APPENDIX A: References

1. Arizona Department of Environmental Quality. **Arizona POU Compliance Program**. July 2005. Retrieved from http://www.azdeq.gov/environ/water/download/pointofuse.pdf#search='arizona%20POU%20 compliance'

2. Bell, F., D. Perry, J. Smith, and S. Lynch. 1984. **Studies on Home Treatment Systems**. Journal AWWA, 76:2. pp. 126-130.

3. Calderon, R. 1987. **An Epidemiological Study on the Bacteria Colonizing Granular Activated Carbon Point-of-Use Filters**. 1987 Water Quality Association Annual Conference Proceedings. Dallas, TX.

4. Drinking Water Leadership Council. **BC Drinking Water Officer’s Guide**. January 2006. Retrieved from http://www.healthservices.gov.bc.ca/protect/pdf/dwoguide.pdf

5. Narasimhan. R. 2005. **POU/POE Feasibility Study for Arsenic Treatment**. AWWA RF Project 2730. Chapter 3. Order Number 91083F

6. Ontario Ministry of Environment. 2001. **Drinking Water Treatment: A Guide for Owners of Private Communal Works and Other Small Community water systems.** December 2001.

7. Province of British Columbia. **Drinking Water Protection Act: Drinking Water Protection Regulation. 2003.** Retrieved from http://www.qp.gov.bc.ca/statreg/reg/D/200_2003.htm

8. Province Of British Columbia. **Drinking Water Protection Act**: [SBC 2001] Chapter 9. 2001. Retrieved from http://www.Qp.Gov.Bc.Ca/Statreg/Stat/D/01009_01.htm

9. US Environmental Protection Agency. **Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water System.** April 2006. Retrieved from http://epa.gov/safewater/smallsys/ssinfo.htm#two

10. World Health Organization. 2002. **Heterotrophic Plate Count Measurement in Drinking Water Safety Management**. 2002 World Health Organization Conference Proceedings. Geneva, Switzerland.

APPENDIX B: Definitions

Absorption: The process in which one substance is taken into the body of another substance, termed the absorbent.

Activated Carbon: A granular material produced by the roasting of cellulose based substances, such as wood or coconut shells, in the absence of air. It has a very porous structure and is used in water conditioning as an absorbent or organic matter and certain dissolved gases.

Adsorption: The process in which matter adheres to the surface of the adsorbent.

Aeration: The process in which air is brought into intimate contact with water, often by spraying water through air or by bubbling air through water. Aeration may be used to add oxygen to the water for oxidation of matter such as iron or to cause the release of dissolved gases such as carbon dioxide or hydrogen sulfide.

Aquifer: A layer or zone below the surface of the earth which is capable of yielding a significant volume of water.

Backwash: The process in which beds of filter or ion exchange media are subjected to flow opposite to service flow direction to loosen the bed and to flush suspended matter collected during the service run to waste.

Calcium Hypochlorite: A chemical compound used as a bleach and a source of chlorine water treatment; specifically useful because it is stable as a dry powder and can be formed into tablets.

Coagulant: A material, such as alum, which will form a gelatinous precipitate in water and cause the agglomeration of finely divided particles into larger particles which can then be removed by settling and/or filtration. The process is often called Flocculation.

Disinfection: A process in which pathogenic, disease producing bacteria are killed.

Domestic purposes: the use of water for, (a) human consumption, food preparation or sanitation; (b) household purposes not covered by (a), or (c) other prescribed purposes.

Fouling: The process in which undesirable foreign matter accumulates in a bed of filter media or ion exchanger, clogging pores and coating surfaces and thus inhibiting or retarding the proper operation of the bed.

Greensand: A natural mineral, primarily composed of complex silicates, which can be coated with manganese oxide to form a catalytic absorptive surface. This surface is used to attract ferrous iron and manganese as well as to absorb dissolved oxygen which is used to oxidize iron, manganese, or hydrogen sulfide.

Hardness: A characteristic of natural water du to the presence of dissolved calcium and magnesium. Water hardness is responsible for most scale formation in pipes and water heaters and forms insoluble “curd” when it reacts with soap.

Hydrogen Sulfide (H_2S): A gas characterized by an offensive odour, commonly referred to as “rotten egg” odour. Flammable and poisonous in high concentrations, corrosive to most metals and can even tarnish silver. Detectable by most people in concentrations as low as 0.5 mg/L.

Ion exchange: A reversible process in which ions are released from an insoluble permanent material in exchange for other ions in a surrounding solution; the direction of the exchange depends upon the affinities of the ion exchanger for the ions present and concentrations of the ions in solution.

Mechanical Filtration: the process of removing suspended particles from water by a straining action. The finest mechanical filters can remove particles as small as 0.2 microns.

Micron: A linear measurement equal to one millionth of a meter or 0.00003937 inch.

Micron rating: The term applied to a filter or filter medium to indicate the particle size above which suspended solids will be removed. Note there are “absolute” (100% of rated particles will be removed) and “nominal” (85% of rated particles will be removed) ratings. Nominal filters are much more common than absolute.

Neutralization: In general, the addition of either an acid or base to a solution as required to produce a neutral solution. The use of alkaline or basic materials to neutralize the acidity of water in common practice in water purification.

Organics: Any of the compounds whose chemical structure is based on carbon (e.g. carbon dioxide, wood, sugar, protein, plastics, methane, THMs, etc.).

Ozone: An unstable form of oxygen (O_3) occurring naturally in the upper atmosphere or artificially produced because of its strong oxidizing or disinfection characteristics.

pH: or the potential of hydrogen expresses the hydrogen ion activity or concentration. oH is a measure of the intensity of the acidity or alkalinity of water on a scale of 0 to 14, with 7 being neutral. When acidity is increased, the hydrogen ion concentration increases, resulting in a lower pH value. Similarly, when alkalinity is increased, the hydrogen ion concentration decreases, resulting in a higher pH. The pH value is an exponential function so that pH 10 is ten times as alkaline as pH 9 and 100 times as alkaline as pH 8. Similarly a pH 4 is 100 times as acidic as pH 6 and 1000 times as acidic as pH 7.

Point of entry (POE) device: a water disinfection device that produces potable water and is situated on or near an end-user premise such that (a) it treats ALL water used for domestic purposes, and (b) can be accessed externally by a third party for repairs and maintenance without requiring special entry into a residence.

Point of use (POU) device: a water disinfection device that produces potable water which is situated on an end-user premise, (typically inside the residence under the kitchen sink) such that (a) it treats some of the water used for domestic purposes, and (b) is not accessible without entering into the residence. Use of POU devices implies there may be water taps that are used for domestic purposes which are not treated (eg, bathrooms, external water taps for gardening).

Pre-treatment: Whatever alterations of the raw water feed are required to prevent damage to equipment after it (often used with Reverse Osmosis systems).

Regeneration: In general, includes the backwash, brine and fresh water rinse steps necessary to prepare a water softener exchange bed for service after exhaustion. Specifically, the term may be applied to the “brine” step in which the sodium chloride solution is passed through the exchanger bed. The term may also be used for similar operations relating to demineralizers and certain filters.

Residual Chlorine: Chlorine remaining in treated water after a specified period of contact time to provide protection throughout a distribution system. The difference between the total chlorine added and that consumed by oxidizable matter.

Reverse Osmosis (RO): A process that reverse, by the application of pressure, the flow of water in the natural process of osmosis so that water passes through a semi-permeable membrane leaving dissolved material behind.

Sediment: The sum of particles of dirt, clay, silt, and vegetation which float or are suspended in water and can be removed by mechanical filtration or flocculation.

Small system: A community water system that serves up to 500 individuals during any 24 hour period.

Tannin: A substance resulting from the decomposition of organic matter (plants and vegetation). The resulting colour does not pose a health hazard but is aesthetically unpleasing and will interfere with certain forms of water treatment (i.e UV).

Trihalomethanes (THMs): A group of suspected carcinogenic organic chemicals formed in water when chlorine reacts with naturally occurring organic matter. One of the most common THMs is chloroform.

Turbidity: Suspended organic and inorganic particles which may make the water seem cloudy. Elevated levels will interfere with certain forms of treatment equipment (i.e UV).

Water purveyor: the person or organization which owns the community water system and is responsible (and liable) for the integrity of the system.

Water Users Community: Administered through the Ministry of Environment under the *Water Act*. Individual water licensees who may wish to create a joint system to store or distribute their water

APPENDIX C: Abbreviations

µg/l Micrograms per Liter
µm Micron Meter
AA Activated Alumina
ANSI American National Standards Institute
AwwaRF American Water Works Association Research Foundation
AX Anion Exchange
BAT Best Available Technology
CCl_4 Carbon Tetrachloride
CCR Consumer Confidence Report
CFR Code of Federal Regulations
cfm Cubic Foot per Minute
cfu Colony Forming Units
CHC_{l3} Chloroform
cm Centimeter
CTA Cellulose Triacetate
CWS Community Water System
CX Cation Exchange
DBA Diffused Bubble Aeration
DNR Department of Natural Resources
DWO Drinking Water Officer
EBCT Empty Bed Contact Time
EPA United States Environmental Protection Agency
GAC Granular Activated Carbon
GFH Granular Ferric Hydroxide
gpd Gallons per day
gpm Gallons per minute
HFTF High-flow Thin-film
HPC Heterotrophic Plate Count
IOC Inorganic Chemical
IX Ion Exchange
kgal 1,000 gallons
MCL Maximum Contaminant Level
meq Milliequivalents
MGD Millions of Gallons per Day
mg/L Milligrams per Liter
ml Milliliter
NPDWR National Primary Drinking Water Regulation
NSF National Sanitation Foundation
NTU Nephelometric Turbidity Units
O&M Operation and Maintenance

PCE Tetrachloroethylene
pCi/L picoCuries per Liter
POE Point-of-Entry
POTW Public Owned Treatment Works
POU Point-of-Use
ppb Parts per Billion
ppm Parts per Million
psi Pounds per Square Inch
PTA Packed Tower Aeration
PWS Public Water System
RCRA Resource Recovery and Conservation Act
RO Reverse Osmosis
SDWA Safe Drinking Water Act
SDWIS Safe Drinking Water Information System
SOC Synthetic Organic Chemical
SSCT Small System Compliance Technology
TCA 1,1,1-trichloroethane
TCE Trichloroethylene
TDS Total Dissolved Solids
TSS Total Suspended Solids
THM TrihalomethanesTTHM Total Trihalomethanes
UL Underwriters Laboratories Inc.
UV Ultraviolet Light
VOC Volatile Organic Compound
WHO World Health Organization
WIA Wattenburg Improvement Association
WQCD Colorado Water Quality Control Division
WQA Water Quality Association

APPENDIX D: Supplementary Information Concerning POU and POE Treatment Technologies

D.1.1 POU Technologies

The following is extracted from Section 3.2.1 of the EPA publication (see Appendix A: reference [9]):

D.1.1.1 Adsorptive Media for Arsenic and Selenium
Adsorptive media includes activated alumina (AA), granular ferric hydroxide (GFH), or other specialty iron-based media. AA is a hydrated aluminum oxide that has been heat-treated. Iron-based media is typically generated in a proprietary process and may consist of granules of ferric oxide or ferric hydroxide, activated alumina coated with iron, or natural minerals impregnated with a substantial quantity of ferric hydroxide.

Centralized AA treatment systems are often used for fluoride removal but are also applicable for arsenic (in an oxidized state) and selenium removal. Inorganic arsenic in groundwater supplies exists in two forms: as arsenate (As V) and arsenite (As III). The arsenite form of inorganic arsenic is uncharged at a pH below 9.2 and is, therefore, harder to remove from water. Arsenate, however, is an anion at a pH above 2.2 and is therefore easier to remove using an iron-based and/or other specialty media. Source water pH is typically adjusted in a centralized AA treatment setting to achieve optimum contaminant removal. Because POU AA units are not equipped to adjust the pH of the incoming water from typically neutral pH values of 7.0, the removal efficiency of POU AA may not be as optimal for these contaminants when compared to centralized treatment. However, EPA has determined POU AA to be a feasible treatment option for small systems treating for arsenic assuming the AA media is used on a throw-away basis (*i.e.*, no regeneration) and that arsenic exists in the oxidized state of arsenate (final Arsenic Rule). EPA is continuing to investigate the use of POU AA for fluoride and selenium; a preliminary review of treatability data indicates it is an effective treatment technology.

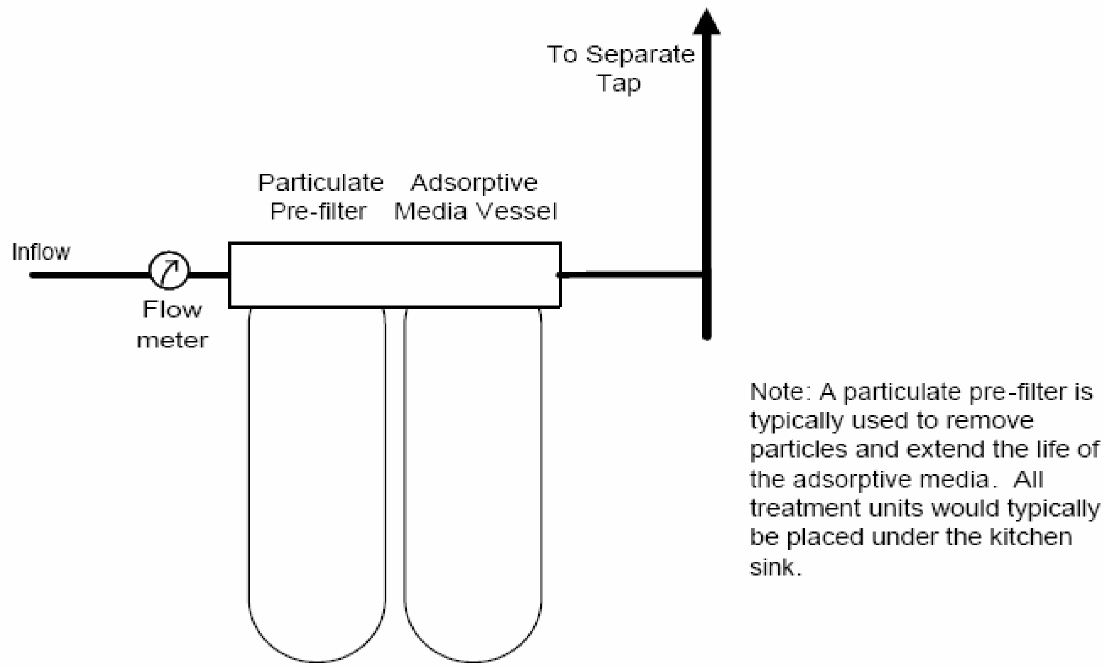
The use of specialty iron-based media is a relatively new treatment technology for arsenic removal and the media are currently being tested for POU feasibility by several companies using this media for centralized treatment. These iron-based media are not as sensitive to competing ions as AA and are typically used on a throwaway basis.

Raw water characteristics should be known, particularly pH and competing ions (fluoride and sulfate), when considering adsorptive media treatment options. When using AA, the greatest removal capacity for fluoride occurs at pH 5.5, and for arsenic, between pH 5.5 and 6.0. Hydroxide ions, which are the most highly preferred ions by AA, are more prevalent at higher pHs, and therefore compete with arsenic, fluoride, and selenium for available sites. Iron-based media have better arsenic removal over a broader range of pH, but manufacturers still do not recommend exceeding a pH of 8.5. Another factor inhibiting arsenic removal is the presence of interfering or competing ions such as silica, fluoride, phosphate, sulfate and dissolved iron and manganese. At certain concentrations, these competing or interfering ions can reduce the adsorptive capacity of the media for arsenic. However, iron-based media are typically not as sensitive to competing ions as AA.

In some cases, pilot testing may be very important to determine the adsorptive media’s capability for each application. Water systems should consult with their State drinking water agencies concerning pilot testing requirements. Adsorptive media units should be installed with a particulate pre-filter to remove particles followed by the vessel containing the adsorptive media.

Exhibit 3.5 below shows a typical POU adsorptive media installation. The units shown in Exhibit 3.5 are equipped with a pre-filter and one vessel filled with adsorptive media or a pre-manufactured cartridge that contains adsorptive media.

Exhibit 3.5: Typical POU Adsorptive Media Installation



D.1.1.2 Ion Exchange (IX) for Various IOCs, Radium, and Uranium (EPA Section 3.2.1.2)

Ion Exchange (IX) can consist of anion exchange (AX) or cation exchange (CX). IX achieves the selective removal of charged inorganic species from water using an ion-specific resin (AWWA/ASCE 1998). As water containing undesired ions passes through a column of resin media, charged ions on the resin surface are exchanged with the undesired ions in the water. In a large centralized treatment system, the resin is regenerated and a regenerant waste stream is discharged. For POU units, the resin is replaced periodically as opposed to regenerating.

Resin fouling may occur if influent water has high concentrations of total suspended solids, iron, magnesium, or copper. Channels may develop in the resin bed if the pressure drop across the bed is too high due to fouling. These channels may permit water to pass through the unit without adequate contact with the treatment resin. Since POU IX units cannot be backwashed, the media life of these devices may be shortened when levels of these solids, iron, magnesium, or copper are high, and may preclude the use of these devices.

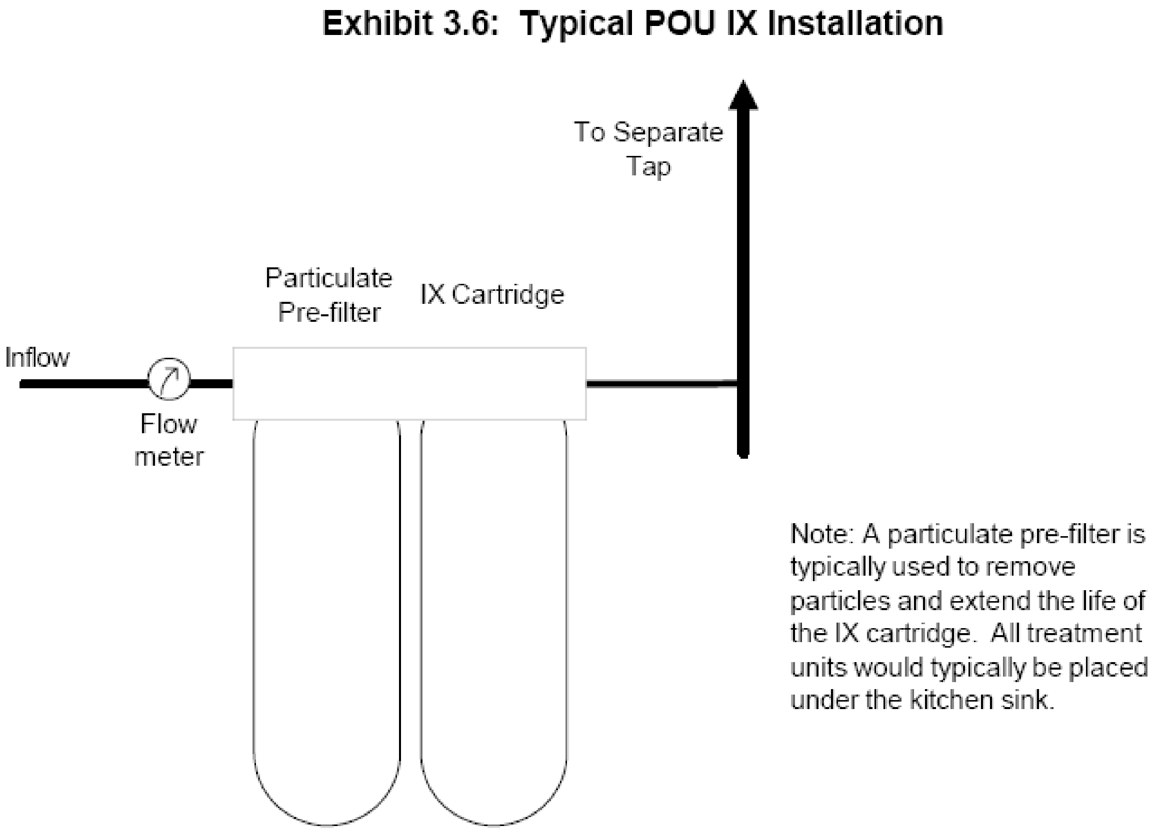
POE AX may be a preferred treatment alternative for nitrate, but POE AX is not listed as an SSCT at this time for any contaminant due to waste disposal and cost considerations. However, POU AX has been suggested by EPA to receive further investigation for nitrate removal. POU AX is listed by EPA as an SSCT for fluoride, antimony, chromium, selenium, and uranium.

POU CX is listed by EPA as an SSCT for copper, lead, barium, beryllium, cadmium, and thallium. POU CX is listed as an SSCT in the final Radionuclides Rule for radium. Exhibit 3.6 shows a typical POU IX installation.

Special Considerations for Nitrate Treatment

Because POU devices do not treat all the water taps in a house, there is a potential health risk to household residents who consume untreated water. Households would need to be careful not to use untreated water to make infant formula. Nitrate is a potential hazard to infants; serious and occasionally fatal poisonings in infants have occurred following ingestion. Almost all established cases of water-related nitrate-induced methemoglobinemia in the United States have resulted from the ingestion of private well water used to make infant formula.

Water systems using POU treatment for nitrate removal should make special efforts to educate customers about the need for using only the tap that is treated, the health risks associated with consuming untreated water, and the need for a proper replacement frequency of the AX resins. Public education could include using the local newspaper, public notification by mail or posted in prominent places within the community, radio, television media and public forums. Including educational materials with the water bill is another option, as is the use of door hangers and fliers. Public outreach may result in significant costs and may offset any savings from using POU devices.

