

# Multiple-Contaminant Private Well Water Treatment Arsenic, Radionuclides, and More

Steve Spayd, PhD, MPH, PG  
Research Scientist - Hydrogeologist  
New Jersey Geological and Water Survey  
New Jersey Department of Environmental Protection  
PO Box 420  
Trenton, New Jersey 08625

email: [steve.spayd@dep.state.nj.us](mailto:steve.spayd@dep.state.nj.us)  
phone: 609-633-1039



# Contributing Authors:

Jenny Goodman, Bureau of Environmental Radiation, NJDEP

Zoltan Szabo, NJ Water Science Center, USGS

Judy Louis, Office of Science, NJDEP

David Grammer, Radata Inc

Videography: Ted Pallis, NJDEP

# Multiple Contaminants in Well Water

- Arsenic (As<sup>3</sup> and As<sup>5</sup>)
- Manganese
- Iron
- Gross Alpha
- Radium
- Uranium
- Radon and Radon Progeny
- Sulfur and Iron Bacteria
- Boron, Lithium, Sodium, and Sulfate



## Arsenic Water Treatment for Residential Wells in New Jersey

### ARSENIC

Arsenic has been found to occur in well water of the Piedmont Physiographic Province of New Jersey (Figure 1) at levels exceeding the drinking water standard. Research by the NJ Geological Survey (NJGS) indicates the arsenic is predominantly naturally occurring.

Arsenic is a toxic element that is known to increase the risk of adverse health effects in people who drink water containing it. Arsenic is a known human carcinogen that causes cancer of the skin, bladder, lung, kidney, and liver. It also causes increased risk of cardiovascular disease, peripheral neuropathy, skin hyperpigmentation and keratoses, and diabetes. The major exposure pathway for arsenic in residential well water is drinking and cooking with the untreated water. There may also be exposure from other uses of water in the home through bathing, showering, and brushing teeth. The NJ Department of Environmental Protection (NJDEP) adopted 5 ppb as the arsenic drinking water standard in New Jersey, effective in January 2006.

### TESTING

Arsenic in well water is colorless, odorless, and tasteless. The only way to identify its presence is to have the water specifically tested for arsenic. You should have your water tested for arsenic if you have your own well and live in the shaded area of the map in Figure 1. Water testing labs can usually be found in the telephone book under "Laboratories-Testing" or "Water Analysis." A list of certified labs can also be found on the Private Well Testing Act web site at <http://www.state.nj.us/dep/pwta/>. Use a

lab that is certified to test drinking water for arsenic and can provide a method detection limit (MDL) of 3 ppb or lower. The lab will report the total arsenic concentration. Although arsenic in New Jersey well water has been found to occur in two species commonly referred to as As3 and As5, the tests for these species are difficult and not widely available from commercial labs at this time. For this reason, if your well requires arsenic treatment, it is important to choose a treatment system that removes both arsenic species.

Confirm your arsenic level by re-sampling your water for arsenic. If you have tested your well and the arsenic level is reported to be greater than 5 ppb, you should re-test to confirm the result before obtaining a treatment system. When re-sampling for arsenic, also test for pH, iron, manganese, sulfate, and silica, as their levels need to be known when designing your arsenic treatment system.

### TREATMENT

NJDEP tested and evaluated treatment systems to determine the most efficient, cost effective, user friendly, and environmentally sound water treatment technologies to remove arsenic from residential well water in New Jersey. Arsenic removal requires special considerations. Water softeners and granular activated carbon do not remove arsenic. As of the publication date, the research has resulted in the following treatment guidance.

The preferred treatment technology for arsenic removal in New Jersey is a whole-house granular ferric adsorption system as shown in the below table. It effectively removes both arsenic species from all water in the home, is easy to operate and maintain, and the arsenic is

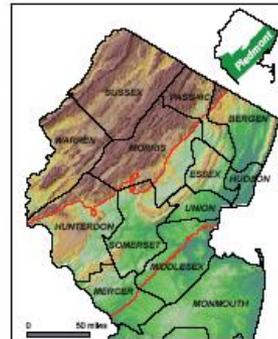


Figure 1. Location of the Piedmont Physiographic Province (shaded area in upper illustration) and color-shaded relief map (lower illustration) of northern New Jersey

not returned to the environment via regeneration. This type of system is called a "Point-of-Entry" system because the water is treated where it enters the home and all the water in the home is treated. This type of system should be installed as shown in Figure 2. The system consists of a shut-off valve, a 5-micron sediment pre-filter, a raw water sampling tap, two 10x40 inch or 9x48 inch tanks each containing at least one cubic foot of adsorption media (if arsenic concentrations are greater than 50 ppb, a greater volume of media should be considered in consultation with your water treatment professional), backwash control valves on each tank, a sampling tap between the tanks, and a shut-off valve after the system. The system

