Appendix K – Additional Information on Compliance Alternatives Included in CO-RADS Reports

Appendix K: Additional Information Provided in CO-RADS Reports

Information presented in this section may be considered by the Association prior to implementing the defined alternative in Section 7 of this Report. The following information is provided to assist further evaluation of options, including high pressure membranes, proprietary solutions, POU/POE treatment, or regionalization.

1.1. Removal of Additional Contaminants by Ion Exchange

The information provided in Section 7 only assumes the removal of uranium as the contaminant of concern, which results in the most cost effective approach to installing and operating an anion exchange system. However, anion exchange is also capable of removing sulfate and nitrate from the source water supply. If the system decides that sulfate and/or nitrate also need to be removed through the anion treatment system described in Section 7, the design and operation of the system could potentially be modified in the following ways:

- Regeneration frequency: the system would likely need to be regenerated more frequently because sulfate and nitrate break through before uranium. This would likely necessitate larger evaporation basins to treat larger volumes of waste.
- Anion exchange vessel sizing and number: larger or more anion exchange vessels would likely be required to optimize the treatment system for the removal of all three contaminants: uranium, nitrate, and sulfate.

If the system decides that hardness or other cations should be removed through the treatment system to further improve water quality (for example, hardness could be removed to improve the taste of treated water), cation exchange resin could be added to the anion exchange vessels or additional cation exchange vessel(s) could be added to the treatment process train. For the former alternative, vessel sizes would likely be increased. These types of changes to the system design would require an increase in the size of the evaporation basins.

1.2. High Pressure Membranes (RO/NF)

RO and NF are pressure-driven processes that target the removal of dissolved contaminants through semi-permeable membranes. Pressure in excess of the natural osmotic pressure of the system is supplied to the feed side of the membrane to force water through, leaving dissolved contaminants on the other side. The membranes are nonporous and can rapidly foul when subjected to significant particle loading. A large portion of the cost of operating RO/NF systems is due to energy required to create the hydraulic pressure to force water through the membranes.

NF membranes remove the same contaminants as RO membranes except for smaller, less charged ions, such as sodium and chloride (monovalent ions). In other words, some contaminants, including salt, are not typically removed through NF membranes, but they are mostly removed by RO membranes. A typical RO/NF system consists of three treatment steps (see Figure 8-1): 1) pre-treatment, 2) the membrane process, and 3) post-treatment. In Figure 8-1 a two-stage membrane configuration is depicted, which is intended to reduce the overall amount of water rejected through the membrane process.

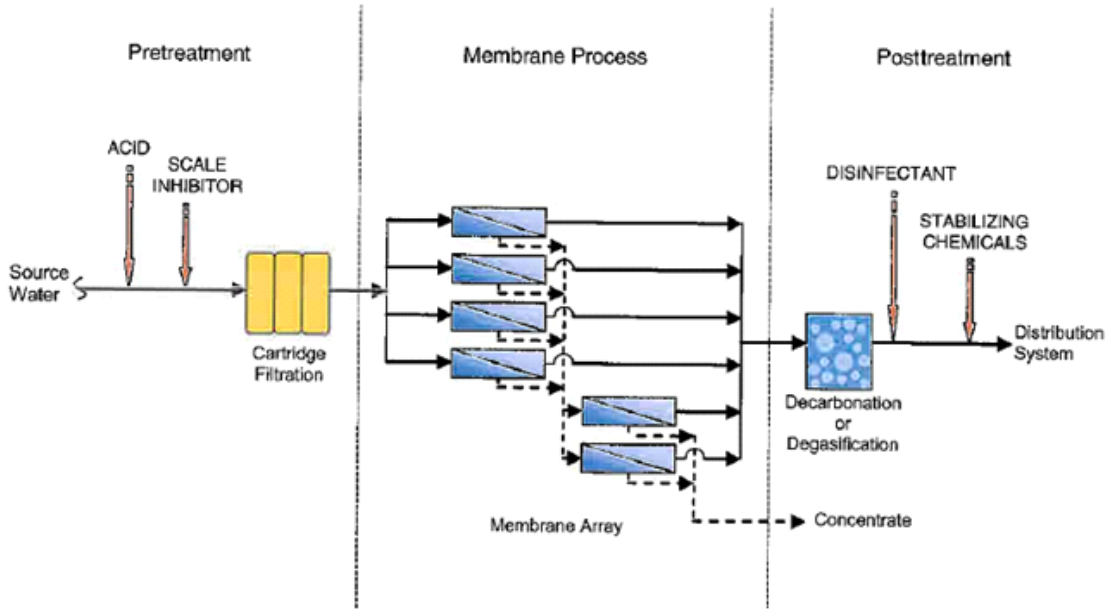

Figure 0-1.
Schematic of a Typical RO/NF Membrane Treatment System

(Taken from Reverse Osmosis and Nanofiltration (M46), 2nd edition, American Water Works Association)