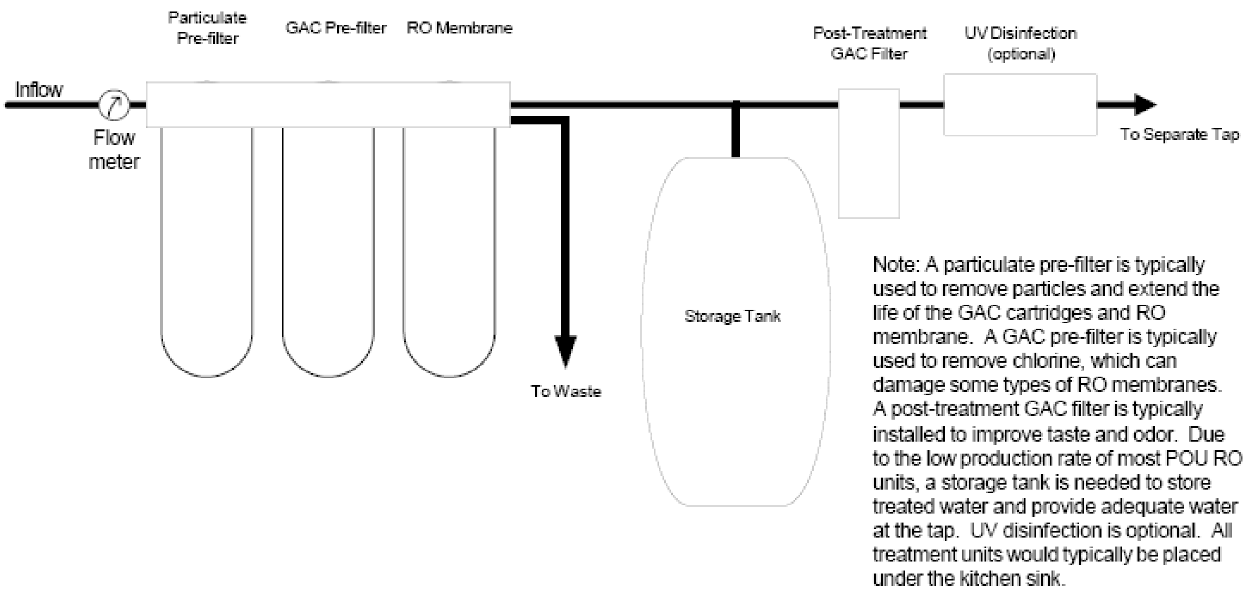


D.1.1.3 RO for Various IOCs, Radium, and Uranium (EPA Section 3.2.1.3)
POU RO units essentially use the same technology as in centralized treatment. In RO, water dissolves into and through a membrane, while contaminant ions are rejected and discharged in a concentrated waste stream. Thus, POU RO units need to be provided with a means of discharging reject water to a drain. Some RO membranes are sensitive to chlorine, a consideration for those systems that have centralized chlorination installed. RO typically has a low production rate (around 40%), and storage is typically needed for a POU RO application.

High levels of water hardness tend to reduce membrane efficacy and result in more frequent replacement of the RO membrane. Also, high levels of iron, manganese, and aluminum can also cause membrane fouling. Additionally, RO units may not be the optimal treatment technology in arid or waterlimited regions since RO units have low recovery rates.

POU RO has been identified in both the Arsenic and Radionuclides Rules as an SSCT for arsenic, uranium, and radium. POU RO is also listed as an SSCT by EPA for copper, lead, fluoride, antimony, barium, beryllium, cadmium, chromium, selenium, and thallium. POU RO is suggested to receive further investigation for its potential application for nitrate removal. The issues associated with using POU RO for nitrate are the same as presented in Section 3.2.2 for POU AX for nitrate. (See box on p. 3-10) Exhibit 3.7 shows a typical POU RO installation.

Exhibit 3.7: Typical POU RO Installation



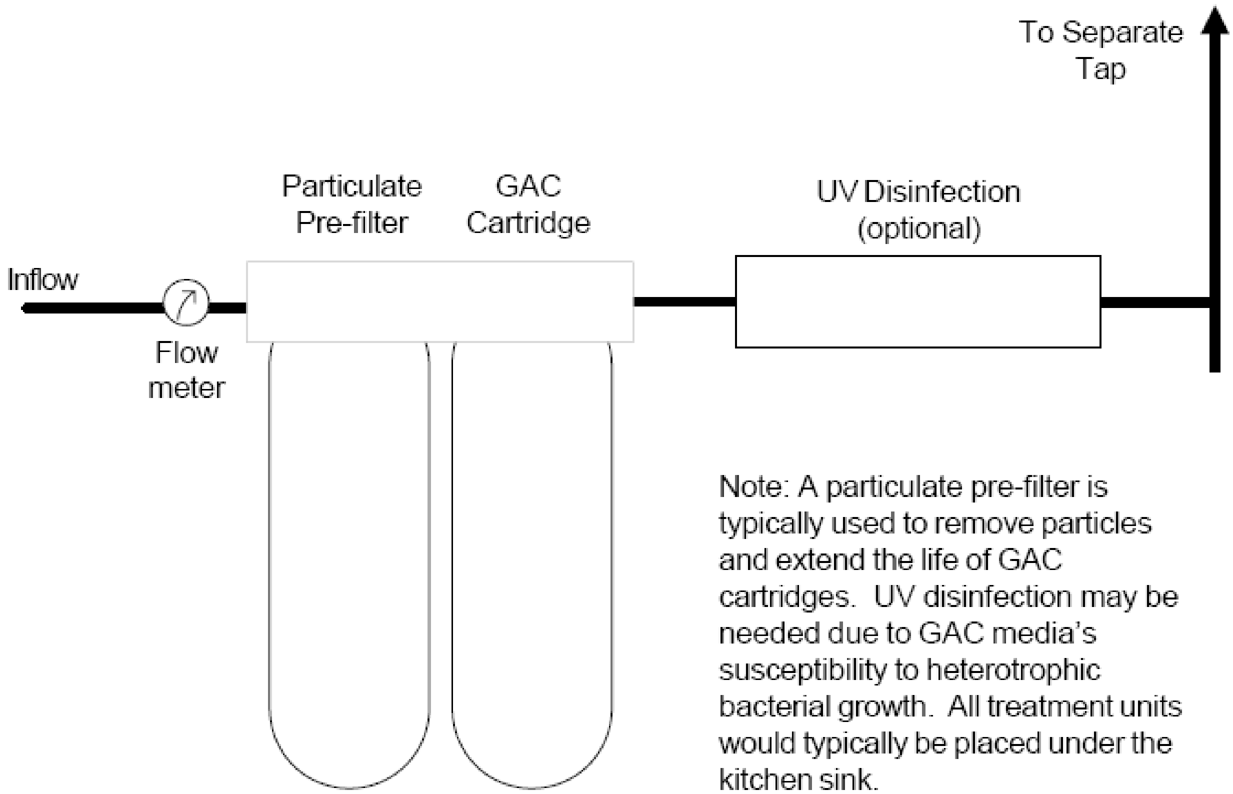
D.1.2 POU or POE Technologies—GAC for SOCs (EPA section 3.2.2)

POU and POE GAC are both potentially useful for small system applications for removal of SOCs. The capacity of GAC to adsorb SOCs varies, depending on the chemical properties of the SOCs. GAC has the added benefit of improving aesthetics (taste, odor, and color) of the water and is sometimes included in POU or POE applications for improved aesthetics. GAC unit performance and bed life depend on the amount of GAC used in the device, presence of co-occurring SOCs, other raw water parameters (e.g., pH) and the nature of the contaminants being removed.

In addition, GAC media are prone to microbial colonization (heterotrophic bacteria) on the GAC media. Some form of HPC monitoring and/or disinfection should be considered when using POU GAC and when using POE GAC, as mentioned in 40 CFR 141.100(d)(2).

POU GAC is listed as an SSCT for all regulated SOCs. POE GAC for SOC removal has been identified by EPA to receive further investigation. Exhibit 3.8 shows a typical POU GAC installation. A typical POE GAC installation is shown in Exhibit 3.10 in Section 3.4.

Exhibit 3.8: Typical POU GAC Installation



D.1.3 POE Technologies—VOCs and Radon (EPA section 3.2.3)

Due to the volatile nature of both VOCs and radon, many of the same concerns apply to both contaminants. Although not explicitly prohibited in SDWA or by rule, POU treatment devices *should not* be used to treat for radon or for most VOCs, including total trihalomethanes (TTHM) for compliance purposes, since these devices do not provide adequate protection against inhalation or contact exposure to these contaminants at untreated taps (*e.g.*, showerheads). Therefore, POU technologies are not considered for compliance technology listing even though many POU units have been certified for VOC reduction and a few for radon reduction. They have also been used by some consumers for further reducing the risk from at least the drinking water portion.

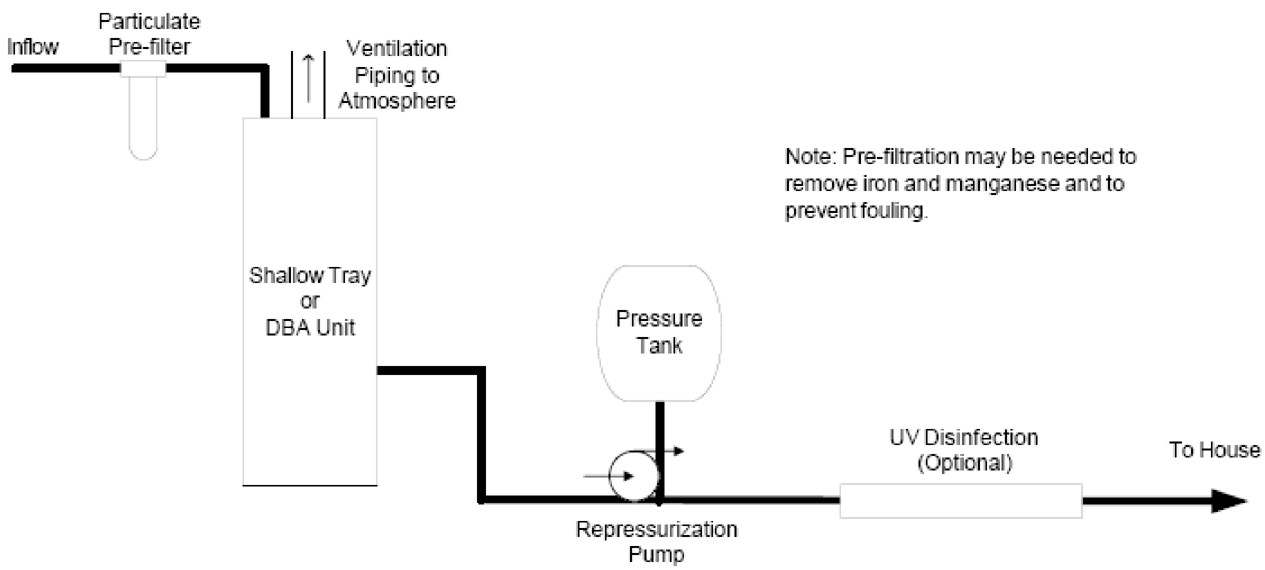
Aeration

Air stripping technologies such as shallow tray aeration and diffused bubble aeration (DBA) have been used in POE systems to remove VOCs from ground water (NRC, 1997). Similar to other aeration technologies, these systems rely on mass transfer to remove VOCs from water. While POE aeration is technically feasible, it is not commonly used for water systems and may not be as cost-effective as centralized aeration systems. Therefore, POE aeration has not yet been identified by EPA as an SSCT for VOCs. In addition, POE aeration was not identified in the proposed Radon Rule since it was not determined to be cost-effective.

The presence of high levels of iron or manganese can cause fouling of POE aeration units. The oxygen in the air bubbling through the water can oxidize the iron and manganese in the water and cause it to precipitate. Therefore, preoxidation and pre-filtration may be needed to remove iron and manganese and prevent fouling. In addition, UV disinfection may be necessary after as aeration devices are prone to bacterial and algal growth.

The potential for off-gas emissions from POE units is more likely to be a problem because these POE units would be located near homes. Off-gases may have to be treated using a scrubber, thereby increasing the complexity and the cost of the aeration units. Also, there is the potential for water quality deterioration from oxidized inorganics and instability resulting in corrosion and biological growth in the aeration device. Post-treatment disinfection may be needed with POE aeration units. For these reasons, this type of technology may be more appropriate for institutions that have adequate maintenance capabilities, rather than for homeowners. Exhibit 3.9 shows a typical POE aeration installation.

Exhibit 3.9: Typical POE Aeration Installation

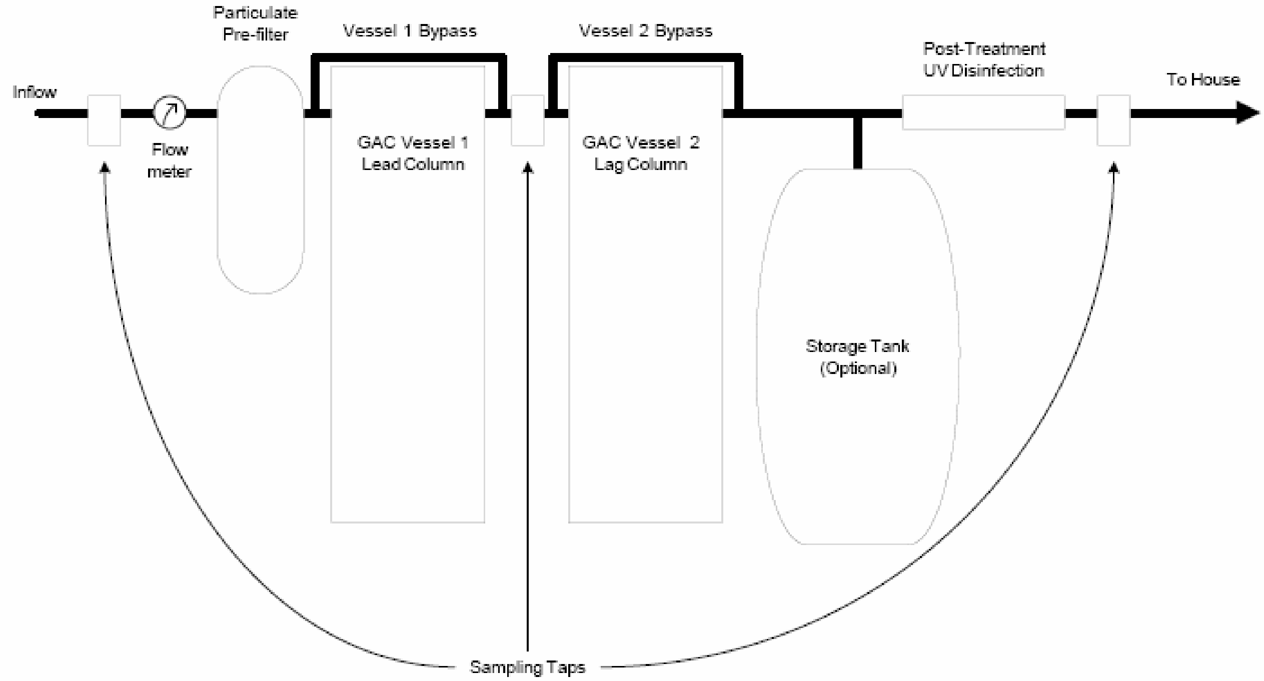


GAC

POE GAC has been identified in the proposed Radon Rule as an SSCT. This technology was determined to be a cost-effective and feasible treatment option for small systems. Proper disposal of GAC media should be evaluated since the spent media will contain radionuclides. Exhibit 3.10 shows a typical POE GAC installation. *Note that the Exhibit is only suggesting vessel bypass and not raw water bypass. This would only happen when media in either column is being replaced.*

As discussed in Section 3.3, natural organic matter and co-occurring VOCs or SOCs can reduce the efficiency of GAC. The pH of the water and the presence of iron, manganese, and calcium salts can affect the adsorption ability of the GAC media. In addition, GAC media are prone to microbial colonization (heterotrophic bacteria) on the GAC media. Some form of HPC monitoring and/or disinfection should be considered when using POU GAC and when using POE GAC, as mentioned in 40 CFR 141.100(d)(2).

Exhibit 3.10: Typical POE GAC Installation



Note: A particulate pre-filter is typically used to remove particles and extend the life of the GAC media. The GAC vessels are typically installed in series as a safety measure, with the first vessel functioning as a roughing unit and second vessel functioning as a finishing unit. A storage tank may be needed to store treated water and provide adequate water at the tap. UV disinfection is needed due to GAC media's susceptibility to heterotrophic bacterial growth.

APPENDIX E: Arsenic in Drinking Water

Arsenic is found naturally in the Earth’s crust and used in a number of industrial processes. When it enters drinking water, arsenic can have serious short-term and long-term health effects. The following information is provided by the BC Ministry of Health.

How does arsenic enter drinking water?

Arsenic can enter drinking water from natural deposits or runoff from agriculture, mining and industrial processes. In BC, natural minerals are the most common sources of arsenic in drinking water. Arsenic concentrations are generally higher in ground water supplies like wells than in surface water supplies such as lakes, streams and rivers.

What are the health effects of arsenic exposure?

There can be short-term or acute symptoms, as well as long-term or chronic health effects, from exposure to arsenic in drinking water. The risks or health effects of arsenic in drinking water are the same for all ages and groups in the population.

The short-term symptoms of exposure to high levels of arsenic include stomach pain, vomiting, diarrhea, muscle pain, weakness, and flushing of the skin. These are generally seen at arsenic levels or concentrations above 1200 micrograms per liter. However, in children with high fluid intake, acute poisoning has been seen with concentrations in the range of 200 micrograms per liter.

Concentrations of arsenic may also expressed as micrograms per liter, abbreviated as µg/L, milligrams per liter (mg/L), parts per billion (ppb) or parts per million (ppm). Micrograms per liter is the same as parts per billion, milligrams per liter is the same as parts per million – 10 micrograms per liter (µg/L or ppb) is the same as 0.01 milligrams per liter (mg/L or ppm).

Exposure to low levels or concentrations of arsenic can produce a number of chronic or long-term health effects over time. The skin can become thickened, heavily pigmented, or develop multiple wart-like lesions. Blood vessels can be damaged and affect the blood supply to the feet and hands. Long-term exposure to arsenic can also be a cause of high blood pressure.

Importantly, arsenic is a known cause of cancer. Long-term exposure to arsenic in drinking water over the course of a lifetime can lead to several types of skin cancers and cancers of the lung, liver and bladder.

The ability to cause cancer was the critical health effect used in setting the National guideline for arsenic in drinking water. When guidelines are developed, Health Canada considers a broad range of potential health effects, but ultimately focuses on those that can result in illness at the lowest concentration. At higher concentrations of arsenic there may be health effects, such as blood vessel damage in addition to the cancer *concerns. Meeting the cancer guideline will also protect people from those other health effects. Guidelines may also consider the practical levels that available treatment devices can achieve, or the ability of lab testing to detect low levels of a given chemical.*

How much arsenic causes health effects?

The Guidelines for Canadian Drinking Water quality published by Health Canada set a Maximum Acceptable Concentration (MAC) of 10 micrograms per litre. This is based on the ability of municipal and residential water treatments to reduce arsenic concentrations to 10 micrograms per litre or less. It is set at a level that is higher than would be associated with an "essentially negligible" risk of cancer over a life-time of exposure. Find more information on http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/index_e.html

At 10 micrograms per litre the risk of internal organ cancers is 3 to 39 cases per 100,000 people exposed. At 5 micrograms per litre the estimated life-time risk of cancer is 2 to 20 cases per 100,000 people exposed. It is only at levels or concentrations of arsenic of 0.4 micrograms per litre or less that the risk could be considered "essentially negligible" (1 new case of lung, bladder or liver cancer per 100,000 people over a life time).

How do I know if there is arsenic in my drinking water?

In drinking water, arsenic has no odor or taste. It is detected by a chemical test.

Public drinking water systems are regularly monitored. However, most private wells are not tested routinely for water quality or contaminants.

It is the well operator's responsibility to test the water for arsenic.

Any well may contain arsenic or other contaminants. Private wells should be tested regularly for water quality. For more information, see BC HealthFile #45 "Should I Get My Well Water Tested?" http://www.bchealthguide.org/healthfiles/hfile45.stm.
Contact the public health unit or public health inspector for information on the water testing in British Columbia, or directly contact laboratory that will test water. Laboratories are generally listed in the yellow pages of the phone book under the heading "laboratories, analytical"

What do I do if there is arsenic in my drinking water?

Water that contains arsenic is only a concern if it is being used for drinking or food preparation. Exposure through breathing and skin contact is not considered significant or harmful. For example there are no known health effects from hand washing, bathing or washing clothing in water containing arsenic.

If an initial test detects arsenic, even at levels below the guideline, it is important to have a second test done to confirm the results. If arsenic is present, then you may want to consider using another source for drinking water or treating the current source.

Chlorination and mechanical filters do not remove arsenic from water. Boiling water may actually increase the concentration of arsenic.

There is no regulatory control over treatment devices for private homes, therefore the well owner must be careful and select the appropriate treatment device.

Since water for laundry, toilets and bathing does not require treatment, it is possible to treat only those sources or faucets which supply drinking water (point of use). Otherwise, water can be treated as it enters the building or home (point of entry).

There are several treatment devices and options including adsorptive media, ion exchange (IX), granular activated carbon (GAC), reverse osmosis (RO) and distillation.

When purchasing a treatment device, you should consider one that has been certified by an organization accredited by the Standards Council of Canada (SCC). The treatment device should meet the following standards: NSF/ANSI Standards 53 on drinking water treatment units — health effects; or 58 on reverse osmosis drinking water treatment systems; or 62 on drinking water distillation systems. Be sure that the device not only meets the standard, but meets it for arsenic removal. Certification assures that a device works as the manufacturer or distributor claims. Devices can be certified for treating a range of water quality concerns, so make sure that the device you purchase is explicitly certified for arsenic removal. Find an up-to-date list of accredited organizations at www.scc.ca.

To become certified some drinking water treatment devices needs to reduce the concentration of arsenic in water from 300 to 10 micrograms per liter. These certified devices are appropriate for treating well water with high concentrations of arsenic.

Devices certified as reducing the concentration of arsenic from 50 to 10 micrograms per litre are intended for treating water with lower initial concentrations of arsenic.

How do I evaluate and decide on treatment options for arsenic?

The following questions may be useful in evaluating options and deciding on treatment for arsenic in water. The dealer you discuss treatment options should be able to provide information about how these considerations affect your particular water quality and the devices being considered.

Water characteristics

- What is the level of arsenic? Will the device be adequate?
- What are the other characteristics of the water – for example, pH, iron, manganese, copper, fluoride, dissolved solids or other? Will they interfere with the ability of the device to remove arsenic? (some chemicals that may be naturally present in your water will interfere with the effectiveness of some types of treatment devices but not others.)
- Will this water need to be pre-treated before the removal or treatment of arsenic?
- Is the well contaminated by surface water? If so, is disinfection required?

Type of treatment for your needs

- Does my water use require treatment at the point of entry into the building or home or at the point of use at the faucet?
- Can the water pressure in my house support the pressure filtration stage of treatment?
- Can the treatment be operated occasionally, or is a storage tank required?
- How frequently must the performance of the unit be monitored through periodic chemical analysis?
- Where will backwash water or spent cartridges be disposed, (both with highly concentrated arsenic)?

Treatment performance

- Will the manufacturer guarantee the performance of the treatment system to 10 micrograms per liter?
- Is the treatment device certified to the appropriate NSF Standard for arsenic removal?
- Is the agency that certified the device approved by the Standards Council of Canada?
- What is the track record of the manufacturer and distributor?
- Does the manufacturer or distributor offer a service contract?
- How are you protected against a catastrophic membrane failure or gasket rupture?
- Does the system monitor or warn when it is time to service the treatment unit?

