Arizona Decision & Costing Tool
Review for Applicability to New England Water Systems

Overview

Based on the Arizona Department of Environmental Quality (ADEQ) Arsenic Master Plan, almost 400 water systems will be impacted by the arsenic standard of 10 ppb. The majority of these systems serve fewer than 500 persons. To assist systems in terms of planning, technology evaluation, cost impacts, and operation and maintenance impacts, the ADEQ contracted Narasimhan Consulting to develop a web-based decision and cost analysis tool. Small water systems can enter data about their system into the on-line tool and the model generates applicable treatment alternatives and associated costs. To view the model, go to http://www.azdeq.gov/environ/water/dw/arsenic.html.

The technology and water quality parameters used in the model are outlined in the following sections. Only design strategies that minimized chemical treatment and did not generate hazardous materials (i.e. media is used on a throw-away basis) were evaluated. The model is applicable for wells with a capacity ranging from 0-1500 gpm. The model also assumes that arsenic is in the +5 or fully oxidized valence state (arsenate); if arsenite (+3) is present, it will be oxidized using chlorine or another simple pretreatment setup. (Note: Based on an initial review by NEIWPCC, the cost to install oxidation equipment is not generated by the model; NEIWPCC will verify). The maximum arsenic influent concentration is 50 ppb (Note: NEIWPCC will verify whether or not the model can evaluate systems with higher levels).

Technologies

Three main categories of arsenic treatment technologies were considered for the impacted small systems in Arizona (see table below). Sub-options were also developed for each category, based on water quality, potential for partial stream treatment and level of redundancy required (sub-options are listed at end of summary).

Technology	*Key Implementation Factors*
Coagulation with Filtration – pressurized granular media filtration process with pretreatment. Arsenic +5 removed effectively as iron particles attach to arsenic for subsequent removal by granular media or microfilter. Backwash water is 5-8% of plant flow and must be recovered on-site. Ferric chloride dose is 5 mg/L.	On-site backwash treatment is also required. Solid non-hazardous residual generated. Ferric chloride storage and feed systems required. Hazardous waste issues not anticipated. Complete demineralization does not occur. Adjustment of pH may be required if >8.
Granular Iron Media – A fixed-bed adsorption process that utilizes granulated ferric hydroxide (GFH) or Sorb-33 to remove As+5. The adsorptive capacity of GFH is several times greater than Fe-AA, as confirmed in recent tests conducted in	Interference from phosphate and silica is significant. pH impacts performance >8 but not as significantly as Fe-AA. Media used on a throw-away basis. Hazardous wastes not generated.

Arizona. System design is similar to Fe-AA.	
Iron Modified AA Media – adsorptive process where arsenic +5 is removed with AA or iron particles coated with iron oxides. Lab tests have shown effective removal rates and the potential for long run lengths. pH adjustment to 6.5 is required.	Additional pilot test data required to verify performance under local conditions. Some media specifications may be proprietary. Silica interference is significant. Media used on a throw-away basis. Hazardous wastes not generated.

Costs for point of use device options were also developed, for very small systems serving fewer than 90 connections. Technologies such as nanofiltration/reverse osmosis, electrodialysis reversal, activated alumina (AA) with on-site regeneration, and ion exchange (IX) (with and without brine recycle) were not considered due to brine disposal issues and hazardous waste considerations. Coagulation with microfiltration was not considered due to its high cost and level of complexity.

Decision and Costing Tool - Input Parameters

The model considers various system parameters including site constraints, capacity, and water quality. Those parameters with a specified input range are listed in the table below.

System Parameter	*Valid Input Range*
• Well capacity (gpm)	0-1,500
• Annual average flow (gpm)	0-1,500
• % Time the well is operating	0-100
Water Quality	
• Influent arsenic (µg/L)	10-50
• Treated water arsenic goal (µg/L)	2-10
• Raw water pH	1-14
• Raw water fluoride (mg/L)	0-10
• Raw water silica (mg/L)	0-100
• Raw water phosphate (mg/L)	0-10
• Raw water iron (mg/L)	0-10
• Raw water manganese (mg/L)	0-10
• Raw water sulfate (mg/L)	0-500
• Raw water TDS (mg/L)	0-2,000
• Raw water alkalinity (mg/L)	0-500

Treatment Alternatives

Each of the web-based model treatment alternatives and their key implementation factors are outlined below.

Fe-AA Adsorption with Single Column

Key implementation factors: achieved with pH adjustment to 6.5; influent concentration should be < 15 ppb (adsorption media design criteria – 15 ppb influent and 5 ppb average effluent arsenic levels).

- Direct pumping into distribution system
- Pumping into a storage tank and re-pumping into distribution system

Fe-AA Adsorption with Two Columns in Series

Key implementation factors: achieved with pH adjustment to 6.5

For wells with > 20 ppb arsenic: adsorption media design criteria – 25 ppb influent and 10 ppb average effluent arsenic levels.

- Full flow treated, direct pumping into distribution system
- Full flow treated, pumping into exiting storage tank and re-pumping into distribution system

For partial stream treatment, where feasible and arsenic < 20 ppb: adsorption media design criteria – 15 ppb influent and 5 ppb average effluent arsenic levels.

- Partial stream treated, pumping into existing storage tank and re-pumping into distribution system
- Partial stream treated, pumping into new storage tank and re-pumping into distribution system
- Partial stream treated, direct pumping into distribution system without any storage

Granular iron media with single column

Key implementation factors: no pH adjustment (impacts performance if >8); adsorption media design criteria – 15 ppb influent and 5 ppb average effluent arsenic levels.

- Direct pumping into distribution system
- Pumping into a storage tank and re-pumping into distribution system

Granular Iron Media with Two Columns in Series

Key implementation factors: no pH adjustment (impacts performance if >8)

For wells with > 20 ppb arsenic: adsorption media design criteria – 25 ppb influent and 10 ppb average effluent arsenic levels.

- Full flow treated, direct pumping into distribution system
- Full flow treated, pumping into existing storage tank and re-pumping into distribution system

For partial stream treatment, where feasible and arsenic < 20 ppb: adsorption media design criteria – 15 ppb influent and 5 ppb average effluent arsenic levels.

- Partial stream treated, pumping into existing storage tank and re-pumping into distribution system
- Partial stream treated, pumping into new storage tank and re-pumping into distribution system
- Partial stream treated, direct pumping into distribution system without any storage (not recommended – control intensive)

Coagulation High-Rate Media Filtration

Key implementation factors: Recommended for larger treatment plants (>1 MGD), with particularly higher levels of arsenic (>20 ppb) and which also have a higher degree of operator expertise. Approximately 5 mg/L ferric chloride would be added to form a floc and precipitate the arsenic. Spent

backwash is settled and thickened solids are disposed off-site. Recovered water from backwash settling is treated through the plant.

- Direct pumping into the system under pressure without a storage tank at the site
- Pumping into an existing on-site storage tank for subsequent re-pumping into the system. A lower pressure rating is used for this treatment system.

Point-of Use Treatment

Key implementation factors: POU may be a cost-effective alternative, especially for systems serving fewer than 100 connections and an average population less than 300.

- POU treatment using adsorption (Mn-AA or iron media)
- POU treatment using reverse osmosis (RO)