Arsenic Treatment Option Summary								
Treatment Type	Preferred	Process & Maintenance	Chemical Use	Waste Generated	Arsenic Species Removed	Typical Media Life	Average Installation Cost	Average Maintenance Cost
Granular Ferric Adsorption Whole House	1 <sup>st</sup> Choice	Simple	None	Low	As3 & As5	2-3 Years	\$2,740	\$0.67-1.00/day
Gran Ferric Single Tap Cartridges Anion Exchange Whole House Reverse Osmosis Single Tap	2 <sup>nd</sup> Choice	Simple	None	Low	As3 & As5	1 year	\$365	\$0.32/day
	No	Complex	Salt	High	As5 Only	10 Years	\$2,000	\$0.27/day
	No	Moderate	Disinfectant	Low	As5 Only	3 Years	\$700	\$0.33/day

# Point-of-Use Treatment for Drinking and Cooking Water at a Single Tap

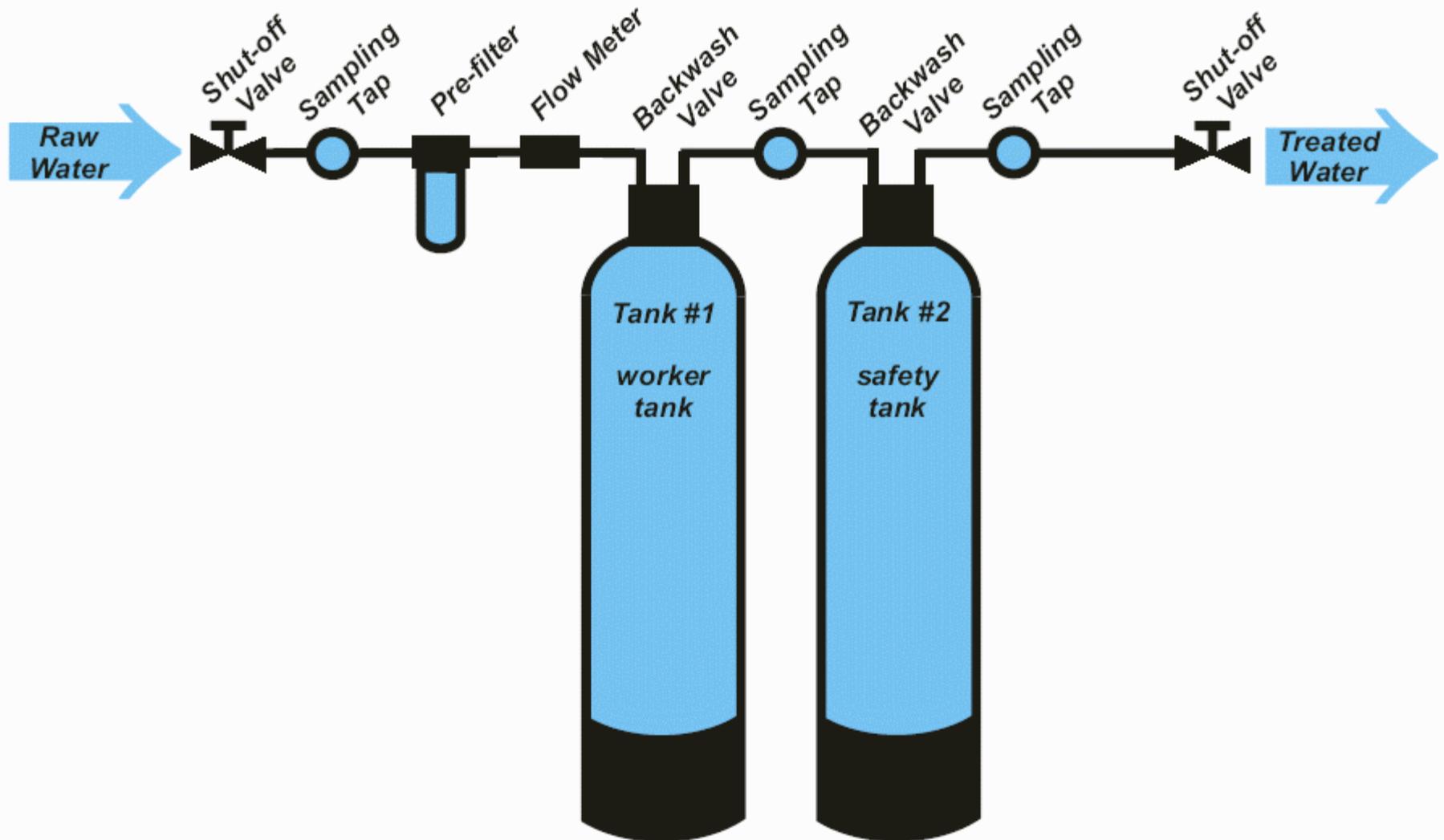


One study suggests that Whole House (POE) water treatment provides more effective reduction of arsenic exposure from well water than does POU.

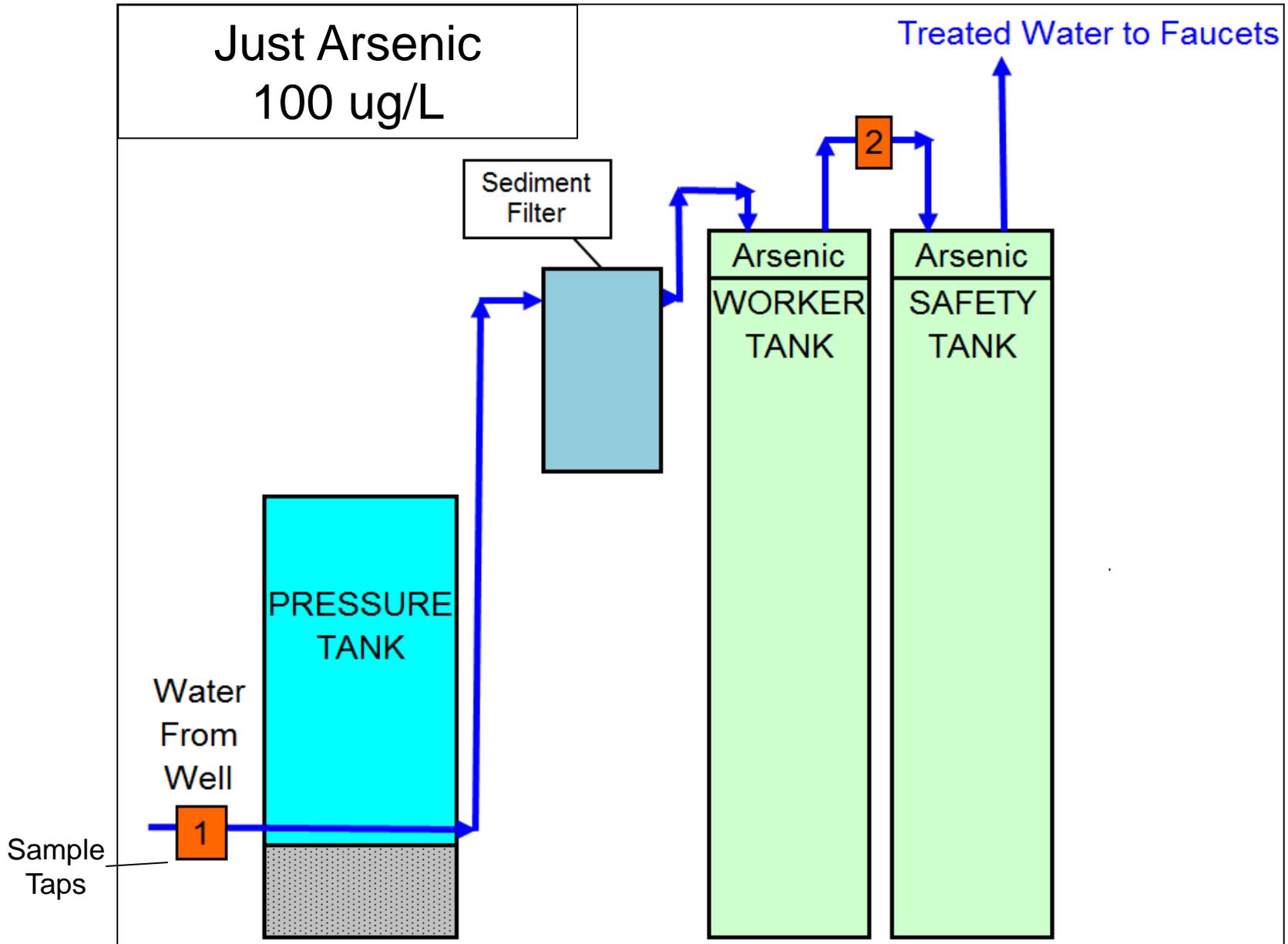


- Skin Absorption
- POU Non Compliance (Drinking from Untreated Taps)