Economic considerations

- What is the initial cost for the system? Remember to include all faucets you want to treat for a point-of-use system (i.e. kitchen and bathroom).
- What are the costs of any upgrades to the plumbing – for example, for a storage tank, pump or pre-treatment?
- What are the maintenance costs?
- How often are replacement filters or other components required?
- How long will the treatment system be effective? Is this guaranteed?

After considering these factors, you can make an informed decision about your drinking water source and treatment plans.

For more information on drinking water and treatment options, contact your local drinking water officer.

APPENDIX F: BC Drinking Water Protection Act and Regulation

Assented to April 11, 2001
Extract:

Community water systems must provide potable water

Subject to the regulation, a water supplier must provide, to the users served by its community water system, drinking water from the community water system that

(a) Is potable water, and

(b) Meets any additional requirements established by the regulations or by its operating permit.

Construction permits and requirements for community water systems

This section applies in relation to the construction, installation, alteration or extension of

(a) A community water system, or

(b) Works, facilities or equipment that are intended to be a community water system or part of a community water system.

Subject to the regulations, a person

(a) Must not undertake activities referred to in subsection (1) unless a construction permit for this has been issued in accordance with the regulations, and

(b) Must not undertake those activities except

(i) In accordance with the regulations or the plans approved in accordance with the regulations, and

(ii) In accordance with the terms and conditions of the construction permit.

In addition to any other requirements established by the regulations, a person applying for a construction permit must submit to an issuing official,

(a) In the case of a permit for the construction of a community water system, the results of water quality analyses in accordance with the regulations, and

(b) In any case, the results of any water quality analyses required by the issuing official or drinking water officer.

The issuing official may refuse to issue a permit until satisfied that the applicant has identified an owner of the community water system who is to be responsible for the ongoing operation of the system, or in charge of managing that operation, in accordance with this Act.

An issuing official may include in a construction permit terms and conditions the official considers advisable respecting the construction, installation, alteration or extension.

Terms and conditions included in a construction permit may set requirements and standards that are more stringent than those established by the regulations.

A construction permit

(a) Is valid for one year, unless a different period is specified in the permit,

(b) Is not transferable unless the transfer is approved by an issuing official, and

(c) Cannot be varied except by the issuance of a new construction permit.

Guidelines and directives respecting drinking water protection

The minister may establish

(a) Guidelines that must be considered, and

(b) Directives that must be followed
by drinking water officers and other officials in exercising powers and performing duties

Operating permits and requirements for community water systems

In the case of a prescribed community water system, the water supplier

(a) Must not operate the community water system unless the water supplier holds a valid operating permit issued in accordance with the regulations,

(b) Must comply with all terms and conditions of its operating permit, and

(c) Must operate the community water system in accordance with any applicable regulations.

An issuing official may include in an operating permit terms and conditions the official considers advisable respecting the community water system

Terms and conditions included in an operating permit under this section may set requirements and standards that are more stringent than those established by this Act or the regulations.

Drinking Water Protection Regulation
[Includes amendments up to B.C. Reg. 352/2005, December 9, 2005]

Extract:

"Small system" means a community water system that serves up to 500 individuals during any 24-hour period.

Exemptions

A small system is exempt from section 6 of the Act if

(a) The system does not provide water for human consumption or food preparation purposes, and is not connected to a community water system that provides water for human consumption and food preparation purposes, or

(b) Each recipient of the water from the system has a point of entry or point of use treatment system that makes the water potable.

[En. B.C. Reg. 352/2005, s. 3.]

APPENDIX G: Unused

APPENDIX H: Unused

APPENDIX I: Unused

APPENDIX J: Sample Monitoring Log for POU or POE Devices

Following is a sample monitoring log that water systems may find useful to track monitoring of POU and POE devices.

Monitoring Log

System Name:

Health Authority:

Type of POE / POU device:

Sample Date	Location	Contaminant	Certified Lab / Field Test kit	Results	Sampled by / other Notes

Example Monitoring Log

System Name: *Main Street System*

Health Authority: *VIHA*

Type of POE / POU device: *RO with pre and post GAC*

Sample Date	Location	Contaminant	Certified Lab / Field Test kit	Results	Sampled by / other Notes
Jan. 1, 2005	*123 Main Street*	*Arsenic*	*Certified Lab*	*.003 mg/L*	*Test by J.Smith*

APPENDIX K: Sample Maintenance Log for POU / POE Devices

This appendix contains a sample maintenance log that CWS may find useful to track maintenance of POU and POE devices. The sample maintenance log is designed to be used for each individual POU or POE device to allow the system to track maintenance at each individual unit. Maintenance logs are important since they will provide information on when components were replaced, how often the alarm was triggered, and if the unit is problematic. Detailed records may be useful to systems to justify to a vendor that certain devices are not functioning and require replacement. The CWS will want to keep these maintenance logs in a central office, have the records located with each individual unit, or both.

Keeping the maintenance logs at the unit location may result in damage to the records and the system may want to keep copies at a central office.

Following is a completed sample maintenance log and a blank maintenance log that systems may want to use.

Example Maintenance Log

System Name: *Main Street System*

BC Health Authority: *VIHA*

Type of POE / POU device: *RO with pre and post GAC*

Device Location: *123 Main Street*

Date Installed: *Jan 1, 2005*

Date & time of service call	Reason for service call	Services provided	Service provider	Notes
July 1, 2005	*Post-purchase follow-up inspection*	*Inspected all parts, discussed operation with customer*	*Smith Consultants under contract*	*Customer seemed satisfied with its operation*
Jan 1, 2005	*Regular Checkup*	*Inspected all parts*	*Smith*	*Customer had no complaints*

Maintenance Log for POE/POU Devices

System Name:

BC Health Authority:

Type of POE / POU device:

Device Location:

Date Installed:

Date & time of service call	Reason for service call	Services provided	Service provider	Notes

APPENDIX L: Sample Public Education Notices for Systems Using POE / POU Devices

The following page contains a model for a public education flyer that may be included in mailings to customers or posted throughout the service community when POU devices are used for nitrate removal.

Continued public education is important when POU devices are used for nitrate removal to educate the community on the health risks associated with nitrate, particularly for infants. Systems should check with their DWO prior to using this notice to verify whether it is suitable or if additional information should be included. If necessary, this flyer should also be translated into appropriate languages depending on the needs of the service community.

Sample Public Education Flyer for Nitrate Contamination

Your Tap Water and Point-of-Use Treatment Devices

What health effects does nitrate have?

Nitrate in drinking water can come from natural, industrial, or agricultural sources. These include septic systems and run-off from farms. Nitrate in drinking water is a serious health concern for infants less than six months old, because their bodies cannot process nitrates as well as older children and adults can.

Infants below the age of six months who drink water containing nitrate in excess of the limit could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome. Blue baby syndrome is indicated by blueness of the skin and means that the blood is unable to absorb oxygen. Symptoms in infants can develop rapidly, with health deteriorating over a period of days. If symptoms occur, seek medical attention immediately.

Why have I received a point-of-use device?

Your water system has installed a point-of-use (POU) treatment device under your kitchen sink to remove nitrate from your water. Treatment is necessary because nitrate levels in your water exceed the standard of xxx milligrams per liter. Because centralized treatment at the water treatment plant is very expensive, your system is instead providing POU devices to all households and other connections.

What steps should I take?

Use water from the tap with the POU device to prepare infant formula, juice, or other foods for children less than six months old. Water from other taps in your house is NOT treated for nitrates; do not use water from those taps to prepare food for infants. Water from other taps may safely be used for bathing infants. Adults and children older than six months can drink water from any tap, although use of the tap with the POU device is recommended. *Only water from a tap with a POU device should be used to prepare infant formula, juice, or other foods for children less than six months old.*

The following page contains a model for a public education flyer that may be included in mailings to customers or posted throughout the service community when POU devices are used for contaminant removal for contaminants besides nitrate. Continued public education is important when POU devices are used for nitrate removal to educate the community on the health risks associated with nitrate. Systems should check with their Drinking Water Officer prior to using this notice to verify whether it is suitable or if additional information should be included.

Sample Public Education Flyer for Chronic Contaminants

Your Tap Water and Point-of-Use Treatment Devices

Why have I received a point-of-use device?

Your water system has installed a point-of-use (POU) treatment device under your kitchen sink to remove chronic contaminants from your water. Treatment is necessary because contaminant levels in your source water exceed an applicable limit. Health effects from chronic contaminants vary depending on the contaminant but can include things like cancer and liver damage. These health effects occur only after chronic exposure (drinking the water over many years).

Because centralized treatment at the water treatment plant is very expensive, *your system* is instead providing POU devices to all households and buildings. By treating only the water used for drinking and cooking, the water system can save money and pass the savings on to its customers.

What steps should I take?

Use water from the tap with the POU device for drinking and cooking. In your kitchen, use the untreated tap for washing dishes. Water from other taps in your house is NOT treated; do not use water from those taps for drinking or for brushing teeth. Untreated water may be safely used for bathing and laundry.

In addition, *the water system* needs your cooperation to properly maintain the POU device. Maintenance ensures that the device is working correctly and that your water is safe. Please allow water system personnel into your home to take water samples or replace devices.

APPENDIX M: Considerations for Selecting a Water Quality Professional

The following is a compilation of extracts from literature produced by suppliers of POE / POU units. It is intended to provide advice to Community Water Suppliers when selecting a water quality professional. It is included to provide background information.

Choosing a water purification system is a difficult task that requires analyzing many interrelating factors. You should always consult a water professional to ensure your system choice is the right one. Consider the following when choosing a water professional:

- Company history and experience. How long has the company been in business? Do they have experience with a wide range of water quality and treatment equipment? Keep in mind that many equipment manufacturers will sell directly to the customer but may very well only recommend their own system(s), which might not always be in the best interest of the consumer.

- Company service. Problems can arise even in the best of cases (such as with water quality variation). Ensure your water professional will be there to support you and your system after installation. Check to see whether they have references from satisfied customers.

- Water quality. Ensure your professional of choice understands all water quality issues that can contribute to treatment (such as pH, Iron, Turbidity, Manganese, Hardness, etc.) and not only those contaminants that appear to be a problem.

- Warranty service. Know who will be responsible in the event of a system failure – the water professional, manufacturer, etc.

Advice from the Pros

1. **Advice is free – use it.** Manufacturers may produce different brands, for different distributors, with different specifications, at different price points. Visit a showroom to view and compare products, and speak to sales representatives. A reputable dealer should be interested in helping you. Talk to several dealers in your area. Sorting through the wide range of technologies and treatment applications can be a daunting task. Are you getting better service? Better product? Or better price? Since you want your water treatment equipment to effectively remove contaminants over a long period of time, it is important to find a service provider you can trust.

2. **Make sure you compare “apples to apples”.** When comparing different brands of the same technology, or comparing costs of different types of technology, make sure the comparisons are appropriate. One brand may have a high initial capital cost but lower operating costs. Another brand

may have a one-year warranty compared to a ten-year warranty. Yet, another brand may use the same technology but cost more because of a compact design that requires less space or have additional features.

3. **There is no “one size fits all” solution.** Every situation is different. Putting the water treatment system together involves integrating individual equipment components. The components will depend primarily on existing raw water quality, flow rate, pipe diameter, and considerations such as space, storage, operator skill requirements, personal preference and cost. Most filters, reverse osmosis units, UV units, and chlorination systems are available for almost any application and/or flow rate from residential through light commercial, to large industrial and municipal applications. Often, it is simply a matter of proper sizing.

4. **You’ll never know unless you test.** In the absence of water testing, some people may opt to purchase water treatment equipment that disinfects and filters as many contaminants as practical. While this may appear to save money, it is a good idea to test water quality before equipment is installed. This way you have a reference point against which to monitor equipment performance. Periodic water testing will tell you if the equipment is operating properly and is being maintained correctly. Furthermore, ensure your test is done under as close to “normal operation conditions” as possible. For example, if a new well has been drilled pump water from it approximating normal usage patterns before taking your water sample.

APPENDIX N: Case Studies from the United States

The US Environmental Protection Agency has published a guidance document for the application of POU / POE devices. The guidance document includes information on 22 POU and POE projects, which was gathered from published studies and by contacting State, EPA, and system personnel. The case studies presented in this appendix are reproduced from the EPA document. They help to provide CWS with information on how to implement a POU or POE treatment strategy. Each case study summary includes information on the following topics, if available:

- The contaminant(s) of concern (and its concentration in the raw water);
- The applied treatment technology;
- Pilot test protocol;
- The number of households equipped with POE or POU treatment units and the number of households served by the water system;
- The administrative strategy used by the water system;
- The monitoring plan used to ensure adequate protection of public health;
- The maintenance schedule selected by the water system;
- Details on the capacity and performance of the treatment units; and,
- The capital and O&M costs for each unit.

The case studies that follow are organized by the primary contaminant of concern. Again, these case studies are presented to provide information that may be helpful when developing a POU or POE treatment strategy. A water system should not select a device described in the following case studies simply because the device was successfully used to treat the same contaminant present in another water system. CWS should contact the DWO to determine what requirements or restrictions may apply to the use of POU and POE devices.

7.1 Arsenic Treatment

7.1.1 Fairbanks, Alaska and Eugene, Oregon (POU AA, AX, RO for Arsenic Removal)

This study investigated the efficacy of AA, AX, and RO devices for arsenic removal. Two homes in Eugene, Oregon and two homes in Fairbanks, Alaska were equipped with POU systems designed to treat household drinking water. Each of these systems was composed of an AA tank, an AX tank, and an RO system. A water meter was used to measure the true throughput of each unit. The households chosen for the study were selected with the cooperation of State organizations and individual homeowners. All relied on private well water that frequently exceeded the MCL for arsenic (0.05 mg/L). This case study was summarized by Fox (1989).

Arsenic concentrations in the source water for the study households ranged from less than 0.005 mg/L to more than 1.1 mg/L during this study. Arsenate was believed to predominate at all four test locations. It is important to note that iron and sulfate concentrations were low in the source water (see Exhibit 7.1) because these contaminants may interfere with the removal of arsenic. Iron compounds will clog and foul AX resins and AA media, thereby reducing the removal capabilities of each unit or reducing water throughput. Sulfate is preferentially selected over arsenic by AX resins and also interferes with arsenic removal by AA. In a 1982 study, Clifford and Rosenblum showed that arsenic adsorption was reduced by 50 percent in the presence of 15 milliequivalents (meq) of sulfate per liter in deionized water. During this study, treated water was not consumed by homeowners.

Exhibit 7.1: Source Water Quality of Surveyed Households in Fairbanks, AK and Eugene, OR

Contaminant	Influent Concentration for Households in Fairbanks		Influent Concentration for Households in Eugene	
	Household One (mg/L)	Household Two (mg/L)	Household One (mg/L)	Household Two (mg/L)
Arsenic (range)	0.25-1.08	0.22-1.16	<0.005-0.28	0.005-0.32
Calcium	22	8.9	18	19
Magnesium	10.6	9.3	5.3	5.5
Sodium	6.0	4.4	40	62
Chloride	<10	<10	<10	<10
Iron	<0.1	0.20	0.24	0.18
Sulfate	<15	<15	<15	<15
Turbidity (NTU)	0.48	0.32	0.43	0.24
Alkalinity	108	56	151	206
PH	8.0	7.4	8.3	8.3

The POU units were operated automatically by a system of solenoid valves and timers. The timers were initially set to open the valves daily at the times when an average family might use water. The system was designed so that each treatment unit would operate separately and no two valves would be open at the same time. The timers actuated the valves nine times a day, permitting the treatment of one gallon of water by both the AX and the AA tank, and 0.5 gallons of water by the RO unit each time the valves were opened. After six months, the valves were opened 18 times a day to increase flow through the units to speed up arsenic breakthrough.

Local and State employees performed all sampling of the units. Samples were collected biweekly from the influent and effluent lines of each of the three treatment elements and were sent to EPA in Cincinnati, Ohio, for analysis.

7.1.1.1 AA

The AA tanks used in this study were 46 inches tall and 9 inches in diameter. Each AA tank was filled with 1 cubic foot of activated alumina media. The AA media was designed to be pre-treated in the tank. The pre-treatment process consisted of passing a sodium hydroxide solution through the tank, rinsing the medium with clean water, and then treating the medium with dilute sulfuric acid to lower its pH. At a flow rate of 1 gallon per minute (gpm), the surface loading rate of the tank was 2.7 gpm per square foot, and the minimum empty bed contact time (EBCT) was 7.5 minutes. The actual contact time was probably greater because the effluent valves were opened for only 1 minute by the timers, and the water sat undisturbed in the tank (in contact with the AA) until the next valve-opening period.

The three AA units that failed to work as well as expected suffered from inadequate pretreatment. The units that failed had not been pre-treated with dilute sulfuric acid. Therefore, the pH of the water in the AA units was well above the ideal level for arsenic adsorption (pH 6). Thus, the tanks’ capacity to adsorb arsenic was much lower than anticipated. However, the six properly prepared AA units performed extremely well, consistently maintaining arsenic levels well below the MCL until they were taken off line. Three units successfully treated more than 10,000 gallons of water (10,784, 15,427, and 18,557 gallons) while the remaining three AA units each successfully treated more than 6,000 gallons. Based on the results of this study, a capacity of about 1.0 mg of arsenic per gram of AA could probably be expected in future applications of AA if source water concentrations of iron and sulfate are limited and the AA undergoes all appropriate pretreatment. (Note: POU AA identified in the Arsenic Rule assumes no pretreatment.)

7.1.1.2 AX

The AX tanks used in this study were the same size as the AA tanks. Each AX tank was filled with 1 cubic foot of a strong base AX resin. The resin was regenerated in the tank into the chloride form. At a flow of 1 gpm, the surface loading rate of the tank was 2.7 gpm per square foot, providing a minimum EBCT of 7.5 minutes. The actual contact time was probably greater because the effluent valves were only opened for 1 minute by the timers, and the water sat undisturbed in the tank (in contact with the resin) until the next valve-opening period.

Two AX units exhibited erratic removal of arsenic. A third unit performed poorly due to inadequate regeneration practices at the start of the project. However, the remaining four AX units worked extremely well, successfully treating water containing as much as 1.16 mg/L of arsenic to concentrations of less than 0.05 mg/L. Three of the units treated more than 10,000 gallons successfully (11,858, 16,254, and 20,935 gallons) and were disconnected at the end of the project even though the capability of the resin to adsorb arsenic had not been exhausted. Depositions of up to 0.86 mg of arsenic per gram of resin were found in the AX tanks when they were opened at the end of the study.

7.1.1.3 RO

The RO units studied for this project were designed to produce between 3 and 5 gallons of drinking water per day and to operate with source water pressures ranging from 20 to 100 pounds per square inch (psi) with a reject-to-product water ratio of about 10:1. Each RO unit was equipped with a 5-m cartridge pre-filter, a carbon post-filter, a cellulose-acetate RO membrane, and a small storage tank. Two years into the study, a second type of RO system was installed at one location. This unit was identical to the old unit, except that a booster pump was added to increase operating pressure to 195 psi.

The use of the high-pressure RO system improved the reject-to-product water ratio to 3:1 but also increased electrical costs.

The low-pressure RO systems initially removed 60 to 80 percent of influent arsenic. However, due to the high arsenic concentrations of the source water at the study sites, the RO units rapidly deteriorated and were not always successful in lowering the arsenic concentration below the MCL. On average, the low-pressure RO units provided only a 50 percent removal rate for arsenic over the life of their membranes. For the low-pressure RO system to serve as an effective treatment option given the raw water characteristics observed during this study, the cellulose acetate membranes would need to be replaced at least twice a year. The high-pressure RO unit successfully reduced arsenic levels below the MCL for 330 days before it was taken off line at the conclusion of the study.

All of the RO systems significantly lowered the level of TDS in the source water.

One potential cause of concern for system administrators who select this treatment technology is the limited production capability of some RO units (less than 3 gallons of treated water each day). The large amount of water wasted by low-pressure RO units may be a source of concern in water-scarce regions. On the other hand, since arsenic is not accumulated on the RO membrane, membrane disposal is not a concern as it may be with media from POU AX and POU AA systems.

7.1.1.4 Cost Data and Study Conclusions

Costs for the various elements of the pilot systems installed in Alaska and Oregon were provided by Fox and Sorg (1987). The capital costs reported in the case study were $350, $250, and $292 for the AX unit, AA unit, and RO unit, respectively (1983 dollars). The author of the study drew several conclusions about the ability of POE and POU devices to treat contaminated water adequately:

- Any medium used in a POE or POU device should undergo adequate pre-treatment to permit efficient and effective contaminant removal. (Note: POU AA identified in the Arsenic Rule assumes no pretreatment.)
- Sampling should be done immediately after installation and periodically thereafter to confirm adequate contaminant removal.
- A complete source water analysis is necessary to determine the proper type of POU or POE devices to be used.
- POE devices should be used when skin adsorption or inhalation of a specific contaminant is of concern.

7.1.2 San Ysidro, New Mexico (POU RO for the Removal of Arsenic, Fluoride, and Other IOCs)

Rogers (1988 and 1990) authored the original report detailing the San Ysidro experience from which much of this summary was drawn. Details regarding this case study were also reported by Lykins, Jr., et al. (1992) and Thomson and O’Grady (1998). A follow-up report was presented by Thomson, Fox, and O’Grady (2000). Additional information was provided by Pasteros (2001). The Village of San Ysidro is a rural community located approximately 45 miles north of Albuquerque, New Mexico. The population over the last 20 years has remained around 200 people.

Village water is disinfected by a hypochlorination system at the source, a nearby infiltration gallery. The village has a long history of water supply problems, including low water pressure, unpleasant aesthetics (poor taste, color, clarity, and odor), sporadic coliform violations, and arsenic and fluoride contamination. The local ground water has a high mineral content because geothermal activity causes leaching from the area’s abundant mineral deposits. At the beginning of the study, the ground water exceeded the MCL for arsenic (0.05 mg/L) and the secondary standards for fluoride, iron, manganese, chloride, and TDS (2.0 mg/L, 0.3 mg/L, 0.05 mg/L, 250 mg/L, and 500 mg/L, respectively). The contaminants of primary concern to the village were arsenic and fluoride. Arsenic and fluoride concentrations averaged 0.17 mg/L and 5.2 mg/L, respectively, in the village well. Of the arsenic found in village water, 35 percent was found to be arsenite.

Four deep test wells were drilled by a local engineering firm to determine if a better water source was available. However, the best of these wells had water merely equal in quality to that of the infiltration gallery. A University of Houston study determined that central treatment of the entire water supply was not feasible for several reasons. First, central treatment would leave the village with the expensive problem of disposing of either arsenic-contaminated sludge from AA column regeneration or the concentrated reject brine produced by a central RO system. Second, building a central treatment plant would be prohibitively expensive. Third, a central treatment facility was deemed too complicated to be operated efficiently by a community the size of San Ysidro (the village had never been able to attract and retain well-trained operators).