Pre-treatment usually comprises the addition of an acid, scale inhibitor, or both to prevent precipitation of soluble salts on the feed side of the membrane as the rejected ions become more concentrated followed by cartridge filtration (5- to 20 μm) to protect the membranes from particulate fouling. Additional pre-treatment may be necessary for waters with higher fouling potential, such as surface water supplies.

Permeate from RO/NF membrane systems often contains significant quantities of dissolved gases, has low pH, and a high corrosion potential. As a result, post-treatment may include aeration, degasification, pH adjustment, addition of corrosion control chemicals, and disinfection to mitigate corrosion in the distribution system and to disinfect.

Pilot testing conducted by the Colorado School of Mines through CO-RADS suggests that NF membranes will remove radionuclides and would likely be a more cost effective solution than RO membranes. WWMHP would need to consider conducting additional pilot testing at WWMHP to further evaluate this process and select an appropriate membrane for WWMHP's source water.

1.2.1. Discharge to POTW

High pressure membranes may be a viable solution for WWMHP to comply with the Radionuclides Rule because WWMHP owns and operates a POTW, which may be able to accept concentrate for disposal. Some considerations would include:

- Upgrades to the POTW would likely be required based on the volume and quality of the RO/NF concentrate.
- The system would have to work with CDPHE's residuals handling agencies to determine if concentrate disposal to the POTW would be allowed and could be successfully permitted.
- Discharge of RO/NF reject water to the wastewater treatment facility may require a new discharge permit for the POTW.
- If POTW has pretreatment requirements, it may preclude brine discharge unless pretreatment is provided.
- Depending on the quality of RO/NF reject water and WWMHP's POTW, RO/NF reject water could significant impact the performance of the POTW and would need to be evaluated prior to RO/NF installation.
- System may need to make upgrades or changes to the biosolids handling practices.
- Pilot testing conducted by the Colorado School of Mines through CO-RADS suggests that NF membranes will remove radionuclides and would likely be a more cost effective solution than RO membranes. WWMHP would need to consider conducting additional pilot testing at WWMHP to further evaluate this process and select an appropriate membrane for WWMHP's source water.

1.2.2. Discharge to Surface Water

If discharge to surface water is further evaluated for RO/NF treatment, the following items should be considered:

- Significant dilution by the receiving stream is needed
- Water quality parameters other than radionuclides (e.g., TDS, selenium) may be the limiting factor
- General steps that should be taken for evaluating this alternative follow:
  - Identify basin standards for the specific stream segment where discharge will occur
  - Identify basic standards (State-wide) to apply to the stream segment

- Identify ambient water quality concentrations and flow rate
- Perform mass balance with ambient stream water quality and low flow rate and the proposed discharge to determine if there is sufficient dilution
- Complete all permitting and final determinations through the WQCD Permits Unit

1.3. Proprietary Solutions

Several companies offer comprehensive Radionuclides Rule compliance services, including water treatment system design/installation, operation and maintenance of treatment equipment, and handling and disposal of wastes. Some potential advantages of this compliance alternative relative to WWMHP installing and operating its own water treatment facility are summarized below:

- WWMHP would be responsible for minimal O&M of treatment equipment; as a result, WWMHP staff would likely not need as much O&M training as would be required to oversee a new water treatment system
- Since the vendor would be responsible for waste handling, WWMHP staff would have less worker exposure to radiation from treatment and handling of wastes
- It would not be necessary to negotiate individual waste handling and disposal agreements with waste handling organizations

Some disadvantages of a proprietary solution would include:

- WWMHP would take on the risks associated with entering into a long-term contract (up to approximately 20 years, depending on the vendor and negotiated terms)
- WWMHP would be locked into a financial agreement and unable to manage or optimize water system costs associated with system installation, operation, or maintenance over the duration of the contract
- There could be some challenges communicating and working with a vendor over the entire duration of the contract
- WWMHP is still responsible for all radioactive wastes generated by the water system, regardless of who is contracted to facilitate the transport and disposal; as a result, vendor decisions about waste disposal could impact WWMHP
- Risks associated with the stability of the vendor could impact WWMHP – for example, if the vendor's business goes under

Cost estimates were requested from several companies that provide proprietary solutions for removal of radionuclides from drinking water as part of the CO-RADS project. Information on some of the treatment services provided by these companies was provided; however, cost estimates cannot be extrapolated to each system in CO-RADS. Systems will need to contact vendors for individual quotes. These vendor quotes can be compared to the option defined in Section 7 of this Report. In addition, companies were reluctant to provide comprehensive information on how the treatment processes work. Because of the lack of information provided by these vendors, Pirnie could not perform a

comprehensive evaluation of proprietary solutions for compliance with the Radionuclides Rule.

If WWMHP decides to further evaluate this alternative as a compliance solution for the Radionuclides Rule, Pirnie recommends that WWMHP seek legal and engineering guidance to support the successful negotiation of a contract with the vendor. Table 8-1 summarizes a few items that WWMHP should consider during contract negotiations to ensure a fair agreement between WWMHP and vendor. In addition, references for some of the vendors that Pirnie contacted as part of this project are included in Appendix F.

Table 0-1.
Contract Negotiation Considerations for Proprietary Solutions

Item	Considerations
Contract Duration	This is one of the most important items that WWMHP would carefully need to evaluate as the risk could go up or down for WWMHP, depending on how the term is negotiated.
Contract Termination Clauses	Identify scenarios that may require WWMHP to terminate the contract and negotiate terms with the vendor.
O&M	Clearly define all of the specific services the vendor is providing, including O&M activities, water quality sampling and reporting to CDPHE, repair/replacement, reporting to WWMHP, and record keeping.
Worker Safety and Exposure	Clearly identify how frequently waste material needs to be removed, who is handling the material, and where it is disposed; these requirements should be linked to an analysis of worker safety and exposure caused by the vendor's water treatment system and O&M strategy.

1.4. POU/POE Treatment

POU/POE may be an attractive solution to systems for which there would be a cost-saving compared to centralized treatment. A recent study on POU for arsenic removal (Narasimhan et al, 2005) found that the annualized cost breakpoint for POU reverse osmosis and POU adsorption treatment (adsorption using throw away media) compared to centralized treatment was 120 and 200 connections, respectively. Annual O&M costs for POU RO and POU adsorption units were found to be higher than for central treatment for systems serving greater than 50 and 60 connections, respectively. Note all treatment costs for radionuclides may be much different than those for arsenic, depending on the type of contamination and treatment technology selected. A similar analysis conducted for POE in this study showed that POE treatment would not be competitive with centralized treatment, even for the smallest systems (20 connections). A cost analysis performed by EPA (Preamble to Final Arsenic Rule, USEPA, 2001) shows significantly lower costs for POE systems, with a cost breakpoint compared to centralized treatment at 53 connections. However, EPA's costs do not include waste disposal issues, labor, operations, or management of a POE treatment program. The costs for POE ion exchange treatment are not included in this Section because these are not identified as SSCTs by EPA. In addition, CDPHE anticipates finalizing guidance for design,

permitting, and implementation of POU/POE treatment by early 2009. This guidance material should be used to further evaluate POU/POE treatment on a system-specific basis.

Approximate costs for POU treatment were obtained from several different sources, as shown in Table 8-2. These feasibility level estimated costs are provided for comparative purposes only and are not specific to water systems in Colorado and not specific for radionuclides. ***Cost estimates do not include residuals disposal, insurance coverage, or additional treatment or protection required due to the nature of radionuclide treatment***.

