arsenic and Vanadium (May 12 through May 28, 2005)

	Arsenic (µg/L)			Vanadium (µg/L)		
	Raw Water	Influent Water	Effluent Water	Raw Water	Influent Water	Effluent Water
Average	15	15	<1.0	107	105	<3.0
Minimum	14	14	<1.0	99	97	<3.0
Maximum	16	16	<1.0	110	110	<3.0
Number of Samples	13	14	14	13	14	14
Standard Deviation	0.49	0.62	NC	4.9	5.6	NC
95% Confidence Interval	(15-15)	(15-15)	NC	(106-108)	(104-106)	NC

NC = Not Calculated.

In addition to removing arsenic and vanadium from the raw water, the BasinWater System had an impact on other water quality parameters, as expected for an IX system. On average as compared to the raw water, the Basin Water System removed 18% alkalinity and 47% nitrate, and removed sulfate to below the detection limit. The average chloride level increased 67%. All other parameters had little to no change between the raw water and effluent water quality. TSS, iron, and magnesium each had non-detectable levels in the raw water, influent water, and effluent water throughout the verification testing.

Consumables and Waste Generation

The analyses of the solid waste generated from both the BPU and the BRA brine treatment systems are presented in the verification report. During the Initial Plant Characterization No. 1 when the bed volumes were set at 1,100, the percentage of waste brine was 0.06-0.08% of the treated water flow. When the bed volumes were reduced to 850 for the Verification Test, the percentage of waste brine was 0.08-0.09% of the treated water flow.

The waste generated from the BPU was found to be classified as nonhazardous based on the results of the California waste analysis methods of Total Threshold Limit Concentration (TTLC), Soluble Threshold Limit Concentration (STLC), and the federal waste analysis method of Toxicity Characteristic Leachate Procedure (TCLP). The total mass of arsenic in the waste was 233 milligrams per kilogram (mg/kg) of waste generated, with a TTLC limit of 500 mg/kg for hazardous waste. The results of the TCLP were <1.0 mg/L, with a limit of 5.0 mg/L. The total arsenic leachate from the STLC analysis was 2.8 mg/L, with a limit of 5.0 mg/L. Therefore, based on both the state and federal waste analyses, the waste generated from the BPU would be classified as nonhazardous (based on arsenic residuals).

The waste generated from the BRA was also found to be nonhazardous, with a TTLC of <3 mg/kg, a TCLP of <0.1 mg/L, and a STLC of 2.8 mg/L for total arsenic. Additional BPU and BRA metals analyses are provided in the verification report.

Quality Assurance/Quality Control

NSF provided technical and quality assurance oversight of the verification testing as described in the verification report, including an audit of nearly 100% of the data. NSF personnel also conducted a technical systems audit during testing to ensure the testing was in compliance with the test plan. A complete description of the QA/QC procedures is provided in the verification report.

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Availability of Supporting Documents

Copies of the *ETV Protocol for Equipment Verification Testing for Arsenic Removal* dated September 2003, the *ETV Protocol for Equipment Verification Testing for Removal of Inorganic Constituents* dated April 2002, the verification statement, and the verification report (NSF Report # 05/21/EPADWCTR) are available from the following sources:
(NOTE: Appendices are not included in the verification report. Appendices are available from NSF upon request.)

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