A public meeting was held in December of 1985 to discuss the water quality problems and the procedures that would be necessary before POU devices could be installed. By July of 1986, all of the eligible water system customers had agreed to participate. Since arsenic and fluoride are harmful only if ingested in excessive quantities for an extended period of time, only water destined for human consumption (i.e., water used for drinking and cooking) needed to be treated in San Ysidro. An analysis of unit removal cost, efficiency, and management requirements led to the identification of POU RO treatment as the best solution to the village’s water supply problems. The village was given permission to use POU RO as a solution to the arsenic and fluoride problems under a variance. Therefore, EPA, in conjunction with the village, began a study designed to determine whether POU RO units could function satisfactorily in lieu of central treatment to remove arsenic and fluoride from the community’s drinking water supply.

A competitive bidding process was used to select a POU RO unit for the village. The selected vendor provided installation and maintained all of the treatment units in the community for a monthly service fee. Over the course of the service contract, the village maintenance specialist received field training from the service contractor. The maintenance contract between the village and the vendor remained in effect for 20 months, after which the village maintenance specialist took over all maintenance and monitoring duties.

In order to ensure the effectiveness of the selected RO membrane and the acceptability of the POU RO unit to the community, a POU RO unit was installed in the community center. In addition, each customer was sent a notification letter and a public meeting was held. The public meeting forum was used to explain the water quality problems and the agreement between the village and EPA to utilize POU RO units to remedy the water quality problems.

To meet its responsibilities under Section 1412(b)(4)(E)(ii) of SDWA, San Ysidro passed an ordinance making the use of village water contingent upon the installation of a POU device in the home.

The ordinance was deemed necessary because POU treatment should not be considered a viable alternative to central treatment if the water system does not supply safe (i.e., treated) drinking water to all of its customers.

The number of units used by the community of San Ysidro ranged from 67 units at the beginning of the project to 78 units at the end. The units were each equipped with a particulate pre-filter, a GAC pre-filter, a GAC post-filter, a spiral-wound polyamide RO membrane, a 3-gallon storage tank, and an inline TDS monitor. Each unit was designed to produce between 5 and 8 gallons of product water per day. Three units were equipped with totalizing (water) meters to measure household water use. All of the units were equipped with alarms that were triggered when the TDS in the treated water exceeded 200 mg/L. No units were equipped with automatic shut-off devices. One unit was installed per household at the kitchen sink. All liquid wastes from the RO units were discharged to the household septic system through a connection with the sink drain. After several samples tested positive for coliforms, an air gap was added at the connection to each RO unit to prevent cross-contamination from the household wastewater.

Samples were collected for the next few months and tested for coliforms. None of these samples tested positive for coliforms. Within the first six months, six units that were not working properly were replaced. Another 35 units required service due to leaks, TDS monitor malfunction, or water flow problems. Customers were expected to pay for any damage to their RO units that resulted from their own negligence.

The successful operation of a community-wide POU treatment strategy requires that the responsibilities of water users and the water utility be clearly identified. The village council of San Ysidro outlined six responsibilities for water users and three for the water utility (the village). All water users were required to:

1. Allow access to their units (each water customer was required to sign a permission form allowing a village designee to enter his or her home for installation and for periodic testing and maintenance);
2. Protect their units from damage;
3. Assume liability for damage to their units;
4. Refrain from tampering with or disconnecting their units;
5. Allow periodic inspection of their units; and,
6. Report any problems with their units to the water utility in a timely fashion.

The village was required to provide unit maintenance, periodic monitoring, and liability insurance to cover any damage caused to a resident’s home by a treatment device. The Village of San Ysidro secured a liability policy designed to cover water damage resulting from improper installation or device malfunction.

The village clerk played a vital role in managing the installation, maintenance, and monitoring of the units. As the contact person for water customers, the clerk made arrangements with customers for unit installation and all necessary maintenance work. The clerk coordinated this effort with the contractor’s service manager during the 20-month service contract and with the village maintenance specialist after the contract expired.

The village made special provisions for commercial establishments. Although the primary responsibility for providing safe drinking water lies with the water utility operator, the village decided to transfer this responsibility to the commercial water user through a new ordinance. This served two purposes. First, the village was relieved of the burden of trying to coordinate the leasing, purchasing, and maintenance of RO units of various sizes. Second, the ordinance allowed commercial establishments some flexibility in selecting the most economical way to provide safe drinking water to their customers.

Note that this transfer of responsibility and liability may not be legal in all localities; it also may not have any effect on liability under federal law.

Data were collected during the San Ysidro study to evaluate the effectiveness of POU RO units in removing arsenic, fluoride, and TDS from the water. Samples were collected from each unit on a bimonthly basis and were analyzed for arsenic and fluoride. Every 4 to 6 months, samples were also analyzed for chloride, iron, and manganese. In addition, samples were periodically collected from a smaller group of 40 units and were analyzed for total coliform organisms. All samples were tested by a certified laboratory. A schedule for sample collection was typically placed in the customer’s water bill.

The RO units were very effective in removing arsenic and fluoride from the community’s water, reducing average influent concentrations of arsenic from 0.17 mg/L and fluoride from 5.2 mg/L to less than 0.05 mg/L and 2.0 mg/L, respectively. The units also reduced chloride, iron, manganese, and TDS to desired levels despite low system pressure (sometimes less than 20 psi). However, the removal percentages were approximately 10 percent below those stated in the manufacturer’s literature. This was most likely due to the quantity and combination of contaminants in San Ysidro’s water.

According to the maintenance plan, units were to be serviced once every three months. The service procedure included inspection of the pre-filter assembly, replacement of the pre-filter, inspection of the carbon post-filter with replacement as needed, inspection of the RO module housing assembly for cracks or leaks, inspection of all hose connections for leaks, inspection of the reservoir tank for cracks or leaks, and restarting the unit and again inspecting for leaks. However, some time after the village took over the maintenance of the units, most units were still being serviced, though seldom on a three-month frequency. Several reasons were given for the infrequent servicing of these units:

- The residents were not home when the operator arrived to perform regular service (many residents commute to Albuquerque and are gone for most of the day);
- Some residents were reluctant to allow outsiders into their homes; and,
- Some residents did not want the POU units and avoided having them serviced. Many of the residents, especially older residents, had been drinking the system water for a long time and were not very concerned about treatment. Few maintenance records were kept by the village maintenance specialist so it is not known how often cartridges and membranes were replaced.

The following recommendations were drawn from early experiences in San Ysidro:

- Since combinations of contaminants may alter the removal efficiencies of POU devices, a pilot test of potential treatment devices should be undertaken using the system’s source water before the device is selected for system-wide use.

- Public acceptance is more vital to the success of a POU treatment strategy than for a central treatment strategy. For example, new water customers should be educated in the procedures and requirements of the POU system. Existing customers should also be periodically reminded of these responsibilities.
- Routine maintenance and sampling operations are best carried out by local water utility employees or members of the immediate community once they have received sufficient training. In this way, travel expenses will be minimized, coordination with customers will be streamlined, and better quality control procedures may be implemented.
- Monitoring costs may be minimized by using conductance (for RO units) as a means to test for breakthrough of inorganic contaminants such as fluoride or arsenic.
- Pre-assembly of POU units may drastically reduce on-site installation time and associated labor costs.
- It is important to ensure that the price residents are charged by the water system covers the actual costs of providing necessary maintenance and monitoring.

In recent years, the San Ysidro water system has experienced compliance problems. Many of the residents are elderly and have been drinking the same water for years. These residents were less concerned about water treatment than by how much the water system is interfering with their lives and were therefore not very motivated to keep the POU units working. The village had been trying to use volunteers to perform maintenance, but had to return to using a full-time staff member to keep up with the demand. EPA assigned staff to the water system to return the system to compliance. The RO units were cleaned and repaired and EPA staff went to San Ysidro once per week to pick up samples until all units were tested and returned to compliance. At least for the time being, San Ysidro will continue to use POU devices to remove arsenic (Thomas 2005).

7.1.3 Hancock, New Hampshire (POE AA for Arsenic Removal)

Monadnock Area Cooperative School, a small non-profit school in Hancock, New Hampshire, is comprised of two separate schools, a preschool and a primary school, located in the same building. A licensed water operator was contracted to develop a plan to address the high levels of arsenic found in the school’s water (Messina, 2001). The operator submitted a compliance plan to the State of New Hampshire for approval. Once approval was obtained, the operator worked with school maintenance personnel to install a POE AA system in late 2000. The unit, consisting of a single AA tank and equipped with GAC pre- and post-filters, has effectively reduced arsenic levels below detection since its installation.

The bids initially provided by local retailers for this system were quite high (in excess of $5,000). Given the financial constraints faced by the school, the school opted to purchase the unit directly from a local manufacturer (based in Londonberry, New Hampshire) instead of a retailer and to hire the operator to install the unit. Purchasing the unit in this manner enabled the school to obtain and install the unit (and all the necessary valves and piping) for less than $1,000. Despite no previous experience in installing this treatment device, the installation process went smoothly and took only three hours. Since the unit was designed to treat only water dispensed at the kitchen tap of each school and a single drinking fountain, the children in the school were told from which taps they may drink. It is unknown whether significant alterations to the plumbing were necessary to supply treated water only to the drinking fountain and kitchen taps.

The treatment device does not include an automatic shut-off valve or warning light; however, high concentrations of contaminants can be detected through monitoring. Monitoring is conducted according to State regulations which mandate quarterly sampling for bacteria and arsenic. Samples are collected by the operator and then submitted to the State laboratory in Concord, New Hampshire, for analysis. Costs for the school for these tests average between $10 and $20 every three months.

The treatment system installed in the school has minimal maintenance requirements. A member of the school’s maintenance staff regularly monitors the system’s pressure gauge to verify that the media has not become clogged. If pressure decreases beyond levels recommended by the manufacturer, the prefilters for the treatment unit are replaced. The pre-filters are expected to last at least one year. The prefilters used in the unit are very inexpensive, costing only $5 to $10 each. Spent filters are disposed of in the school’s trash.

To date, Monadnock’s AA unit has presented no problems and continues to successfully reduce the arsenic levels in the school’s drinking water. The operator who recommended and installed this system emphasized that the system is not only very simple, economical, and effective, but also easily maintained.

7.1.4 Lummi Island, Washington (POE AX for Arsenic and Cyanide Removal)

This case study is summarized from system documentation provided by Thielemann (2001) and Kunesh (2003). Marine View Estates is a subdivision with a homeowners association on Lummi Island, in Whatcom County, Washington. Ten homes within the subdivision are served by one centralized well and classified as a community water system by EPA and the State of Washington. Another 10 homes within the subdivision are served by individual wells.

A homeowner attempting to develop a lot on the island was unable to obtain financing due to high arsenic levels in the water. The homeowner investigated centralized AX treatment, but the Washington Department of Ecology would not approve a discharge permit from the treatment process to a new drainfield due to concerns that the AX regeneration process might produce a hazardous waste stream. Instead, the homeowner proposed and received approval for the installation of POE units at each home, including the proposed home. The spent regenerant and backwash from each unit would be discharged to the existing individual drainfields, which did not require a permit. The approval of the use of the POE units was contingent on the following:

- The system must have a certified operator;
- Units must be checked monthly;
- Subsequent homeowners must be notified of the POE units; and,
- It must be demonstrated that the units could be checked in the field by a simple method. The arsenic concentration in the source water is around 0.27 mg/L and is well above the current MCL of 0.05 mg/L. Cyanide is also present at a concentration of 0.25 mg/L, just above the MCL of 0.20 mg/L. During the pilot testing, it was shown that arsenic levels could be reduced to less than 0.01 mg/L and cyanide levels could be reduced to less than 0.02 mg/L with the POE AX treatment. Throughout the treatment cycle the arsenic concentration remained below 0.02 mg/L.

The POE AX unit that was pilot tested and selected for this system consisted of a twin tank system with Purolite A-300E strong base resin. The tanks are operated in parallel to provide a larger flow rate and the backwash cycles are staggered so that water is available continuously. The tanks are preceded by a sediment pre-filter. The system also contains a flow restriction to ensure that the flow rate through the system does not exceed the design flow rate. The POE AX units are non-electric and contain non-electric flowmeters to initiate backwash and regeneration.

Pilot tests were conducted between 1995 and 2000. The initial pilot test was conducted to determine the effectiveness of the POE AX technology to remove arsenic and cyanide from the source water. Water was run through the unit at a rate of 1 to 2 gpm until 1,000 gallons had passed through the unit. The pilot test was operated without preoxidation for the first 500 gallons and with preoxidation for the last 500 gallons. The pilot test showed that preoxidation was not required for efficient removal of arsenic and cyanide from the source water.

The second pilot study was conducted at one household for six months. The purpose of this pilot t est was to achieve the following:

- Evaluate system operating parameters, such as flow rate and run length;
- Verify that a simple field test, such as pH or alkalinity, can be used for routine evaluation of the treatment system;
- Confirm that the treated water remains free from coliform bacteria;
- Verify that the drop in pH after resin regeneration is not a concern in successive cycles;
- Verify that preoxidation is not required for effective arsenic and cyanide removal; and
- Verify the effectiveness of backwash and regeneration.

During the second pilot study, samples were taken daily when possible and before each regeneration cycle. Samples were analyzed for arsenic, cyanide, bacteria, pH, and alkalinity.

Approval of the use of POE AX for the Marine View Estates water system took about four years from inception. This was largely due to the time required for pilot testing and a great deal of paperwork. The homeowners were not resistant to the implementation of the plan. All residents were notified by a memo that failure to install the proposed treatment could present an obstacle to the sale or transfer of their property.

To obtain approval for the use of the POE AX devices, the homeowners association was required to develop an O&M manual to be distributed to all homeowners. The homeowners are responsible for installation, maintenance, and daily operation of the POE AX units. However, the homeowners association was also required to retain the services of a certified operator to provide ongoing technical assistance, routinely verify proper operation of the POE treatment units, and collect samples for compliance.

Compliance with the arsenic MCL for the CWS is determined on a house-to-house basis. Compliance with all other contaminants regulated at the entry point to the distribution system is based on entry point monitoring. Maintenance is performed on an as needed basis for both the sediment pre-filter and the resin. The sediment pre-filter is checked every 6 months and is replaced if a change in system pressure occurs. The media has not yet needed to be changed (longest media in use has been six years), but the media is expected to last for about five years. The media will be replaced more frequently if it is no longer effectively removing arsenic and cyanide throughout the complete treatment cycle. Since there are no toxic pollutants held within the media, it is expected that the AX resin may be disposed of with the household trash.

The cost of the units is dependent on the contaminant(s) being removed. The average cost of the units treating for arsenic only was about $3,400, but ranged from about $2,500-$8,000 (the more expensive units also remove such contaminants as excessive sodium). This cost includes an initial and follow-up annual sampling done by the vendor in the first year, as well as necessary additional sampling. After the first year, it costs $4.50 per sample for the vendor to test the water for arsenic. All sampling results are sent to the State. The CWS is monitored by a certified operator on the island, who is responsible for sampling and routine maintenance. This certified operator is required to check the AX units every three months to ensure that they are operating properly.

The POE AX units are still in use at Marine View Estates. The units are considered a permanent compliance solution to the arsenic and cyanide problem in the water system. However, modifications to the systems may be necessary to comply with the new MCL for arsenic of 0.010 mg/L. As noted previously, the units are capable of achieving arsenic removal to below 0.010 mg/L, but by the end of the treatment cycle may rise to about 0.02 mg/L.

The homeowners are considering changing to an iron oxide media system. The problem with this system is that the media is expensive to replace (though it too can be thrown out with household trash) and needs to be changed every three to four years. Currently, there is only one distributor of these types of systems, so the cost is prohibitively high. If the cost of these units drops, the water system will likely change over to these units.

7.1.5 Fallon Naval Air Station (POU RO for Arsenic Removal)

This case study is summarized from information provided by Mazanek (2003), Jones (2001), and Manley (20
quarters, and various other base facilities. NAS Fallon water comes from three, 500-foot deep wells tapping an underground source of water called the Basalt Aquifer. The Basalt Aquifer also provides water for the City of Fallon and the Fallon Paiute-Shoshone Tribe through their respective distribution systems. The Basalt Aquifer has high, naturally occurring levels of arsenic, which are greater than the MCL. After water comes out of the NAS Fallon wells, it is treated with a chlorine disinfectant to protect consumers against microbial contaminants and pumped to the NAS Fallon water distribution system. At this site, a temporary POU treatment measure was decided upon to lower the arsenic levels. The affected population was provided information regarding the reason for treatment units and the danger of arsenic by means of the annual CCR. Individuals new to the base are informed through the military indoctrination process that familiarizes new employees and residents with the base and its operation.

POU RO devices, equipped with GAC pre- and post- filters and a sediment pre-filter, were installed all over the base. There was no pilot test because this was intended to be a temporary treatment solution. The units do not have water meters, automatic shutoff, or warning lights, but do have storage tanks and re-pressurization chambers. The units were tested and certified by NSF International. The units typically filter around 25 gallons per day (gpd).

The units were installed and are maintained under contract with the vendor. Installation required about one hour per unit, including PVC piping between the unit and a separate stainless steel tap, which was included in the purchase price of the unit. Maintenance and disinfection are performed every nine months, sediment and GAC filters are replaced every nine months, and RO membranes are replaced every 27 months. The vendor disposes of all the residuals. Access to units is assured through Navy mechanisms set up to enable house inspections. There is no contract set up for the vendor to insulate the system should a unit fail. Base maintenance or the vendor handles complaints or questions within 24 hours.

About 360 POU RO under-the-sink units were installed in base quarters in May 2001.

Additionally, approximately 75 water cooler style RO machines were installed in common areas such as offices, gyms, and daycares, and there are 11 strategically located RO vending machines for on and offbase residents to fill one- to five-gallon bottles. The RO units effectively remove 90 percent of arsenic from the water, reducing the average influent concentration of 0.10 mg/L down to below detection limits.

The RO units are serviced quarterly and tested twice a year to make sure the water meets drinking water standards. No major operational problems have been identified thus far, and the base residents seem satisfied with the units’ performance.

The costs associated with the under-the-sink RO devices are about $300 per unit for purchase and installation and about $129 per unit per year for maintenance and replacement. The costs of maintenance run high, partially due to the distance (65 miles) between the system location and the vendor, and partially due to the costs for replacement parts ($9 per sediment filter, $12 per GAC filter, and $55 per RO membrane).

NAS Fallon is collaborating with the City of Fallon to design and build a central water treatment facility for treating arsenic. Once the central treatment is on-line, the POU devices will be abandoned.

7.1.6 EPA Demonstration Project in Grimes, CA (POU AA and Iron Media for Arsenic Removal)

The information in this case study is summarized from information provided by Bellen (2003 and 2004), EPA (2004), and Narasimhan (2005). An EPA demonstration project was completed to identify, measure, and record the conditions necessary for successful implementation of a centrally managed POU treatment strategy for compliance with the new arsenic standard of 0.010 mg/L. The focus of this study was on POU AA and POU iron media for arsenic removal. However, because POU iron oxide media was not commercially available at this time, only POU AA devices were installed in the community. Iron oxide media was pilot-tested along side AA. Based on that pilot, it could have lasted twice as long as the AA device.

The criteria for site selection included community size (25-100 service connections), an arsenic level between 20 and 50 ppb, compliance with MCLs for all other contaminants, water quality, and local and/or State support. Grimes, California, with a population of about 300, was selected as the site for the study. POU devices were installed in 122 locations, of which 105 were residences and 17 were community buildings or businesses. One of the residences in the study includes a daycare. Eleven residences or businesses declined to participate.

The pH of the water is 8.0–8.4, and the arsenic is present in the system as arsenic V due to chlorination. There are slightly elevated levels of silica in the water as well.

Each unit had an automatic shutoff device. The POU AA units were equipped with two AA media cartridges and a GAC post-filter. The AA media cartridges were expected to last for 500 gallons before needing to be replaced. After one year, 90 percent of the POU AA cartridges did not need replacement. The POU iron media units used in the pilot were equipped with one iron media cartridge, one pre-sediment filter and a carbon post-filter. Installation of each AA device took about one hour due to the age and diversity of the plumbing in the community. In a community of more modern homes, installation would probably have required only 15 minutes per device. Cartridge replacement for both devices took about 15 minutes. The POU devices, installation, and maintenance were donated to the community by Kinetico for the study. Access to the homes for installation and maintenance of the POU devices was not difficult to achieve, but coordination of schedules to ensure that someone was home was sometimes difficult. One other problem is that some residents may not have actually been using the POU systems after they were installed.

Every POU device was sampled for arsenic after installation, with composites of samples from five units analyzed to save on analytical costs. Then, a portion of the POU devices was sampled quarterly with each device sampled at least once during the study period. Two samples exceeded the new arsenic MCL of 10 ppb during the study. Each device was re-sampled and the cartridge was replaced if the result was confirmed. Microbiological samples were also collected during the study. The geometric mean for HPC was 320 cfu/mL. None of the samples tested positive for fecal coliforms. If any of the samples had tested positive for fecal coliforms, the media cartridges would have been replaced and the system would have been sanitized. The units were rated at 500 gallons capacity. The iron media cartridges actually treated 800 to 1,100 gallons before breakthrough; the AA media cartridges lasted longer, treating as much as 1,600 gallons before needing replacement.

At the end of the study, the overall attitude of the community toward the use of the POU devices was positive.

The POU devices cost about $300 each retail; however, Kinetico stated that it would consider providing POU units at cost. Management and reporting could cost $125 to $200 per year per unit, resulting in a household cost of $17 to $25 per month (using a 3 percent interest rate over 10 years).

Depending on the frequency of sampling and filter cartridge change-out, this approach could cost less than half the estimated cost of central treatment. For additional information, contact the National Sanitation Foundation, which has conducted research on this system.

7.1.7 American Water Works Association Research Foundation (AwwaRF) Project 2730 (Multiple POU/POE Technologies for Arsenic Removal)

An AwwaRF project evaluated the feasibility of using POU and POE treatment systems for small system compliance with the new arsenic MCL of 0.010 mg/L (Narasimhan 2005). Technologies examined in this study include POU RO, POU AA, POU manganese AA, POE GFH, and POE iron AA.

These technologies were evaluated at various sites in Arizona, Nevada and Texas. These devices were operated in both continuous and intermittent conditions. Contaminants being monitored include arsenic, TDS, silica, hardness, and HPCs.

POU and POE devices were field tested at the water systems’ facilities, rather than at residents’ homes, in tests designed to simulate one year of residential use. The field testing program had two phases.

During phase A, which lasted two weeks, POU devices were conditioned by operating 40 minutes on followed by 40 minutes off, 16 hours per day. POE devices were run 16 hours on and 8 hours off. During the 10 weeks of Phase B, POE devices were operated continuously. POU devices were operated according to the schedule shown below in Exhibit 7.2.