Table 0-2.
Approximate Costs for POU/POE Treatment

Treatment Technology	Approx. Capital Cost	Estimated Cost Per Household	Assumptions/Comments	Source
Purchase of POU RO	$112,000	-$32/household/ month - Average annual cost per household = $380	- 3 persons per household - Each person consumes 2 liters per day Treatment of groundwater containing radium at 112 households - Capital discounted at 7% over 5 years - Capital cost includes one water quality sample/household in the first year - O&M costs (average annual cost per household) include radionuclides sampling at 1/3 of households each year assuming an analytical cost of $257.50 and $28.18 for shipping and laboratory fees - Includes installation, educational program, and maintenance - Permitting, pilot testing, and legal as 3% each of capital - Engineering as 15% of capital - 10% contingency - $650 for public education	EPA Cost Estimating Tool for Point-of-Use and Point-of-Entry Devices, Final Version December 19, 2006

Treatment Technology	Approx. Capital Cost	Estimated Cost Per Household	Assumptions/Comments	Source
POU RO Rental	$28,000	- $31/household /month - Average annual cost per household = $370	- 3 persons per household - Each person consumes 2 liters per day Treatment of groundwater containing radium at 112 households - 5-year rental period - Capital cost includes one water quality sample/household in the first year - O&M costs (average annual cost per household) include radionuclides sampling at 1/3 of households each year assuming an analytical cost of $257.50 and $28.18 for shipping and laboratory fees - Includes installation, educational program, and maintenance - Permitting, pilot testing, and legal as 3% each of capital - Engineering as 15% of capital - 10% contingency - $650 for public education	EPA Cost Estimating Tool for Point-of-Use and Point-of-Entry Devices, Final Version December 19, 2006
POU IX	$37,000	Not available	- Source of estimated capital cost is for arsenic removal with activated alumina (2005 US dollars) - Assumed purchase of POU treatment units for 112 homes	POU/POE Implementation Feasibility Study for Arsenic Treatment (2005) AwwaRF

Other issues will need to be considered as part of an evaluation of a POU/POE treatment program, including potential CDPHE policy requirements as follows:

- 100% customer participation (i.e., all customer must have the POU/POE treatment at their home)
  - Ordinance, board by-law, or other mechanism must be in place to ensure 100% participation
- The water system must own all the devices
  - All devices must be the same make and model
  - No grandfathering of existing units
  - Water system must have access to all devices
- At least 1/3 of devices must be tested annually
- Potential homeowner radon exposure must be addressed; radon mitigation may be required prior to distribution
- Discharge to residential septic system

  - Commercial or industrial discharges are subject to regulation under the EPA UIC Class V injection well classification; therefore, POU/POE may only be an option to systems with only residential users
  - Accumulation of radionuclides in septic sludge and leach field, and groundwater impacts must be addressed
- Discharge to POTW will also need to be evaluated (See comments regarding RO/NF in Section 8.2.1); however, impacts to the POTW (influent volume and water quality) are expected to be minimal compared to centralized RO/NF treatment.

1.5. Regionalization

Water systems may achieve cost savings by taking advantage of the economies of scale that regionalization provides. Regionalization can take many forms, including the following:

- Inter-system services agreements, such as chemical purchasing and delivery and residuals management/transportation
- Full consolidation of multiple water systems into one organization
- Construction of a pipeline so that one system can purchase water wholesale from another system

Some of the advantages of regionalization follow:

- Minimization of redundancy – administrative, management, technical, accounting, information technology, and legal resources may be able to be reduced.
- Increased purchasing power – potential to realize greater buying power for materials, supplies, and equipment compared to buying supplies and services separately
- Greater economies of scale – reduced costs may be realized through combining resources as a result of greater economies of scale. A regional utility may be able to better manage staff and employ specialized staff than a smaller utility.
- Increased credit strength – A more stable customer base may be able to obtain better credit ratings from bond underwriters which would reduce the cost of borrowing.
- Affordability – A regional utility can provide more affordable services as a result of a larger customer base.

Some of the disadvantages are summarized below:

- Potentially high start up costs – while long-term cost savings may be realized, full consolidation can be costly to create a new entity, acquire assets, and set up a governing structure.
- Local control and service concerns – some may perceive a loss of control and without proper planning, customer service may suffer.
- Potential staff reductions – level of staffing may change.

If the system decides to evaluate regionalization, the following should be considered:

- Good communication with other organizations and the system's customers is very important. Customers need to have confidence their level of service will not be reduced.
- Strong leadership is needed to make regionalization successful.
- It is important for the regionalizing entities to have common goals.