During both phases, samples were taken weekly from raw water for arsenic and other water quality parameters. Treated effluent was sampled for arsenic and certain parameters three days per week.

Exhibit 7.2: Operational Schedule for POU Devices During Phase B

Period	Operating Times	Duration (minutes)
1 (Weeks 1-2)	6:00 am	2
	8:30 am	5
	11:30 am	5
	5:30 pm	2
	6:30 pm	5
	9:30 pm	3
2 (Week 3)	no flow (simulated vacation)	
3 (Weeks 4-10)	6:00 am	2
	8:30 am	5
	11:30 am	5
	5:30 pm	2
	6:30 pm	5

Exhibit 7.3: POU and POE Performance Summary

Location	Technology	Effluent Si, as SiO_2 (mg/L)	Effluent pH	Effluent Arsenic (mg/L)	Gallons Treated before 10 ppb Breakthrough	Sufficient for 1 Year Operation in 5-Person Home? (1,000 gal)
Metro Water, Tucson, AZ	POU RO	4.8– 7.7	6.7–8.8	<0.002	>780	Yes
	POU AA	0.2–15.0	7.4–8.6	<0.002	2,660	Yes
	POE Fe-AA	24–39	7.0–7.7	<0.001–0.010	356,400	Yes
	POE GFH	34–39	7.2–7.7	<0.001–0.006	343,400	Yes
Sun City West, AZ	POU RO	0.9–2.3	7.1–8.7	<0.002	>1,300	Yes
	POU AA	<0.1– 14.9	7.7–8.4	<0.001–0.025	1,780	Yes

Exhibit 7.3 (continued): POU and POE Performance Summary

Location	Technology	Effluent Si, as SiO_2 (mg/L)	Effluent pH	Effluent Arsenic (mg/L)	Gallons Treated before 10 ppb Breakthrough	Sufficient for 1 Year Operation in 5-Person Home? (1,000 gal)
Sun City West, AZ (continued)	POU Mn-AA	<0.1– 14.2	7.9–8.5	<0.001–0.026	1,780	Yes
	POE Fe-AA	1.3–13.6	7.2–8.5	<0.001–0.022	63,400	Yes
	POE GFH	0.1–15.4	7.2–8.5	<0.001–0.014	368,600	Yes
Stagecoach, NV	POE Fe-AA	1.2–26.0	8.0–8.3	<0.001–0.014	34,600	Yes[1]
	POE GFH	4.1–29.0	8.0–8.3	<0.001–0.009	110,000	Yes
Unity, ME	POU RO	<1.0	8.2	0.053–0.100	0	Yes[2]
	POU Mn-AA	7.0–8.5	8.0–8.1	<0.001–0.110	640	Yes
Carson City, NV	POU GFH	1.3–23	7.7–8.3	<0.002–0.012	15,200	Yes
	POU Mn-AA	1–21	8.0–9.0	<0.002–0.016	7,700	Yes
Houston, TX	POE GFH	not available	6.2–7.8	<0.001–0.008	>328,900	Yes
	POE Fe-AA	not available	5.2–7.0	<0.001–0.014	201,450	Yes

Notes:
1 May be applicable with periodic backwashing of the Fe-AA media.
2 May be applicable with pre-oxidation, prior to treatment.

7.2 Copper Treatment

7.2.1 Florence, Montana (POU CX for Copper Removal)

POU CX units were installed at a school and a trailer park in Florence, Montana, to study the efficiency of these units in reducing copper levels at these sites as part of a study (Abdo, et al., 2000).

One POU CX unit was installed at a drinking fountain at the school and another unit was installed under a sink in a residence in the trailer park.

Florence-Carlton School is a nontransient, noncommunity water system that serves approximately 950 students and 100 staff members during the school year. Water for the school is obtained from two wells sunk in alluvial fan deposits and is stored in a 500-gallon tank prior to distribution. The source water is characterized by low levels of copper. However, the source water also has low TDS (<150 mg/L) and is corrosive to the school’s water distribution system, causing relatively high levels of copper in school drinking fountains.

The Bitterroot-Pines Trailer Court is a CWS that serves 16 trailers and two homes. This system relies on water pumped from the same aquifer as the school. Copper levels in the source water are below detection limits, and TDS levels are even lower than those found at the school (<100 mg/L). The source water is also corrosive to the plumbing materials used in the trailer park residences.

Weekly samples were collected at locations directly before and after the POU CX units. These samples were analyzed for pH, sodium, alkalinity, bicarbonate, specific conductance, copper, lead and heterotrophic bacteria. The total flow through each of the devices was also recorded weekly.

Breakthrough of copper was observed after about five months (approximately 125 gallons of water treated) at the school and after about two months (approximately 170 gallons of water treated) at the trailer park. Prior to breakthrough, the unit reduced influent copper levels by 8 to 84 percent at the school and 58 to 98 percent at the trailer park. It is believed that the broad range of removal rates (especially those observed at the school) is related more to the variability of influent copper concentrations than to the effectiveness of the treatment unit. However, it is important to note that when breakthrough did occur, chromatographic peaking was observed (i.e., the treated water had higher levels of copper than the influent). This observation indicates that copper was being displaced from the resin by another contaminant (not identified in this study) in the water for which the CX resin had a higher affinity. The use of a special-purpose copper-specific resin may increase run length.

7.2.2 Location 2, Montana[1] (POU RO for Copper and Lead Removal)

Four-stage POU RO units were installed in a 16-unit trailer park in Montana in the spring of 2000 to reduce high levels of lead and copper (0.005 mg/L and 3.25 mg/L, respectively). The units consist of a particulate pre-filter, a GAC pre-filter, an RO membrane, a 3-gallon storage tank, and a GAC post-filter.

A separate tap was also included with each RO unit. The cost of each system was $970 installed ($15,520 for the entire trailer park). The trailer park has entered into an ongoing maintenance agreement with the vendor for $150 per year. Under this agreement, the vendor will check each RO unit twice per year and handles disposal of the spent cartridges and membranes. However, the cost of replacement parts is not included in the $150 fee and is borne by the trailer park.

To date, the units have worked well, reducing the copper levels to 0.22 mg/L (93 percent reduction) and reducing lead levels to 0.003 mg/L (40 percent reduction).

[1] Name of trailer park and location withheld at request of system for confidentiality.

7.3 Fluoride Treatment

7.3.1 Suffolk, Virginia (POU RO for Fluoride Removal)

The King’s Point subdivision in Suffolk, Virginia was chosen by EPA and the State of Virginia as a demonstration site to evaluate the feasibility of POU RO treatment for fluoride. The study later became a part of the compliance plan for King’s Point. This study was summarized from Lykins Jr., et al. (1995) and Werner (2001, 2002, and 2003).

King’s Point subdivision has its own water system served by two well sources. At the beginning of the study, the water from the two well sources was not disinfected or otherwise treated. The water available to King’s Point contained fluoride in the range of 5.0 to 6.1 mg/L, which exceeds the primary MCL of 4.0 mg/L. When the site was chosen for inclusion in the study, the King’s Point water system served 40 connections (39 residential, one commercial); by the end of the project period it served about 57 connections (56 residential, one commercial).

Due to the high concentration of fluoride in the drinking water system, Suffolk received two notices of violation, one from the Virginia Department of Health in 1989 and one from EPA in 1991.

After examining its options, the city chose POU treatment as the most attractive option based on cost, timeliness, and O&M requirements. In 1992, the city and State agreed to the POU demonstration project as part of the city’s compliance plan.

The project team included EPA, the Virginia Department of Health, the City of Suffolk, and three manufacturers of consumer drinking water products. During the study period, the unit suppliers were responsible for all costs. The POU units used in the study consisted of a sediment pre-filter, a high-flow thin-film (HFTF) membrane, a storage tank, and GAC post-filter. Initially, flowmeters were not installed on the POU RO units. The units were also not equipped with alarms or shut-off devices. The units were installed under the kitchen sink at all homes and were also connected to refrigerators that were equipped with ice-makers. The units were installed in all homes in April 1992. Three manufacturers supplied units and services for the study, with each manufacturer supplying one-third of the RO units used in the study.

No pilot testing was done before installing the RO units since the project was intended as a demonstration study.

All homeowners in the King’s Point subdivision were required by the City of Suffolk and the Virginia Department of Health to participate in the study before the State and EPA would accept the POU alternative. The EPA regional office required 100 percent participation in this study, lest they continue with the enforcement proceedings regarding the fluoride violation, since POU treatment was not acceptable as the best available technology (BAT). The homeowners were also required to sign a home access agreement that relieved the city of liability for damages caused by the treatment units. There were no significant problems in achieving 100 percent homeowner participation in the study.

The subdivision was divided into three regions, each served by a different manufacturer of POU RO units. The initial monitoring plan called for one resident from each region to volunteer their home as a distribution sampling site, where chemical and microbiological samples would be collected monthly by a city official. The analyses were performed and recorded by the Suffolk Department of Public Utilities.

The analyses included conductivity, fluoride, HPC, pH, sodium, TDS, and turbidity. Coliform analysis and a semiannual complete inorganic scan were later included. A representative of the manufacturer was called if a unit required routine service.

Shortly after initiation of the project, high HPC levels were detected in the water treated by the RO units. To remediate this problem, central chlorination of the well water was implemented. In addition, the chlorine sensitive HFTF membranes were replaced with cellulose triacetate (CTA) membranes, the sediment pre-filter and GAC post-filters were replaced with non-carbon turbidity filters or no filter at all, and all of the RO units were disinfected. The GAC post-filters were believed to be a significant factor causing the high HPC levels. In response, an additional monitoring and sampling site in each manufacturer’s service region was added. In the event of high HPC or fluoride levels, a manufacturer’s service representative scheduled necessary maintenance with the homeowner. Data were collected from the sampling sites for nearly two years.

After implementing the disinfection strategy, the HPC levels appeared to be rising again. To reduce these levels, a weekly flushing program was implemented at all dead end mains to ensure that a 1.5 mg/L free chlorine residual was maintained at the ends of the distribution system. In addition, educational flyers were mailed to each household instructing the customers that frequent use of the RO devices improves the water quality delivered. The flyers also included information on the high quality of the water produced by the RO units.

A new plan was developed in 1994 to monitor all of the RO units and to demonstrate typical maintenance. The manufacturers were responsible for scheduling and collecting samples from residences in their respective regions quarterly on a monthly rotating basis among manufacturers. The sampling within each month was staggered throughout the month rather than conducting all sampling on the same day. Sampling was usually conducted by paying a visit to target homes after 5 p.m. or on the weekends.

Approximately 10 percent of all appointments were not kept. During each visit the homeowner was asked if the treatment unit was operating and if they used the water from the treatment unit for all of their cooking and drinking needs. In addition, the homeowner was informed of good operating practices, such as frequent use and flushing, that would improve the quality of the water from the treatment unit. In a routine service call, pre- and post-device free chlorine, total chlorine, and conductivity measurements were recorded. Observations indicated that the conductivity reduction from the influent to the treated water was generally lower than the fluoride rejection rate. Therefore, conductivity could be used as a surrogate for monitoring the efficacy of the unit in removing fluoride. Membranes were replaced when the conductivity reduction fell below 70 percent of the influent.

In the event that mechanical problems occurred with the RO units, the customers could call a manufacturer's representative. It was mandated that such problems were to be addressed within 24 hours of the service call. Any other problems or complaints were addressed to representatives of the city.

Liquid residuals from the RO treatment process were sent to the kitchen sink drain and ultimately were disposed of with the household wastewater into septic systems. The RO unit manufacturers were responsible for membrane and cartridge replacement, and ultimately for the disposal of spent membranes and cartridges.

Fluoride levels in tap water were maintained below 2.0 mg/L in all households in the subdivision. Monitoring results for a one-month period showed fluoride concentrations at the tap ranging from roughly 0.1 mg/L to 0.6 mg/L. Variations in fluoride concentrations from month-to-month or residence-toresidence were explained by membrane degradation. Exhibit 7.4 shows the data for treated water collected from one residence and the raw feed during a quarterly sample collection.

Exhibit 7.4: Performance Data for a Typical POU RO Unit in Suffolk, VA

Contaminant	Influent (1/12/95)	Effluent (1/9/95)
Total Coliform (coliform organisms/100 mL)	< 1	< 1
Heterotrophic Plate Count (cfu/mL)	12	5
Fluoride (mg/L)	5.62	0.352
Sodium (mg/L)	207	18.0
Total Dissolved Solids (mg/L)	474	36
Turbidity (NTU)	0.18	0.08
Conductivity (μmho/cm)	768	62.5

If units were not meeting the MCL or found to be otherwise in non-compliance, they were targeted and resolved on an individual basis.

A customer survey was conducted at the beginning of the study, after disinfection was implemented, and again at the end of the study. Customers were asked questions about how they would rate the water before and after the POU RO units were installed, water usage, maintenance visits, and their preferred option for dealing with the high fluoride levels in the system. In the final survey, 75 percent of the respondents indicated that they used the RO water for all of their drinking and cooking.

Overall, the customers were satisfied with the service and quality of the RO water. Some homeowners initially resisted the installation of the RO units because it required that a hole be drilled in the sink to insert a tap for the RO unit. However, this problem was circumvented when the city agreed to replace the sinks when the RO units were removed. Five of the homeowners indicated that they resented the intrusion into their homes that was necessary for installation and service of the RO units.

In March 1995, the demonstration project was completed, and the City of Suffolk chose to lease the POU RO units so that the distributors would maintain responsibility for routine service and O&M activities. The approximate costs for water treatment ran $400/year/unit to rent the units and $400/year/unit for labor, maintenance, sampling, and analyses. Despite the overall success of the project, the King’s Point subdivision was ultimately connected to the Suffolk, Virginia, city water system in February of 1998. The decision to connect to the city water system was largely due to rapid growth in the King’s Point subdivision, which made POU treatment increasingly less economical.

7.3.2 Emington, Illinois (POU RO for Fluoride and TDS Removal)

This case study is summarized from Bellen, et al. (1985) and Lykins Jr., et al. (1992). In Emington, Illinois, 47 low-pressure RO units were installed by equipment dealers and monitored for eight months. The primary target contaminants for removal were fluoride and TDS. The RO systems consisted of a 5-μm particulate pre-filter, a GAC pre-filter, a pressurized 2-gallon tank, a GAC post-filter, and a thin-film RO membrane. Treated water was stored in the tank and passed through the GAC post-filter before being dispensed.

The POU units removed an average of 86 percent of the fluoride from source water containing 4.5 mg/L. TDS rejection averaged 79 percent from source water concentrations of 2,620 mg/L. A wide variation in rejection rates was observed. Most of the variation was attributed to a pressure drop across the pre-filter assembly. RO membranes (especially cellulose acetate membranes) are more effective for contaminant removal in high water pressure environments. Exhibit 7.5 tabulates the performance data for the Emington POU project.

While the POU RO units operated satisfactorily, a significant drawback was their low water output—approximately 3 gpd. To supplement their needs, many homeowners purchased up to 30 gallons of bottled water per month at a cost of $1 per gallon.

The HPC of treated water was found to be an order of magnitude higher than that of untreated water. Controlled sampling from various stages of the RO unit established that most bacterial growth occurred in the GAC polishing unit (i.e., post-filter). Coliforms were found in four pre-device and 11 post-device samples (16 percent of all samples).

Exhibit 7.5: Performance Data for POU RO Devices in Emington, IL (1985$)

Number of Participating Sites	47
Service Area Type	Central system with single family homes
Mean Treated Water Use (gpd)	0.8
Mean Flow Rates (gpd) Product Water Reject Water	 2.9 22.5
Fluoride (mean mg/L) Influent Effluent	 4.5 0.6
Total Dissolved Solids (mean mg/L) Influent Effluent	 2,530 520

7.3.3 New Ipswich, New Hampshire (POE RO, AA, UV for Fluoride Removal)

Boynton Middle School, located in New Ipswich, New Hampshire, serves approximately 600 students and staff. In early 1997, the school hired a consulting firm to implement a drinking water treatment system to reduce high fluoride levels in the school's water (Guercia, 2001). Prior to the installation of a new treatment system, the maximum fluoride concentration in the school's water was greater than 5.5 mg/L. To achieve a goal of 90 percent reduction in influent fluoride, the consultant recommended that the school install a single treatment system with a parallel plumbing system that would treat water traveling to six water fountains and two sinks in the kitchen. This option was predicted to be less costly and easier to maintain than installing multiple individual units at each fountain and sink.

Multiple and redundant treatment components were incorporated into the treatment system to ensure the efficient removal of the contaminant of concern. Water first travels through a 5 x 20 inch 5-μm sediment pre-filter cartridge, followed by a 5 x 20 inch 1-μm sediment cartridge. The water is then forced through a 900 gpd RO unit. Next, the water passes through a contact vessel containing one cubic foot of AA and two cubic feet of crushed limestone in order to restore the pH to its original level. The water then enters a 500-gallon atmospheric storage tank before it is repressurized and sent through a UV element. Finally, the water travels through a GAC post-filter containing two cubic feet of media prior to distribution.

After receiving State approval, the system was installed in the summer of 1997. In addition to the system itself, the consultant also recommended that the school incorporate a drinking water quality section into its science program to educate the students on the importance of safe drinking water and to inform them of the particular water fountains and sinks in the school from which they should drink. The system cost $17,230 installed. The development and submission of all documentation required for State approval of the system was included in this price.

The consultant continues to serve as the operator of the Boynton system and is responsible for the unit’s maintenance and monitoring. Every six months, the consultant visits Boynton to perform preventative maintenance on the system. This maintenance includes: ensuring that the machinery is operating efficiently, replacing cartridges, testing for TDS before and after the treatment unit, adding crushed limestone as needed, changing the AA and carbon media as needed, testing for fluoride before and after the RO unit once per year, and changing the UV lamp once per year. The preventative maintenance takes approximately three to four hours to complete and is covered under the school’s contract with the consultant. Rather than charging the school for each individual service call, the consultant bills the school at the beginning of each year for all services expected to be provided over the course of the year. The school has the choice of pre-paying (and receiving a 10 percent discount) or making monthly payments on the annual fee. Based on the average number of service calls made each year, the school is charged approximately $500 for each maintenance visit.

The consultant is also required by the State to sample for fluoride on a quarterly basis. Since it is often not possible for school maintenance personnel to monitor the system even on a weekly basis, the treatment system was designed with enough redundancy to reduce the potential for a problem to arise between scheduled maintenance and monitoring visits. It should be noted, however, that the system lacks an alarm or automatic shut-off. The school has contacted the consultant on several occasions in response to visual signs of problems, such as an overflowing or empty storage tank.

The consultant recommends that the RO membrane for this system be replaced every 3 to 5 years; both of the sediment filter cartridges be replaced every 4 to 6 months; the AA media be replaced after 2 to 3 years; limestone be added every 6 to 12 months; and the GAC media be replaced after 4 to 5years.

For every one gallon of water that the RO generates, one gallon of water is wasted (50 percent recovery). The wastewater, which contains approximately twice the mineral content of the untreated well water, goes directly to the school’s septic system. The spent cartridges are disposed of in the garbage at no cost, and the AA is incinerated at a nearby facility at a cost of $65 per cubic foot. Note, however, that the spent AA could be disposed of in a standard landfill since it is not classified as a hazardous material.

Thus far, the Boynton system has been extremely effective at treating the school’s drinking water and reducing the fluoride levels. The school has encountered very few problems with the system. However, an unidentified black material has recently begun to accumulate on the cartridge filters.

Because this material obstructs the flow of water, the consultant has had to make one or two additional visits to Boynton in order to replace the clogged filters. In general, additional maintenance visits are uncommon (about one unscheduled service call every other year).

7.3.4 Opal, Wyoming (POU RO for Fluoride and Sulfate Removal)

This case study was based on information from Jack Theis of EPA Region 8 (2002, 2003). The town of Opal, Wyoming, is a small, rural community of about 40 homes and roughly 98 people. The community is served by a centralized well that is chlorinated and has individual septic tanks and drainfields serving each home. The system is regulated by EPA Region 8.

The town’s well water was in violation of EPA drinking water standards, containing an average fluoride concentration just over the MCL of 4 mg/L and elevated levels of sulfate which adversely affected the taste and odor of the water. EPA Region 8 determined that POU RO treatment was the most economically feasible approach for this community. After several sparsely attended town meetings, the town passed an ordinance to guarantee 100 percent participation in the POU project. EPA Region 8 decided to first conduct a six-month pilot study prior to full-scale installation, during which they paid the installation and monitoring costs for six NSF-certified POU RO units. Two different out-of-state home water treatment unit vendors were contracted to handle installation, on-site maintenance and monitoring of the POU RO units. From inception to installation, the process took about 16 months.

Each household that participated in the pilot study had an under-the-sink unit installed at the kitchen sink tap. Each unit contained GAC cartridges before and after the RO membrane. The first GAC cartridge was to remove chlorine that could damage the RO unit, while the second, after the RO membrane, was for taste and odor. The units themselves were equipped with both storage tanks and repressurization mechanisms, but not flowmeters. The units had warning lights to indicate unit (membrane) failure, based on a conductivity test. In addition, a bad taste or odor, caused by sulfur passing through the device, would indicate failure. The units were not equipped with an automatic shut-off device.

During the pilot test, fluoride, sulfate, and HPC bacteria were monitored monthly at each unit.

High HPC counts were observed during the pilot study, but were not determined to be harmful. HPC levels were around 20,000 to 30,000 cfu/ml and were reduced to around 5,000 cfu/ml after flushing the unit. The residents were highly satisfied with the removal of the water’s unpleasant tastes and odors.

During the pilot testing, only a few leaks and other problems occurred in the units that required a visit by the vendor.

The town obtained special consent from the State to use the lowest level of state-certified water system operator in the servicing, operation, and maintenance of these units, since they are extremely simple to operate. Complaints about the units went through the system operator or the mayor of the town.

Access to the units was fairly simple to arrange; scheduling maintenance appointments was also fairly simple, since the residents were generally cooperative and interested in the project. However, the residents in the pilot study were hand-picked, and other residents may not be as cooperative. The biggest problem was getting the vendor to arrive and make the repairs in a timely manner. By the end of the sixmonth pilot test, all of the units were working satisfactorily and treating fluoride to less than 0.1 mg/L.

An administrative order outlining the units’ maintenance requirements when the whole town goes on-line has been sent out to relevant and interested parties, but thus far the sampling protocol/schedule is still under development, and the final protocol must be approved by legal staff. The recommendations are as follows:

- One unit per month will be sampled for heterotrophic bacteria. A different unit must be sampled each month. Heterotrophic bacteria will be sampled at the regular kitchen tap and the tap served by the POU device for comparison.
- One unit will be sampled for fluoride each quarter. This can be the same unit that is sampled for heterotrophic bacteria.
- SOCs and inorganic chemicals (IOCs) will still be sampled at the entry point to the distribution system to determine how the water quality is changing.
- Lead and copper will be sampled, but a new protocol/approach must be developed.
- This sampling schedule will be dictated by treated water quality and a conservative maintenance/replacement schedule.

In disposing of the residuals, the town is considering either contracting this service out, or maintaining responsibility itself. Since the principal contaminants are fluoride and sulfate, the present plan is to dispose of solid residuals (such as used cartridges and membranes) in the household trash.

Liquid residuals from the RO treatment process were sent to the kitchen sink drain during the pilot study and ultimately were disposed of with the household wastewater into septic systems. Both GAC cartridges and RO membranes are scheduled to be changed annually upon inspection.

Compliance will be determined based on all units treating to below the fluoride MCL. The whole system is to be considered in violation upon the failure of any one of the units to treat to below this MCL.

The system is also required to maintain records of each unit and make these records available during sanitary surveys.

There was some reluctance on both the State’s and the citizens’ part at first, mostly focused around the cost of operating the system. The purchase price was around $700-800 per RO unit, and the maintenance fees are anticipated to run about $16 per month per household. However, due to the improved taste of the water treated by the RO units, a POU system has become the favored and accepted option for water treatment in this area. This POU treatment strategy requires considerable involvement from the regulatory agency and the success of this project will lie in the maintenance and sampling program, but overall, the POU RO water treatment seems to have high potential as a solution to Opal’s water problems.

7.4 Nitrate Treatment

7.4.1 Suffolk County, New York (POE/POU GAC, IX, RO, and Distillation for Nitrate Removal)

A 1983 study evaluated various water supply options for the towns of Riverhead and Southhold, both located in the predominantly rural North Fork of Suffolk County. This case study was summarized from Lykins Jr., et al. (1992). Due to the size and demographics of the communities, it was determined that the development of public water supplies throughout the high nitrate areas would be prohibitively expensive. Individual POU/POE units were recommended for these contaminated areas.

POE devices and countertop and line bypass POU units were examined in this study. Several treatment technologies were tested, including GAC, IX, RO, and distillation. All units demonstrated the ability to remove the contaminants of concern to the necessary levels, and consumers were satisfied with the performance of the units. Exhibit 7.6 summarizes the water quality problems, the types of POU/POE devices used to treat the nitrate, chloride, and/or VOCs, and the performance of each unit.

Exhibit 7.6: Performance Data for POU and POE Devices in Suffolk County, NY

Unit Number	Water Quality Problem	Type of Device	Average Nitrate		Average Organics	
			Influent (mg/L)	Effluent (mg/L)	Influent (μg/L)	Effluent (μg/L)
1	Nitrate	Countertop (GAC+IX)	9.2	3.3	NA	NA
2	Nitrate	Countertop (GAC+IX)	7.7	2.4	NA	NA
3	Nitrate, chloride	Line bypass (RO+GAC)	10.8	4.6	NA	NA
4	Nitrate	Line bypass (RO+GAC)	9.9	4.3	NA	NA
6	Nitrate, VOC	Countertop (Distiller)	12.2	< 0.2	12	< 2
7	Nitrate	Line bypass (RO+GAC)	11.1	0.3	NA	NA
8	Nitrate	Line bypass (RO+GAC)	7.7	0.2	NA	NA
10	Nitrate	Line bypass (RO+GAC)	11.2	0.3	NA	NA
12	Nitrate	Batch (distiller)	9.3	0.2	NA	NA
15	Nitrate	Line bypass (RO+GAC)	8.6	0.8	NA	NA
17	Nitrate	Line bypass (RO+GAC)	11.5	0.3	NA	NA
18	Nitrate	POE (IX)	12.1	0.6	NA	NA

Despite the success of the units, the sampling results during the study revealed several problems that could be traced to improper installation or inadequate maintenance. Several units developed plumbing leaks that required repair. Organic contaminants leached into treated water from three units due to solvents used during the manufacturing or assembly of the units. High levels of copper were found in the effluents from two units that used copper discharge lines. Once these units were replaced, all units functioned satisfactorily for the duration of the study.

Bacteria were present in samples from all of the treatment units that included a GAC filter. However, no evidence of pathogenic bacterial growth was found, even in samples that exhibited elevated HPCs.

The effluents from three units tested positive for coliform bacteria after installation, though follow-up samples were satisfactory. Two of the contaminated units were countertop models, which are more susceptible to cross-contamination by homeowner activity. Additional disinfection procedures should be followed before and after installation of these models if they are selected by the water system for use in a compliance strategy.

The RO units exhibited varying removal efficiencies. This was probably due to the lower efficiencies of the cellulose acetate membranes used in some units relative to the thin film composite membranes used in others.

A detailed description of the monitoring plan, the capacity of the POU units, a full discussion of the division of responsibilities, and the cost per gallon of water treated were not provided in the literature reviewed. However, the study did emphasize the need for conservative design of POU/POE treatment devices to preclude premature contaminant breakthrough due to interactions between multiple contaminants (and from contaminants as yet undiscovered in the area).

7.4.2 Hamburg, Wisconsin (POE AX for Nitrate Removal)

Prior to the installation of a POE AX treatment system, Maple Grove Elementary School, a small rural school located in Hamburg, Wisconsin, experienced several problems with its drinking water (Maher, 2001). First, the corrosive nature of the system’s source water led to high levels of lead and copper scavenging from the school’s pipes. Second, because the school is located in an area with sandy, gravel-like soil that was once heavily farmed, high nitrate levels were also present in the water. To address these water quality issues, Maple Grove installed a treatment system in 1996. The system is comprised of an AX element for nitrate reduction, and a polyphosphate feed as a corrosion inhibitor.

Although the school still encounters some difficulties with corrosion control, the AX element has been extremely successful at reducing the nitrate levels present in the water, maintaining levels well below the MCL since the system’s installation.

Maple Grove purchased its treatment system from a local vendor. The vendor was also responsible for installing the system. The installation process took approximately seven hours to complete. The treatment system includes two resin beds with automatic regeneration, two feed pumps, and two solution tanks (one feeding chlorine and one feeding orthophosphate). Currently, the system serves approximately 200 students and staff members.

The unit lacks both an alarm and an automatic shut-off system; however, the vendor has supplied the school staff with test kits for sampling purposes. Under the regulations established by the Wisconsin DNR, the vendor must establish a service contract with its customers to ensure proper system operation to retain its license. As a result, all of the vendor’s service contracts include a provision that provides for monthly visits to perform testing and to confirm ongoing effective system operation. Although these monthly visits are included under the service contract between Maple Grove and the vendor at no extra charge, Maple Grove is charged for any additional maintenance visits that may be required. Since the system has been installed, the school has required about three additional visits per year at a cost of $42 for the first half-hour and $42 for each additional hour.

A timer triggers regeneration of the AX units once per week during the night. To ensure ongoing water availability, the two resin beds are operated in parallel. A saturated brine solution (60 percent) is used for regeneration.

The AX resin is expected to last for 10 to 16 years. Since the system was only recently installed, the school has not yet had to deal with media disposal issues. At other installations, the vendor re-bedded the system on site and the property owner disposed of any remaining spent media in a standard landfill.

7.4.3 Fort Lupton, Colorado (POU RO for Nitrate and Total Suspended Solids (TSS) Removal)

To comply with an enforcement order for nitrate issued by the Colorado Water Quality Control Division (WQCD), the Wattenburg Improvement Association (WIA) elected to install POU RO units in each residence in Wattenburg, a town of approximately 100 households (Alberts and Peterson, 2000).

Prior to selecting the specific device to install, the WIA hired a contractor to evaluate the capabilities of RO units manufactured by three different firms. Each device was equipped with a booster pump to increase line pressure from 30 to 60 psi.

Pilot testing was conducted in the homes of three volunteers from the Board of Directors of the WIA. One device was installed underneath the kitchen sink in the house of each volunteer in June of 2000 and was operated for approximately three months. Over the course of the evaluation period, the volunteers were asked to answer questions regarding the convenience and performance of the units.

Homeowners were pleased with the taste of finished water and the quantity of water available from the treated tap. They were also satisfied with the convenience of the units. However, the volunteers reported being less satisfied with the installation and maintenance of the filters. Specifically, they were concerned that maintenance would be difficult if POU RO units were installed in each household in the community.

The homeowners did, however, recommend hiring knowledgeable professional maintenance personnel to perform all necessary maintenance activities.

Following the pilot test, a vendor was selected to provide treatment units to the community. The unit selected by the WIA consistently removed 91 percent of nitrate and more than 90 percent of TSS.

Despite the concerns of the Board of Directors regarding the difficulties associated with installing and maintaining the units and their liability should the units stop working correctly, the WIA began to install POU RO units in each of the houses in Wattenburg. The community planned to hold a town meeting during the installation of the units to explain the reason for installing the treatment units (including the health effects associated with the consumption of excess nitrate), the operation of the units, the effectiveness of the units, and the manner in which the purchase of the units would be completed. In addition, all residents would be provided with an owner's manual for the treatment unit as well as informational materials printed in both English and Spanish that explained:

- Nitrate contamination of drinking water;
- The role of the Colorado WQCD and the WIA; and,
- The funding process.

Due to the Board of Directors’ concerns about liability for damages in the event of unit leakage, they supported the use of a licensed plumber and licensed electrician to oversee each installation. In addition, they requested the development of a specifications manual to detail the requirements for each installation. Further, the Board of Directors recommended the use of an independent inspector to verify the quality of each installation. At the time of installation, the installer was to reiterate to each resident the points covered in the public meeting (e.g., unit operation, need for treatment, etc.).

The responsibility for conducting routine maintenance was to be borne by the WIA since the Board of Directors did not feel that residents, particularly renters, should be required to know how and when to perform this maintenance. The WIA is also responsible for keeping records of all maintenance on the units.

7.5 Radon Treatment

7.5.1 Various States (POE GAC for Radon Removal)

This case study is summarized from a report by Lowry, et al. (1989). To determine the effectiveness of POE GAC units in removing radon from drinking water, 121 POE GAC units in 12 states were monitored to varying degrees over seven years. Each house was equipped with a separate POE GAC system consisting of fiberglass vessels filled with either 1.0, 1.7, or 3.0 cubic feet of GAC, supported on a bed of gravel. The units were installed downstream of the existing pressure tank and operated in the downflow mode. Sixty percent of the installations were done by the homeowner without outside assistance.

Most units underwent initial sampling and analysis three weeks after installation to confirm the success of the installation. Sampling and analyses were conducted every six months thereafter for a period of two years. Samples were collected by homeowners and mailed to the Radon Research Laboratory at the University of Maine for liquid scintillation analysis. Some units were selected for longterm or monthly monitoring. The monitoring protocol used either direct syringe scintillation vials or glass septum capped vials (VOC type).

The GAC units in this study treated water supplies with a wide variety of radon levels, ranging from 2,576 picoCurie per liter (pCi/L) to more than 1,000,000 pCi/L. Average household water use was estimated at 157 gpd for purposes of determining performance. Performance data for the POE GAC devices observed in this study are presented in Exhibit 7.7.

Exhibit 7.7: Performance Data for POE GAC Devices

GAC Device	Flow (gpd)	Average EBCT (hrs)	Expected Removal Rate	Observed Removal Rate
GAC 10	157	1.14	96.7%	90.7%
GAC 17	157	1.94	99.7%	92.5%
GAC 30	157	3.43	> 99.99%	98.6%

In most cases, O&M costs were negligible. In a very few instances, GAC beds had to be replaced at a cost of $130 per cubic foot of GAC. Gamma emissions from POE GAC units used to treat for radon may lead to negative health effects for both members of the household and maintenance personnel.

Exposure to gamma radiation depends upon the level of radon in the raw water and the location and shielding of the GAC unit. Therefore, the need for shielding or other protective measures should be evaluated for each specific site. If necessary, shielding may be provided either by a metal cover surrounding the treatment unit or by placing the GAC treatment vessel inside a larger vessel filled with water. Cost data for the POE GAC devices observed in this study are presented in Exhibit 7.8.

Exhibit 7.8: Cost Data for POE GAC Devices

GAC Device	Cost of GAC Unit	Cost of Sediment Filter	Cost of Water Shield	Installation Cost	Total Cost
GAC 10	$600	$50	$25	$100	$775
GAC 17	$750	$50	$90	$100	$990
GAC 30	$950	$50	$125	$100	$1,225

Note: Shipping costs (averaging $30 per unit) were paid by the installer.

7.5.2 Derry, New Hampshire (POE GAC and Aeration for Radon Removal)

POE GAC and POE aeration for radon removal were evaluated by Kinner, et al. (1993). The effectiveness of two GAC units and two aeration units (one diffused bubble aeration (DBA), one bubbleplate aeration) were studied over the course of one year of continuous operation.

Each of the two GAC units consisted of a fiberglass contact vessel preceded by a sediment filter.

The contact vessels were filled to 70 percent of their capacity with GAC (1.6 cubic feet of GAC per unit), providing an EBCT of 6 minutes at a flow rate of 2.0 gpm. One of the POE GAC units incorporated a separate CX element to remove iron and manganese in addition to the sediment filter and GAC element.

The CX bed contained 1.4 cubic feet of strong-acid CX resin. The CX resin was regenerated every two weeks over the course of the study using a standard sodium chloride solution.

The DBA unit was comprised of a single vessel with three compartments in series, each containing an internal diffuser. The bubble-plate aeration system was also housed in a single vessel, however, this system contained a single spiral diffuser. For both units, finished water was stored in a 20-gallon hydropneumatic tank. A 38 cubic foot per minute (cfm) blower powered the DBA system while the bubble-plate aeration system was powered by a 315-cfm blower. Off-gases from both systems were vented via separate PVC vent pipes.

Radon levels of 22,837 to 54,765 pCi/L (average 35,620 ± 6,727 pCi/L) were reduced by more than 97.5 percent to less than 900 pCi/L for the first four months of the study by both of the POE GAC systems. For the remaining eight months of the study, radon levels in finished water rose to 3,000 to 6,000 pCi/L. This POE GAC configuration would not comply with the radon MCL (300 pCi/L) or alternative radon MCL (4,000 pCi/L) per the proposed Radon Rule. While the authors of this study were not able to determine the reason for the reduction they observed in system performance, they postulated that the presence of a contaminant that was also removed by the GAC reduced its capacity for radon. It should also be noted that the GAC system that incorporated the CX element remained somewhat more effective than the GAC unit that did not include this element (removal rates of 85 percent verses 79 percent), and also removed 99 percent of influent radium. Iron residues found in the top layers of GAC in the latter unit may have fouled the media or contributed to channelization which reduces effective contact time.

Both GAC units were colonized by bacteria. As a result, the use of such devices for compliance with the SDWA may require the use of some form of post-treatment disinfection to ensure the microbiological safety of the finished water, particularly for immuno-compromised individuals.

The POE DBA system reduced influent radon levels to less than 200 pCi/L (> 99 percent) throughout the course of the study. The small size of the bubbles forced through the water in this unit contributed to the high radon removal rates, as did the high air-to-water ratio (119:1 assuming a water flow rate of 2.3 gpm). The POE bubble-plate system also typically reduced radon by more than 99 percent. However, when the air intake for the blower for this system was clogged, restricting airflow through the system, radon removal rates dropped significantly. This potential problem could have been avoided if the system had been equipped with an automatic alarm or shut-off valve or through more frequent inspection of the unit. Based on monitoring conducted outside of the building in which these units were installed, it is expected that the exhaust from aeration units will be rapidly diluted to background levels. If influent radon levels are exceptionally high, it may be necessary to further dilute the exhaust (through the use of a more powerful blower) or to treat the exhaust prior to release.

The costs in Exhibit 7.9 are based on actual expenditures incurred during this project. However, engineering/subcontractor and contingency fees were built into the capital costs for these estimates based on records from actual POE installations at well sites in New Hampshire. These cost estimates are reflective of the market in the New England region. These estimates do not include the costs associated with radon monitoring ($15 to $50 per sample - in 1990 dollars). Both estimates for the GAC units do, however, assume the worst-case scenario for waste disposal (handling and disposal of spent media as low-level radioactive waste at a cost of $28.09 per cubic foot - in 1990 dollars). The cost evaluation of the aeration systems was based on the assumption that additional treatment for the off-gases produced by the units would not be required.

Exhibit 7.9: Cost Estimates for POE GAC and Aeration Systems (1990$)

Item	GAC (w/o pretreatment)	GAC (w/pretreatment)	Diffused Bubble Aeration	Bubble-Plate Aeration
Capital Costs				
Equipment	$785	$1,500	$2,215	$3,295
Installation	$275	$345	$880	$880
Total Capital Costs	$1,060	$1,845	$3,095	$4,175
Amortized Capital Costs (9% for 5 yrs)	*$273*	*$475*	*$796*	*$1,074*
Annual O&M Costs				
Power ($0.10157/kW-hr)	- NA -	- NA -	$80	$54
Maintenance	$160	$185	$345	$368
Labor	$45	$50	$545	$583
Administration	$49	$56	$195	$209
Disposal Costs	$56	$113	- NA -	- NA -
Total O&M Costs	*$310*	*$404*	*$1,165*	*$1,214*
Total Annual Costs	**$583**	**$879**	**$1,961**	**$2,288**
Production Cost (270 gpd design flow)	**$5.34/Kgal ($5.91/Kgal)**	**$7.77/Kgal ($8.92/Kgal)**	**$19.90/Kgal**	**$23.22/Kgal**

7.6 Trichloroethylene (TCE) Treatment

7.6.1 Byron, Illinois (POU/POE GAC for TCE Removal)

This case study is summarized from a paper presented by Bianchin at the 1987 Conference on Point-of-Use Treatment of Drinking Water (Bianchin, 1987). The Byron Johnson Salvage Yard is a 20-acre facility located in a rural area of northern Illinois. In the 1960s, the salvage yard was operated as a junk yard. From 1970 to 1972, the Illinois EPA conducted periodic inspections to identify operating deficiencies. In 1972, the Illinois EPA ordered the yard closed, and in 1974 the salvage yard ceased operation. In December 1982, the site was placed on the Superfund National Priority List. Illinois EPA began a remedial investigation/feasibility study, focusing on contamination directly on or below the site.

The study revealed that both major aquifers in the area were contaminated by VOCs. In addition, cyanide and some inorganic compounds were found in the ground water beneath the salvage yard.

From 1983 through 1985, contamination levels in nearby (down-gradient) wells were monitored by EPA, Illinois EPA, and the Illinois Department of Public Health. Private wells were found with TCE levels of up to 710 μg/L. In July 1984, EPA temporarily placed residents in areas adjacent to the salvage yard, whose water was characterized by TCE concentrations greater than 200 μg/L, on bottled water. In May 1986, EPA installed POU GAC treatment devices as an interim measure for residents using bottled water. In July 1986, EPA initiated a monthly sampling program of these units to monitor the effectiveness of the POU devices.

In October 1985, EPA undertook a phased feasibility study to investigate the health threat posed to another nearby development from exposure to the contaminated water supply. Rock River Terrace Subdivision is located 1.5 miles down gradient of the salvage yard along the Rock River. Wells in the subdivision were contaminated with TCE levels up to 48 μg/L. Three treatment alternatives were analyzed for their potential to solve the subdivision’s contamination problem. First, all residences could be connected to the Byron Municipal Treatment Facility. This alternative would cost approximately $900,000 (in 1986 dollars) and would take one to two years to implement. Second, all affected homes could be supplied with bottled water. This alternative was estimated to cost $91,150 per year and could be implemented almost immediately. However, since the water entering local households is not treated, and since bottled water would only be used for drinking or cooking, this alternative would provide no protection from inhalation of or direct contact with contaminated water. Third, each household could be equipped with a POU treatment unit. This alternative would cost $26,000 and installation would take about three months. However, as with the bottled water option, since all taps would not be treated, residents would not be completely protected from health problems resulting from inhalation or direct contact with contaminated water. Fourth, each household could be equipped with a POE treatment unit.

This alternative would cost $115,000 and, like the third option, would require about 3 months to install.

The fourth alternative would provide treated water at all taps within the household.

The fourth alternative was selected as the strategy most protective of public health and most economically feasible. Beginning in September 1986, EPA installed POE GAC systems in the basements of residences or in insulated, outdoor sheds throughout the subdivision. Each system consisted of a 5-μm pre-filter and two GAC tanks in series. Each GAC tank was 54 inches tall and contained 110 pounds of GAC. The system was designed for a flow of 7.5 gpm. Since carbon replacement rates depend on many factors including the level of contamination, water temperature, pH, water usage, and the presence of other constituents, periodic monitoring was conducted to ensure that contaminants were being effectively removed. Samples were collected on a monthly basis, before and after the carbon tanks, and sent to a local lab for analysis. The carbon was scheduled for replacement upon breakthrough. However, a year after installation, breakthrough still had not occurred.

7.6.2 Elkhart, Indiana (POE GAC, Aeration for TCE and Carbon Tetrachloride (CCl_4) Removal)

This case study is summarized from Lykins Jr., et al. (1992) and Bianchin (1987). In June 1986, severe contamination by TCE (800 μg/L) and CCl_4 (488 μg/L) was detected in a well in Elkhart, Indiana.

EPA instituted a sampling program covering 88 wells. Significant levels of TCE (5,000 μg/L) and CCl_4 (7,500 μg/L) contamination were detected in this effort (Bianchin 1987). EPA immediately provided bottled water to all affected residents and advised those with the most contaminated wells not to use their water for any reason. Due to the time required to extend the city’s water mains, EPA decided to install 54 POE GAC and 22 POU GAC units at private residences. The Indiana Department of Environmental Management agreed to sample the affected homes periodically to ensure the continued efficiency of the treatment units.

The POE GAC units were 13 inches in diameter and permitted the use of up to 3.8 cubic feet of carbon (50 inches of carbon depth). Each POE unit contained 110 pounds of 20 x 50 mesh size GAC.

Carbon replacement costs were approximately $510 per tank, while the sediment pre-filters cost $40 each to replace (in 1989 dollars).

Two residences were equipped with treatment systems consisting of a PTA element connected to two GAC tanks in series. These units were located in the basement and were vented outside. The air strippers had a 40:1 air-to-water ratio and operated at a rate of 5 gpm. The air strippers were packed with 1-inch diameter polypropylene cylinders. Although no microbiological problems have been encountered, a UV light may be installed in the POE system for post-GAC disinfection. The installed cost of the entire unit (one air stripper and two GAC tanks) was about $4,000 (in 1989 dollars). The installer recommended flushing the system any time that water stood unused for more than a day. Special monitoring was undertaken to test the effectiveness of these POE systems. The results of this monitoring showed that the units effectively reduced the levels of CCl_4 and TCE in the water.

GAC isotherm calculations, sometimes used to estimate breakthrough for GAC media, proved unreliable in accurately predicting breakthrough in the POE GAC units in Elkhart. The time to breakthrough was significantly over- or under-estimated. The number of gallons successfully treated before breakthrough ranged from 25,000 to over 300,000 gallons. Competitive effects, possibly from CCl_4 or TCE, were evident in one dual GAC unit in Elkhart that was monitored for a special EPA study.

In this case, isotherm data predicted breakthrough for chloroform at approximately 225,000 gallons, but chloroform ($CHCl_3$) was estimated to have actually broken through after about 130,000 gallons were treated by the unit. Over the course of the study, methylene chloride concentrations of 115 μg/L were consistently lowered below detection levels. Exhibit 7.10 summarizes data from homes in Elkhart that experienced breakthrough and provides an illustration of GAC capabilities.

Exhibit 7.10: Performance Data for POE GAC Devices in Elkhart, IN

Site	Average influent concentrations (μg/L)			Gallons treated	Months	Possible Cause for CCL_4 Breakthrough
	TCE	CCl_4	$CHCl_3$			
1	170	291	15	30,500	25	Competitive effects; bacterial colonization
2	60	2,864	ND	120,000	22	High influent levels
3	418	2,188	ND	150,000	24	High influent levels
4	331	135	10	135,000	16	Competitive effects; TCE concentration
5	1,686	348	50	140,000	18	TCE concentration

7.6.3 Hudson, Wisconsin (POE GAC for TCE and 1,1,1-Trichloroethane (TCA) Removal)

This case study is summarized from system information provided by Anklam (2001). In the 1960s and 1970s, TCE, TCA, as well as low levels of tetrachloroethylene (PCE) and 1,1-dichloroethylene seeped into well water in the town of Hudson, Wisconsin. In the 1980s, it was discovered that the ground water source for a populated subdivision in the western part of the town was also contaminated. The State of Wisconsin conducted an investigation and identified an industrial facility as the source of the contamination. As a result, the State required the industrial facility to either provide treatment or provide an alternate water source for the subdivision. The industrial facility chose to provide POE GAC units to the affected homes. Prior to the installation of the POE GAC units, the water for this subdivision was not subject to any kind of treatment.

The industrial facility is the responsible party for oversight and maintenance of the water systems.

A private consulting firm is under contract with the industrial facility to provide administrative oversight and sampling for the system. A home water treatment unit vendor is contracted to handle on-site maintenance of the POE units and carbon replacement.

Two pilot tests were conducted prior to full-scale installation of the POE GAC units in Hudson.

The POE GAC unit was installed at six residences with State approval. The POE unit consists of two, 1.25 cubic foot tanks in series, filled with FCS-AC11 coconut-shell granular activated carbon. The effluent was sampled monthly for TCE, TCA, and other organics over a two-year period. A larger unit, comprised of two, 3.61 cubic foot tanks, was pilot-tested separately at a local business. This unit was operated continuously and sampled regularly until breakthrough was detected. In 1995, at the beginning of the study, the average concentration of TCA and TCE in the source water was 51.2 μg/L and 33.3 μg/L, respectively. The POE GAC units consistently maintained TCA and TCE concentrations well below the MCLs of 0.2 mg/L and 5 μg/L, respectively.

The pilot tests demonstrated that the POE GAC units effectively remove TCE, TCA, and other trace organics present in the raw water to below detectable levels. After obtaining state approval for a full-scale POE compliance strategy in 1995, the industrial facility conducted a residential sampling program to verify water quality. After determining which residences qualified for POE treatment, the industrial facility began offering GAC units to the residents of Hudson to treat their contaminated ground water at no charge. Currently, about 155 households and ten businesses have POE GAC units installed.

In order to obtain a POE unit, residents are required to sign an access agreement with the industrial facility that, among other provisions, requires the residents to schedule appointments with the contractor and subcontractor for periodic maintenance, water sampling, and carbon replacement. If the resident refuses access, the industrial facility will then provide bottled water as an alternative, although the Wisconsin DNR does not recognize bottled water as a “permanent water supply.” Residents that refuse to have a POE GAC unit installed must also sign a consent form indicating that they understand that the water is contaminated and choose not to treat the water. Only one household chose bottled water over POE GAC filtration. If residents have questions concerning the contaminated water supply, they are referred to the Wisconsin Department of Health for additional information about potential health effects.

Both the influent water characteristics and water usage at a specific site are considered when deciding what size POE GAC unit to install. For low concentrations of TCE and TCA (11-12 μg/L and 15-16 μg/L, respectively) at normal-sized households (six or fewer people), the smaller unit is installed.

In cases where the contaminant levels are higher (>12 μg/L for TCE and >16 μg/L for TCA) or water usage is greater (*e.g.*, nearby businesses), the larger unit is installed. In order to complete the installations, the vendor was required to have Wisconsin Restricted Appliances Journeyman Plumber certification or greater. A cartridge-type pre-filter for iron and/or sediment removal is installed on some units, depending on the characteristics of the influent water quality. Sediment filters are required more frequently than iron filters, due to the town’s raw water characteristics. The subcontractor will change the filter cartridges during the annual carbon change-out, or on an as-needed basis.

As a permanent solution to the water supply contamination problem, ground water remediation was initiated. Since that time, the TCE and TCA concentrations in Hudson’s wells have steadily decreased to about 3-4 μg/L. As a result, a less rigorous residential sampling schedule was implemented.

Initially the POE effluent was tested for TCE and TCA on a quarterly schedule, but with State approval the sampling frequency was reduced to semi-annual testing and eventually, to annual testing as the concentrations decreased. Concentrations of TCA and TCE in the treated water are currently below the detection limits of 0.2 μg/L and 0.4 μg/L, respectively. Tests are also performed for total coliform bacteria at points before and after the filter unit, to determine if bacterial growth is occurring in the GAC media. All samples are processed by a certified laboratory.

One unconfirmed instance of TCE breakthrough was detected at a household POE unit in the initial years of operation, but no additional breakthroughs have been detected since then. Rather than resampling and confirming the single instance of breakthrough, the media was changed out.

The carbon is replaced in all of the POE GAC units on an annual or biennial cycle, depending on water usage. During change-outs the carbon in both tanks is replaced simultaneously to avoid potential bacterial growth in the filter media. The spent carbon from the households is taken to a holding facility and then trucked to a regeneration facility, where it is re-activated for other purposes. Regenerated carbon is not used in Hudson’s POE GAC units.

The vendor bills maintenance and carbon replacement appointments at two different rates. A lower rate is charged if the call can be completed during the day, and a higher rate (by at least 10 percent) is charged if the call must be completed in the evening or on a Saturday. Scheduling appointments to gain access to the POE units can be difficult at times, but generally runs smoothly.

Some minor technical issues have been encountered with the operation of the POE GAC units.

Some customers complain about pressure drops in their taps, and during the summer condensation may cause water to collect beneath the GAC tanks. In addition, residents with swimming pools are reluctant to fill them with the POE treated water, and some have tried installing bypasses before the treatment unit to fill the pool with untreated water. However, these bypasses are highly discouraged because of liability issues.

7.7 Radium Treatment: Illinois EPA Study (POE CX)

This case study is summarized from a presentation given by Selburg at the NSF International and the Center for Public Health Education Conference on Public Water System Compliance Using Point-of-Use and Point-of-Entry Treatment Technologies (Selburg, 2003). In this project, which is currently in the planning stages, POE CX will be evaluated as a compliance option for radium removal for small systems.

The objectives of this project are:

- To determine how many samples and homes with softeners are needed to demonstrate hardness as a surrogate indicator for radium concentration;
- To determine how many homes are needed to demonstrate the effectiveness of softeners for radium removal; and
- To determine how many radiological samples are needed to verify that the public health protection provided by POE CX treatment for radium is equivalent to that provided by central treatment.

Several criteria have been set in order for this study to proceed. First, 100 percent participation by homeowners in the community is required. Second, in accordance with SDWA, the water system must be totally responsible for all aspects of the operation. In addition, only POE units will be allowed in the study.

One CWS will be selected for the pilot study, though other interested systems will be allowed to participate in the project after the first quarter of the pilot study has been completed. Before the pilot study begins, the selected water system must work with regulatory authorities and a consultant to develop technical provisions for the pilot study and timeliness and dates for a compliance agreement. The selected water system must also submit plan documents, the compliance agreement, an operating plan, a contractor agreement, and any other related documents to the Illinois EPA for review. The Illinois EPA will then draft a permit and review all documentation with EPA Region 5. After the permit has been issued, the pilot study may begin.

In the first phase of the pilot test, one POE CX unit will be installed in a residence and samples will be collected once per month for two months. Each sample will be analyzed for hardness, gross alpha, and combined radium. If the results from both months are satisfactory, the second phase of the pilot study will begin with the installation of additional POE CX units in 11 other homes served by the water system.

Hardness will be monitored at least quarterly in all 12 homes during the second phase of the pilot test to verify hardness as a surrogate indicator for radium. Four homes will also be selected for collection of four quarterly radium samples for compositing. The four-quarter composite and the samples that are collected at the end of the second quarter will be analyzed for gross alpha and combined radium. If the results of this sampling are satisfactory, the operational practices will also be considered satisfactory.

During the second and third years of operation, quarterly hardness monitoring will be continued in all 12 of the pilot homes. Two of these homes will also be selected for collection of four quarterly samples for compositing. These composite samples will be analyzed for gross alpha and combined radium. At the end of the three-year study, a follow-up report will be prepared by the Illinois EPA to discuss the findings and evaluate the use of hardness as an indicator for radium.

Based on the hardness and radium data from pilot testing, a hardness indicator level correlating to combined radium exceeding 5 pCi/L will be selected for each participating CWS. This hardness indicator level will be incorporated as a permit condition for the system. When full-scale operations have begun, POE units must be serviced if the hardness exceeds the trigger level. After a unit is serviced, a sample will be collected and analyzed for hardness, gross alpha, and combined radium. No further radionuclide monitoring will be required if the gross alpha and combined radium are less than the MCLs. However, if the gross alpha or combined radium exceeds the MCL, quarterly monitoring will be required for the unit with continued servicing. If the unit continues to exceed the MCL after one year of quarterly monitoring, the CWS will be considered out of compliance. In addition, if the gross alpha or combined radium samples from any unit exceed a level four times greater than the MCL at any time, the CWS will be considered out of compliance. In either situation, the system must issue public notification and take whatever actions the State deems necessary. If the hardness trigger level is exceeded more than once at the same CWS, the problem will be evaluated by the Illinois EPA and EPA Region 5 to determine the appropriate testing and remedy. If the hardness trigger level is exceeded repeatedly by a single POE CX device or within a single CWS, resin change-out or radium testing will be required unless other actions are determined by the regulatory authorities to be more appropriate.

7.8 References

Abdo, G.N., B.J. Keller, and G. Rupp. March 2000. Ion Exchange Studied for Copper Removal at Pointof-use. Water Technology. pp. 108-112.

Alberts, R. and M. Peterson. 2000. Wattenburg Improvement Association Nitrate Removal Pilot Project – Preliminary Point of Use Filter Evaluation. Prepared for Wattenburg Improvement Association, Fort Lupton, CO.

Anklam, J. 2001. Personal communication.

Bellen, G. February 2003. Centrally Managed POU Treatment for Compliance with the Arsenic Rule. Presented at the NSF International and the Center for Public Health Education Conference on Public Water System Compliance Using Point-of-Use and Point-of-Entry Treatment Technologies. Orlando, FL.

Bellen G. August 2004. Personal communication.

Bellen, G., M. Anderson, and R. Gottler. 1985. Final Report: Management of Point-of-Use Drinking Water Treatment Systems. National Sanitation Foundation for EPA, Cincinnati, OH. Cooperative Agreement #R809248010.

Bianchin, S. October 6-8, 1987. Point-of-Use and Point-of-Entry Treatment Devices Used at Superfund Sites to Remediate Contaminated Drinking Water. Proceedings of the Conference on Point-of-Use Treatment of Drinking Water. Cincinnati, OH.

Clifford, D. and E. Rosenblum. 1982. The Equilibrium Arsenic Capacity of Activated Alumina. U.S. EPA, Cincinnati, OH. Cooperative Agreement CR-807939-02.

EPA. 2004. EPA’s Arsenic Rule Web Cast Written Transcript. December 1, 2004. www.epa.gov/safewater/ars/pdfs/webcast-04_arsenic_transcript.pdf.

Fox, K. February 1989. Field Experience with Point-of-Use Treatment Systems for Arsenic Removal. Journal AWWA.

Fox, K. and T. Sorg. October 1987. Controlling Arsenic, Fluoride, and Uranium by Point-of-Use Treatment. Journal AWWA.

Guercia, S. November 2001. Secondwind Environmental. Personal communication.

Jones, M. May-June 2001. Environmental Office of Naval Air Station Fallon. Personal communication.

Kinner, N., J. Malley, J. Clement, and K. Fox. June 1993. Using POE Techniques to Remove Radon. Journal AWWA.

Kunesh, T. June 2003. Whatcom County Health Department, Washington. Personal communication.

Lowry, J.D., S.B. Lowry, and J.K. Cline. January 1989. Radon Removal by POE GAC Systems: Design, Performance, and Cost. Risk Reduction Engineering Laboratory, U.S. EPA, Cincinnati, OH. Contract No. 8C6155TTST.

Lykins Jr., B.W., R. Astle, J.L. Schlafer, and P.E. Shanaghan. November 1995. Reducing Fluoride by Managed POU Treatment. Journal AWWA.

Lykins Jr., B.W., R.M. Clark, and J.A. Goodrich. 1992. *Point-of-use /Point-of-entry for Drinking Water Treatment*. Lewis Publishers, Ann Arbor, MI.

Maher, W. November 2001. Maher Water Corporation. Personal communication.

Manley, D. June 2001. Housing Office of Naval Air Station Fallon. Personal communication.

Mazanek, T. July 2003. Environmental Office of Naval Air Station Fallon. Personal communication.

Messina, R. December 2001. Personal communication.

Narasimhan. R. 2005. POU/POE Feasibility Study for Arsenic Treatment. AWWARF Project 2730. Chapters 2, 4. Order Number 91083F

Pasteros, C. November 2001. Personal communication.

Rogers, K. November 1988. Point-of-Use Treatment of Drinking Water in San Ysidro, NM. U.S. EPA DWRD, Risk Reduction Engineering Laboratory, Cincinnati, OH, CR-812499-01.

Rogers, K. March 1990. Project Summary: Point-of-Use Treatment of Drinking Water in San Ysidro, NM. U.S. EPA, Risk Reduction Engineering Laboratory, Cincinnati, OH. EPA/600/S2-89/050.

Selburg, R.D. February 13-14, 2003. Illinois EPA - Point of Entry Treatment Program. Presented at the NSF International and the Center for Public Health Education Conference on Public Water System Compliance Using Point-of-Use and Point-of-Entry Treatment Technologies. Orlando, FL.

Theis, J. November, 2002. EPA Region 8. Personal communication.

Theis, J. June 2003. EPA Region 8. Personal communication.

Thieleman, J. October 2001. Personal communication.

Thomas, C. August 2005. Personal communication with Blake Atkins of EPA Region 6.

Thomson, B., K. Fox, and M. O’Grady. June 12, 2000. Arsenic Removal by Point-of-use Treatment Systems at San Ysidro, New Mexico. Presented at the AWWA Annual Conference. Denver, CO.

Thomson, B. and M. O’Grady. February 1998. Evaluation of Point-of-use Water Treatment Systems, San Ysidro, New Mexico. Report to U.S. EPA (Contract No. 2C1102NTEX).

Werner, T. October 2001. Personal communication.

Werner, T. June 2002. Personal communication.

Werner, T. June 2003. Personal communication.

APPENDIX O: NSF Survey of Use of Standards

The following is a summary of a survey conducted by NSF International. The survey is titled: *Use of NSF Standards and ETV Reports, March 2006: Point of use and Point of Entry Treatment Devices.*

Overview

NSF International, in cooperation with the Association of State Drinking Water Administrators (ASDWA), recently conducted a survey of US state drinking water agencies about their recognition and use of NSF/ANSI Standards, as well as for the EPA's Environmental Technology Verification (ETV) program for drinking water treatment systems, a program administered by NSF.

Standard 60 and 61

ASDWA members were asked about each of their state’s compliance requirements to NSF/ANSI Standard 60: *Drinking Water Treatment Chemicals -- Health Effects* and NSF/ANSI Standard 61: *Drinking Water System Components -- Health Effects.*

Drinking Water System Components fall into two categories of regulation. Municipal and distribution products up through the water meter are regulated by state drinking water offices. Water distribution systems downstream of the water meter or inside a building are regulated by state or local plumbing codes. The information shown in this document applies to products regulated by state drinking water offices only. While all major model plumbing codes require the use of NSF/ANSI Standard 61 certified products, the specific requirements for those product types can be found in state or local plumbing codes.

Since the previous NSF/ASDWA survey, two states have revised their regulations that reference NSF/ANSI Standards 60 and 61 for products used in public drinking water systems. Idaho now requires third-party certification and Massachusetts now requires a 3% maximum lead content limit for brass products in addition to NSF/ANSI Standard 61 Certification. The 3% lead content limit mirrors the requirement in the Massachusetts plumbing code.

Seven states regulate point-of-use or point-of-entry water treatment systems and six states require these to conform with NSF Standards. Three states regulate residential products, and four states regulate products when used in place of centralized treatment.

Survey Highlights

45 states have legislation, regulations or policies requiring drinking water treatment chemicals to comply with NSF/ANSI Standard 60.

- 43 states have legislation, regulations or policies requiring drinking water system components to comply with NSF/ANSI Standard 61.
- 40 states require products to be certified to the applicable standard by an ANSI accredited third-party certifier.
- Utah has a formal reference recommending ETV reports for drinking water treatment systems. Massachusetts’ water permit application mentions ETV and the State of Washington's water system design manual references ETV protocols for surface water treatment.
- 24 states report that they can allow for reduced pilot testing of drinking water treatment systems for those products with acceptable ETV reports.

APPENDIX P: Ontario Amendments to Ontario Regulation 170/03 (June, 2006)

The following taken from the web site of the Ontario Ministry of the Environment, is an extract from an Environmental Bill of Rights (EBR) posting (EBR Registry Number: RA05E0005.) It outlines some of the concerns to be addressed in connection with the use of POE / POU devices in the Province of Ontario.

“The EBR posting also requested input on the feasibility of allowing small residential systems [small municipal residential, non-municipal year-round residential, non-municipal seasonal residential (serving a designated facility)] in O. Reg. 170/03 to use Point of Entry (POE) treatment. Eleven of the submissions made mention of POE treatment. After considering comments received, the ministry is proceeding with the following additional amendments to O. Reg. 170/03. Highlights of these amendments include:

• The drinking water system (DWS) owner is required to deliver notice/information to owners and occupants (if other than owner) of all private residences, designated and public facilities supplied water by the system. The information notice would serve to inform people of basic information they should be aware of, including:
- POE units are for the purpose of drinking water safety;
- The drinking water system owner owns and is responsible for the POE units;
- The drinking water system owner will periodically request access to units within the dwelling for purpose of maintenance of POE units and sampling of water;
- POE units are installed with automatic shut-offs – if the water supply is interrupted or if the POE treatment unit requires repairs, the resident must contact the owner of the drinking water system.

• The drinking water system owner is required to sign and submit to the ministry a statement that they have delivered the above notice to all owners and occupants (if other than owner) supplied water by the system, and they have verbally contacted all owners and occupants, and made best efforts to ensure that they are aware and understand the information that was provided.

• There is an additional requirement for the owner of the drinking water system to ensure that, as soon as reasonably possible, any new owners/occupants are delivered the notice/information and are verbally contacted to ensure they are aware of and understand the information provided.

• Microbiological sampling is required on a rotational basis inside buildings, with some built-in flexibility for cases where the DWS owner cannot gain access to a particular home for an extended period of time.

• 100% of private residences, designated and public facilities in the system are required to have POE equipment.

• Ownership of POE equipment and responsibility for operation and maintenance resides with the owner of the system.

• For non-municipal year-round residential systems, the secondary disinfection exemption granted for systems with POE treatment is allowed only if the system serves 100 or fewer private residences.

• POE treatment units require an automatic shut-off in the event of equipment malfunction or power loss.

• POE treatment units cannot use chlorine (safety issue).

Point of entry treatment is an alternative to centralized treatment that may not be a suitable choice for all systems which are allowed to utilize it under these new requirements. The requirements that are set forth are designed to ensure that operational responsibility and ownership of POE equipment resides with the owner of the system and that there is a reasonable prospect of cooperation and access to private residences (for equipment maintenance and water testing) between system owners and owners/occupants of dwellings.”

APPENDIX Q: Examples of POE /POU Treatment Costs for Groups of Contaminants

System 1: For source water with low turbidity, high UVT, acceptable metals / minerals, total / fecal coliforms present.

System recommendation: 5 micron sediment filtration and UV.

Features/options: UV: audio/visual alarms, auto-shutoff, UV intensity monitor, remote monitoring, lamp usage timer (replacement reminder), power surge protection.

Maintenance: change filter as needed (average – once per year) and bulb once per year; clean sleeve at time of bulb change.

	# Connections				
	5	10	20	50	100
Supply and Install					
Assessment					
Basic source water analysis & system assessment[1]	$250	$250	$500	$1250	$2500
Advanced source water analysis & system assessment (if required)[2]	$0	$100	$150	$300	$600
Supply and Shipping					
Supply treatment components[3]	$4,000	$7,200	$13,600	$32,000	$56,000
Supply housing					
Supply local monitoring & alarm components[4]	$3,750	$6,750	$12,750	$30,000	$52,500
Supply of System Communication & Monitoring					
Shipping costs to Water District[5]	$250	$450	$700	$1,500	$2,000
Installation and Commissioning[6]					
Install Housing and Access Facilities	$750	$1,500	$3,000	$7,500	$15,000
Install Treatment System	$1,500	$3,000	$6,000	$15,000	$30,000
Install Local Monitoring and Alarm Components	$375	$750	$1,500	$3,750	$7,500
Commission System and Instruct Homeowner[7]	$125	$250	$500	$1,250	$2,500
Central Monitoring and Communications[12]					
Install Monitoring and Communications Equipment					
Supply and Install Totals:					
Supply and Install Totals per connection:					
Annual Operation and Maintenance[8,3]					
Maintenance (equipment)	$750	$1,350	$2,550	$6,000	$10,500
Maintenance (labour)	$100	$200	$400	$1,000	$2,000
Sampling and Analysis[9]	$290	$580	$1,160	$2,900	$5,800

Records Maintenance/Customer Communication[10]	$200	$400	$800	$2,000	$4,000
Central Monitoring and Troubleshooting					
Other Operating Costs[11]	$100	$200	$400	$500	$1,000
Financing/Leasing Costs					
Annual Maintenance Totals:					
Annual Maintenance Totals per connection:					

Notes:

- It is the intent that these cost guidelines include all costs incurred by the community water system for the procurement, installation, and operation of a Point of Entry treatment system. These numbers are for illustration purposes only and can vary considerably with individual conditions.
- Shipping costs based on installation in the Kelowna area
- Central monitoring and Communications provides the water supply organization with components that enable monitoring of each system from the system operator’s office.

Footnotes:

1) $250 water testing for every 10 households
2) Extra analysis and quote prep time (site visit is extra)
3) Discount schedule (# units/discount): 5/0%, 10/10%, 20/15%, 50/20%, 100/30%
4) Includes UV intensity monitor, auto shutoff, lamp replacement reminder, audio/visual alarms
5) Shipping from Vancouver area to Kelowna
6) Assumes installation done at $75/hr, does not include travel time
7) Assumes individual training with each homeowner (can also be done with group training)
8) Assumes maintenance labour at $40/hr
9) Assumes one test per year, five homes per hour
10) Assumes average of 1 hour per home per year
11) Electricity consumption (24x7 operation, $0.0633 per kWh)
12) Information to follow in subsequent stages of work

Group 2. Moderate levels of Iron/Manganese/H_2S, pH between 6.5-8.5, Bacteria present

System Recommendation: Greensand, 5 micron sediment filtration and UV.

Features/options: Greensand: metered or time controlled backwash/regeneration. UV: audio/visual alarms, auto-shutoff, UV intensity monitor, remote monitoring, lamp usage timer.

Maintenance: change filter as needed (average – once per year) and bulb once per year. Clean sleeve at time of bulb change. Add Potassium Permanganate as required.

	# Connections				
	5	**10**	**20**	**50**	**100**
Supply and Install					
Assessment					
Basic source water analysis & system assessment[1]	$250	$250	$500	$1250	$2500
Advanced source water analysis & system assessment (if required)[2]	$0	$100	$150	$300	$600
Supply and Shipping					
Supply treatment components[3]	$11,500	$20,700	$39,100	$92,000	$161,000
Supply housing					
Supply local monitoring & alarm components[4]	$3,750	$6,750	$12,750	$30,000	$52,500
Supply of System Communication & Monitoring					
Shipping costs to Water District[5]	$750	$1,300	$2,500	$5,500	$8,000
Installation and Commissioning[6]					
Install Housing and Access Facilities	$750	$1,500	$3,000	$7,500	$15,000
Install Treatment System	$3,000	$6,000	$12,000	$30,000	$60,000
Install Local Monitoring and Alarm Components	$375	$750	$1,500	$3,750	$7,500
Commission System and Instruct Homeowner[7]	$375	$750	$1,500	$3,750	$7,500
Central Monitoring and Communications[12]					
Install Monitoring and Communications Equipment					
Supply and Install Totals:					
Supply and Install Totals per connection:					
Annual Operation and Maintenance[8,3]					
Maintenance (equipment)	$1,350	$2,430	$4,590	$10,800	$18,900
Maintenance (labour)	$300	$600	$1,200	$3,000	$6,000
Sampling and Analysis[9]	$290	$580	$1,160	$2,900	$5,800
Records Maintenance/Customer Communication[10]	$200	$400	$800	$2,000	$4,000
Central Monitoring and Troubleshooting					
Other Operating Costs[11]	$100	$200	$400	$500	$1,000
Financing/Leasing Costs					
Annual Maintenance Totals:					
Annual Maintenance Totals per connection:					

Notes:

- It is the intent that these cost guidelines include all costs incurred by the community water system for the procurement, installation, and operation of a Point of Entry treatment system. These numbers are for illustration purposes only and can vary considerably with individual conditions.
- Shipping costs based on installation in the Kelowna area
- Central monitoring and Communications provides the water supply organization with components that enable monitoring of each system from the system operator’s office.

Footnotes:

1) $250 water testing for every 10 households
2) Extra analysis and quote prep time
3) Discount schedule (# units/discount): 5/0%, 10/10%, 20/15%, 50/20%, 100/30%
4) Includes UV intensity monitor, auto shutoff, lamp replacement reminder, audio/visual alarms
5) Shipping from Vancouver area to Kelowna
6) Assumes installation done at $75/hr, does not include travel time
7) Assumes individual training with each homeowner (can also be done with group training)
8) Assumes maintenance labour at $40/hr
9) Assumes one test per year, five homes per hour
10) Assumes average of 1 hour per home per year
11) Electricity consumption (24x7 operation, $0.0633 per kWh
12) Information to follow in subsequent stages of work

Group 3. Clear, Excessively Hard water, no bacteria present

System Recommendation: Water softener.

Features/options: Softener: metered or time controlled backwash/regeneration.

Maintenance: Add salt to brine tank as required.

	# Connections				
	5	**10**	**20**	**50**	**100**
Supply and Install					
Assessment					
Basic source water analysis & system assessment[1]	$250	$250	$500	$1250	$2500
Advanced source water analysis & system assessment (if required)[2]	$0	$100	$150	$300	$600
Supply and Shipping					
Supply treatment components[3]	$6,000	$10,800	$20,400	$48,000	$84,000
Supply housing					
Supply local monitoring & alarm components[4]	$0	$0	$0	$0	$0
Supply of System Communication & Monitoring					
Shipping costs to Water District[5]	$750	$1,300	$2,500	$5,500	$8,000
Installation and Commissioning[6]					
Install Housing and Access Facilities	$750	$1,500	$3,000	$7,500	$15,000
Install Treatment System	$1,875	$3,750	$7,500	$18,750	$37,500
Install Local Monitoring and Alarm Components	$0	$0	$0	$0	$0
Commission System and Instruct Homeowner[7]	$125	$250	$500	$1,250	$2,500
Central Monitoring and Communications[12]					
Install Monitoring and Communications Equipment					
Supply and Install Totals:					
Supply and Install Totals per connection:					
Annual Operation and Maintenance[8,3]					
Maintenance (equipment)	$250	$450	$850	$2,000	$3,500
Maintenance (labour)	$400	$800	$1,600	$4,000	$8,000
Sampling and Analysis[9]	$290	$580	$1,160	$2,900	$5,800
Records Maintenance/Customer Communication[10]	$200	$400	$800	$2,000	$4,000
Central Monitoring and Troubleshooting					
Other Operating Costs[11]	$12.50	$25	$50	$125	$250
Financing/Leasing Costs					
Annual Maintenance Totals:					
Annual Maintenance Totals per connection:					

Notes:

- It is the intent that these cost guidelines include all costs incurred by the community water system for the procurement, installation, and operation of a Point of Entry treatment system. These numbers are for illustration purposes only and can vary considerably with individual conditions.

- Shipping costs based on installation in the Kelowna area
- Central monitoring and Communications provides the water supply organization with components that enable monitoring of each system from the system operator’s office.

Footnotes:

1) $250 water testing for every 10 households
2) Extra analysis and quote prep time
3) Discount schedule (# units/discount): 5/0%, 10/10%, 20/15%, 50/20%, 100/30%
4) Not applicable
5) Shipping from Vancouver area to Kelowna
6) Assumes installation done at $75/hr, does not include travel time
7) Assumes individual training with each homeowner (can also be done with group training)
8) Assumes maintenance labour at $40/hr=
9) Assumes one test per year, five homes per hour
10) Assumes average of 1 hour per home per year
11) Electricity consumption (24x7 operation, $0.0633 per kWh)
12) Information to follow in subsequent stages of work

Group 4. Surface water, tannins, high turbidity, low pH, and bacteria present

System recommendation: POE Reverse Osmosis and UV (Note: This is only one option for treatment and is intended as an example. Colour and tannins have multiple options for treatment. Ensure the right solution is recommended to you by your treatment professional and you have examined all potential options).

	# Connections				
	5	**10**	**20**	**50**	**100**
Supply and Install					
Assessment					
Basic source water analysis & system assessment[1]	$250	$250	$500	$1250	$2500
Advanced source water analysis & system assessment (if required)[2]	$0	$100	$150	$300	$600
Supply and Shipping					
Supply treatment components[3]	$25,000	$45,000	$85,000	$200,000	$350,000
Supply housing					
Supply local monitoring & alarm components[4]	$3,750	$6,750	$12,750	$30,000	$52,500
Supply of System Communication & Monitoring					
Shipping costs to Water District[5]	$1,125	$1,950	$3,750	$8,250	$12,000
Installation and Commissioning[6]					
Install Housing and Access Facilities	$750	$1,500	$3,000	$7,500	$15,000
Install Treatment System	$7,500	$15,000	$30,000	$75,000	$150,000
Install Local Monitoring and Alarm Components	$375	$750	$1,500	$3,750	$7,500
Commission System and Instruct Homeowner[7]	$375	$750	$1,500	$3,750	$7,500
Central Monitoring and Communications[12]					
Install Monitoring and Communications Equipment					
Supply and Install Totals:					
Supply and Install Totals per connection:					
Annual Operation and Maintenance[8,3]					
Maintenance (equipment)	$2,500	$4,500	$8,500	$20,000	$35,000
Maintenance (labour)	$600	$1,200	$2,400	$6,000	$12,000
Sampling and Analysis[9]	$290	$580	$1,160	$2,900	$5,800
Records Maintenance/Customer Communication[10]	$200	$400	$800	$2,000	$4,000
Central Monitoring and Troubleshooting					
Other Operating Costs[11]	$600	$1,200	$2,400	$6,000	$12,000
Financing/Leasing Costs					
Annual Maintenance Totals:					
Annual Maintenance Totals per connection:					

Notes:

- It is the intent that these cost guidelines include all costs incurred by the community water system for the procurement, installation, and operation of a Point of Entry treatment system. These numbers are for illustration purposes only and can vary considerably with individual conditions.

- Shipping costs based on installation in the Kelowna area
- Central monitoring and Communications provides the water supply organization with components that enable monitoring of each system from the system operator’s office.

Footnotes:

1) $250 water testing for every 10 households
2) Extra analysis and quote prep time
3) Discount schedule (# units/discount): 5/0%, 10/10%, 20/15%, 50/20%, 100/30%
4) Includes UV intensity monitor, auto shutoff, lamp replacement reminder, audio/visual alarms
5) Shipping from Vancouver area to Kelowna (storage tank and pump sourced locally)
6) Assumes installation done at $75/hr, does not include travel time
7) Assumes individual training with each homeowner (can also be done with group training)
8) Assumes maintenance labour at $40/hr
9) Assumes one test per year, five homes per hour
10) Assumes average of 1 hour per home per year
11) Electricity consumption (24x7 operation, $0.0633 per kWh)
12) Information to follow in subsequent stages of work

APPENDIX R: Information about Leasing of Equipment

Some Community Water Suppliers may wish to explore the leasing of POE / POU treatment technology rather than direct purchase. The following information covers leasing of equipment.

Advantages of Leasing

Advantages that lease-to-own programs can offer to organizations including community water suppliers are as follows:

- Overcomes Budget Restrictions
- Conserves Working Capital
- Provides 100%+ Financing
- Avoids Obsolescence
- Flexible Payment Options
- Lower Payments Than A Loan
- Potential Tax Advantages
- Planned Asset Management
- Allows For Easier Cost Allocation
- Avoids Restrictions on Future Borrowings
- Protection From Increases In Bank Borrowing Rates
- Reduces Impact of Sales Tax
- Preserves Credit Lines
- Quick & Convenient Approvals
- Simplifies Budgeting
- Inflation Reduces the Cost
- Competitive Rates
- Easier To Qualify For Than Loans
- Improved Financial Reporting
- Preserves Shareholder Equity
- Establishes An Additional Credit Reference
- Matches Cash Flows And Benefits Resulting From New Equipment
- Simplifies Accounting

Comparison of Leasing with a Bank Loan of Cash Purchase

Leasing companies are ready to articulate the advantages of leasing compared with a bank loan or cash purchase. The features of a typical leasing plan compared with a bank loan or a cash purchase, as shown on a leasing company web site, are given in the following table:

Leasing	Bank Loan	Cash Purchase
Fixed-term rental agreement with option to purchase.	*Arranging a demand or term loan.*	*Using internally generated funds for acquisition of equipment.*
Normally provides fast credit approval.	Often involves a lengthy credit approval process.	No credit investigation involved.
Usually requires no down payment.	Usually requires a down payment of 20-25% or equipment cost.	100% initial cash outlay.
No additional collateral required. Equipment being leased is normally the only security provided.	Additional collateral is usually necessary. Normally a blanket lien on other business assets required.	No requirements for collateral or security.
Delivery, installation and other soft costs often may be included in lease.	Soft costs usually not included in loan. A further reduction of working capital.	Soft costs are also paid from cash reserves. A further reduction of working capital.
Payment of sales tax is normally deferred and paid over the term of the lease agreement.	Payment of full amount of sales taxes is due upon purchase. A further reduction of working capital.	Payment of full amount of sales taxes is due upon purchase. A further reduction of working capital.
Conserves cash reserves and working capital. Funds remain available to invest in other areas of the business and earn greater returns.	Conserves a portion of cash reserves and working capital for investment in other areas of the business.	Reduces cash reserves and working capital. Cash paid is not available to invest in other opportunities and generate greater returns.
Credit lines and bank borrowing capacity remain unaffected. No restrictive covenants on future ability to borrow.	Total lending exposure with the bank is increased. May exhaust operating credit lines. Likely to have covenants restricting future ability to borrow.	Depleted cash reserves and reduced liquidity may affect future ability to borrow.
Monthly payments are fixed and predictable for the full duration of the agreement.	Floating or variable bank rates are subject to change. Future costs and cash flow may not be predicted.	No impact from future changes in prevailing interest rates.
The effects of inflation reduce the value of future payments, reducing the effective cost of the equipment.	The effects of inflation reduce the value of future payments, reducing the effective cost of the equipment.	No benefits from inflation. Full equipment cost is paid in present value dollars.
Lease payments may qualify as	Bank interest and capital cost	Entitled to capital cost

a tax-deductible expense. This can reduce taxable income and reduce or defer taxes payable.	allowance may qualify as tax-deductible expenses. This can reduce taxable income and reduce taxes payable.	allowance according to government schedules. No additional tax benefits. Slow amortization of original investment capital.
Simplifies capital budgeting and planned future replacement. Helps to avoid technological obsolescence.	Complicates capital budgeting in a changing rate environment. No incentives to avoid technological obsolescence.	May have a negative effect on capital budgeting. No incentives to avoid technological obsolescence.
No restrictive covenants. As long as payments are made, lessor will not reclaim the equipment or demand early payment of principal.	Usually includes restrictions which will allow for the loan being called, and the outstanding balance demanded in full.	Equipment is owned. May still be subject to claim however if previous bank borrowing has been put in place.
Easy upgrades and no obligation to own the equipment at the end of the lease. Simplifies planning and budgeting for future upgrades. Often will not require reapplication for upgrade equipment values less than $50,000.	Owned equipment is often kept longer than its optimum productive life. Will likely have to reapply to bank for the financing of future upgrades.	Budgeting and planning discipline required to plan for future upgrades. Owned equipment is often kept longer than its optimum productive life.

APPENDIX S: Information on Turbidity from the Interior Health Authority

In some regions of BC, seasonal increases in the turbidity of certain water sources can cause problems. The Interior Health Authority has taken steps to respond to these problems. The following section is adapted from the web site of the Interior Health Authority.

> Turbidity –cloudiness or particles in water –is more than just an aesthetic concern. As turbidity rises, so does the risk of gastrointestinal illness. While this might not be of great concern to many people, the risk for the very young, the very old, and people with weakened immune systems can be higher. To help people make informed choices about their drinking water, water suppliers have partnered with the Interior Health Region to create the Turbidity Education & Notification Campaign. The campaign educates users about turbidity and notifies them of elevated turbidity levels. The heart of the campaign is the Turbidity Index, a user-friendly tool that shows whether water quality is Good, Fair, or Poor.
>
> In keeping with federal standards and provincial regulations, water suppliers regularly test and monitor drinking water to ensure customer safety.
>
> - If turbidity exceeds 1-NTU (nephelometric turbidity unit), a water supplier will issue a Water Quality Advisory through the local media and, where possible, on websites and at public facilities. Children, the elderly, and people with weakened immune systems will be advised to drink boiled water or a safe alternative.
> - Turbidity greater than 5-NTU may trigger a Boil Water Notice, during which all customers will be advised to drink boiled water or a safe alternative.

Importance and Effects of Turbidity

Turbidity is an important water quality indicator because contaminants such as bacteria, viruses, and parasites (e.g. Giardia and Cryptosporidium) can attach themselves to the suspended particles in turbid water. These particles interfere with disinfection by shielding contaminants from the disinfectant (e.g. chlorine). Nor is chlorine effective in deactivating Cryptosporidium.

Turbidity is caused by fine suspended particles of clay, silt, organic and inorganic matter, plankton, and other microscopic organisms that are picked up by water as it passes through a watershed. While turbidity usually results from natural events such as spring runoff or high precipitation, it can also be caused by manmade erosion.

Turbidity, reported in nephelometric turbidity units (NTU), is an optical measurement of water's ability to scatter and absorb light rather than transmit it in straight lines.

Turbidity levels are much higher in water from surface sources than in groundwater. Turbidity levels can range from less than 1-NTU to more than 1,000-NTU. At 5-NTU, water is visibly cloudy, and at 25-NTU it is murky.

APPENDIX T: Planning for POE / POU Pilot Projects

In this section:

- Purpose and Objectives of the Pilot
- Characteristics of POE / POU Systems to be Examined
- Composition of Team that Undertakes Pilot
- Proposed Pilot Project Tasks
- Associated POE / POU projects

As part of the follow-on work to this report, a series of pilot projects is proposed. These projects will occur in various locations in British Columbia. The initial plan for these pilot projects is outlined in the following.

T.1 Purpose and Objectives of the Pilot

The purpose of the pilot project is to examine technical, economic and operational aspects of the installation and operation of POE/POU technology by water suppliers (CWS) in British Columbia. These community water systems may include commercial, industrial and institutional usage. The pilot projects will be undertaken to explore the use of POE / POU in treating several contaminants of concern, and to review the use of POE /POU in a variety of geographical and organizational contexts

The pilot project will aim to achieve the following objectives:

1. Refine guidelines for POE/ POU
2. Explore technologies that are suitable
3. Refine approach to application of POE/ POU in treating microbial contaminants
4. Refine elements of the DWO guide
5. Explore other technical, economic & operational issues.

T.2 Characteristics to be examined

The following is a list of characteristics of a POE / POU system that may be examined during the pilot.

1. Availability and affordability of technology
2. Compliance with standards

3. History of operating experience
4. Reliability of operation
5. Ease of access and maintenance
6. Environmental footprint
7. Capital, operating and maintenance costs
8. Availability of experienced supply and support
9. Use of automatic shut-off and alarm
10. Amenability to remote monitoring

T.3 Composition of Team

The team undertaking the pilot projects should consist of individuals representing a range of experience and expertise as shown in the following. In some cases, a single individual may fulfill several of the roles shown.

- Project manager
- Regulatory representatives
- Microbiologist
- Water chemistry specialist
- Professional engineer
- Costing specialist
- Technology specialist
- Small water systems representative
- Specialist experienced in previous POE / POU pilot projects
- Standards & certification specialist (CSA / UL)

T.4 Pilot Project Tasks

The following is an outline of tasks that will be involved in the pilot projects.

Prepare Detailed Project Plan: Prepare detailed project plan, including confirmation of scope, objectives, deliverables, budget and schedule and project team composition.

Identify and Select POE/POU Technologies for Testing – Review and select which technologies should be examined. These technologies will be those expected to find significant application in British Columbia. Some examples may be: Ultraviolet (UV), Micro/Ultra/Nanofiltration, and Reverse Osmosis. At least one pilot project may be identified for each of the main classes of technology.

Agree on Criteria for Selecting Pilot Test Sites – Discuss and determine what criteria should be applied in selecting actual sites on which to conduct the pilot test. The criteria may include the following:

- ❑ Representative of an expected POE/POU application (E.g. arsenic removal)
- ❑ Addresses at least one technology of interest

- Opportunity for POE / POU is recognized
- Accessibility
- Owners agree to cooperate
- Funding has to be evident.

Identify and Select Potential Candidate Sites – Several potential test sites should be identified, by reference to sources including the following: BC Hydro (probably John Hart dam), Small Water Users Association of BC, suggestions by BC Health Regions, and water systems that failed to qualify for SIS sponsored liability insurance. A table can be created which shows how each of the potential candidates relates to the typical system characteristics that are to be examined. The table should show the technologies that could be examined at each candidate site. The criteria established in a previous task should be applied and several candidates selected to participate in the pilot projects.

Define Testing Protocol – Define the testing protocols and parameters of the pilot project for each of the chosen test sites. These parameters would reflect interests of the BC Ministry of Health and the Health Regions. Parameters may include the following:

- Length of pilot test
- Installation and implementation issues to be monitored
- Water quality parameters to be monitored, including identified contaminants in source water Operational parameters
- Monitoring methods and frequency
- Reporting format
- Continuous monitoring of microbiological contaminants.

Plan, Design and Implement Individual Test Sites – Review the characteristics of each individual test site:

- Ownership and governance issues
- Characterize site-specific elements (e.g.: seasonal variability, characterization of source water)
- Amenability to remote monitoring
- Record keeping by CWS
- Funding available and financing opportunities; purchase / lease
- Engineering input required.

In general the sequence of activities at each site will include:

1. Describe system including water testing and evaluation (See BC Hydro approach)
2. Preparation of draft drawings and specifications by specialist supplier
3. Review of material by team members including engineering specialist
4. Prepare working drawings and specifications, certified by engineer
5. Negotiate contract for supply, install and maintenance of treatment technology
6. Supply and install technology on site

7. Carry out monitoring and testing
8. Carry out continuing operation and maintenance.
9. Report on process and results

Document Operations, Monitoring & Maintenance of Test Sites – Monitor progress of pilot project activities and regularly report to project team.

Conclude Pilot Project and Produce a Summary Report of Findings - Interpretation of results, comments on lessons learned, do’s and don’ts, recommendations concerning guidelines. Preparation of report.

T.5 Associated Projects

The following work will be included in projects separate from the pilot projects described above. This work will complement the pilot project activities:

- Preparation of tables listing existing POE / POU technology and compliance with standards
- Tables showing each BC health region and the water quality requirements for potable water
- Table showing functional treatment requirements (E.g. 4 log removal), and cost comparisons between proprietary technologies which can meet these requirements, including technologies which comply with applicable standards and those which do not comply with applicable standards.
  Discussions with companies who are able to manufacture housings for POE systems, and with companies providing technology for monitoring signal generation, transmission and remote display.