# Whole House Water Treatment is Best



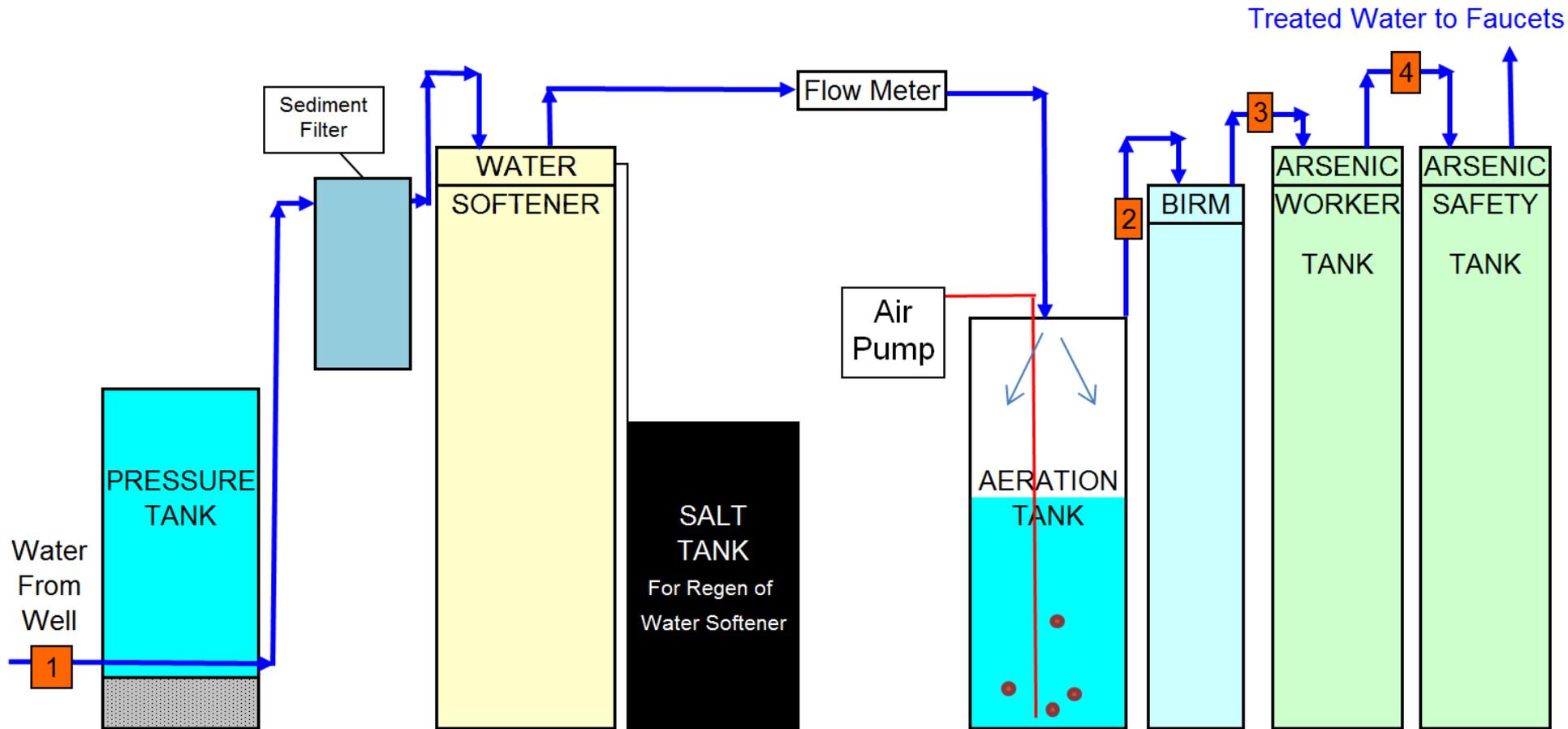
# Whole House Arsenic Water Treatment



# Whole House Arsenic Water Treatment



# As<sub>3</sub>, Fe, Mn, S – Phase 1



Raw Water Quality: As=48, Fe=1200, Mn=42 ug/L

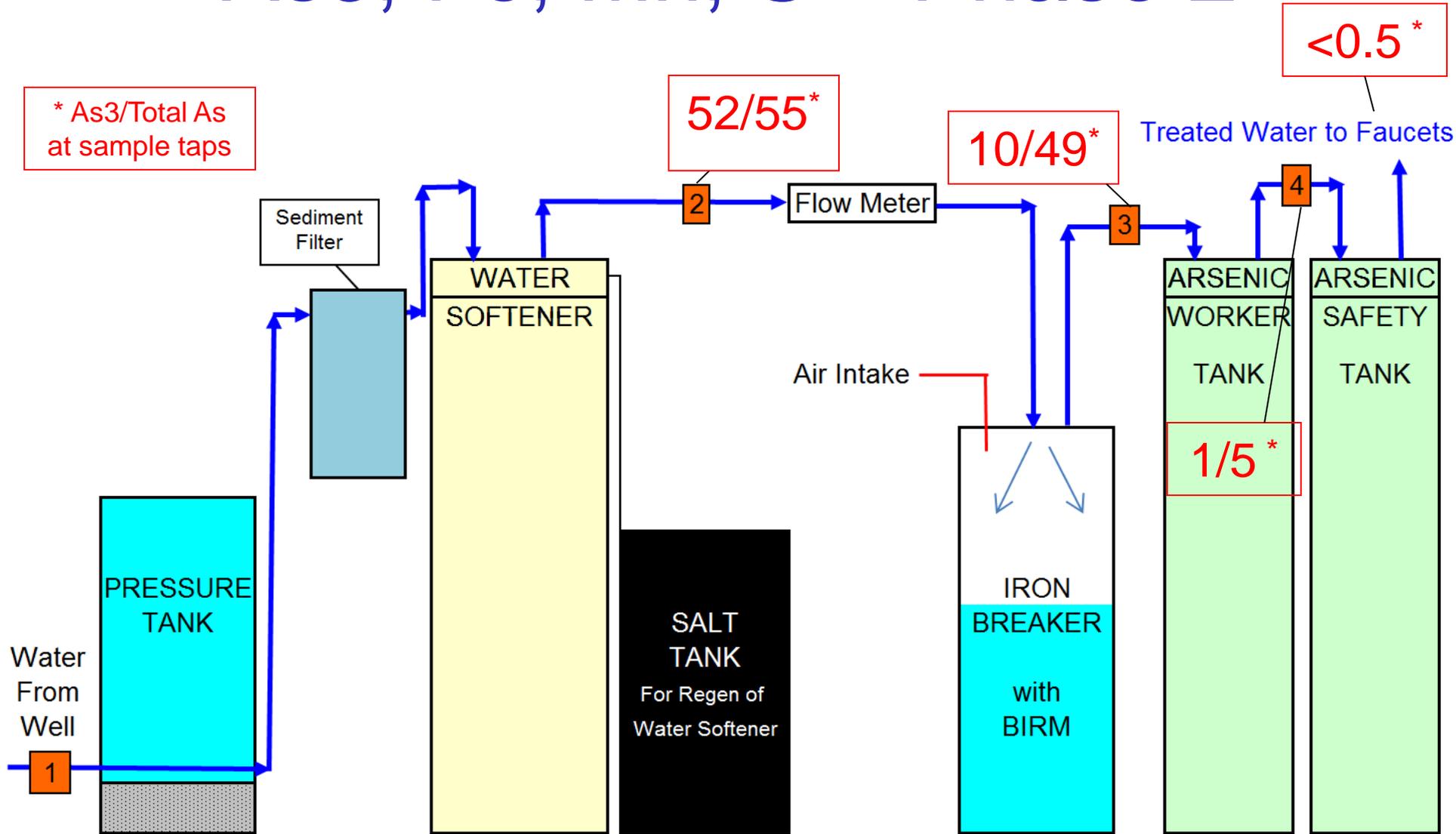
# As3, Fe, Mn, S – Phase 2

\* As3/Total As at sample taps

52/55\*

10/49\*

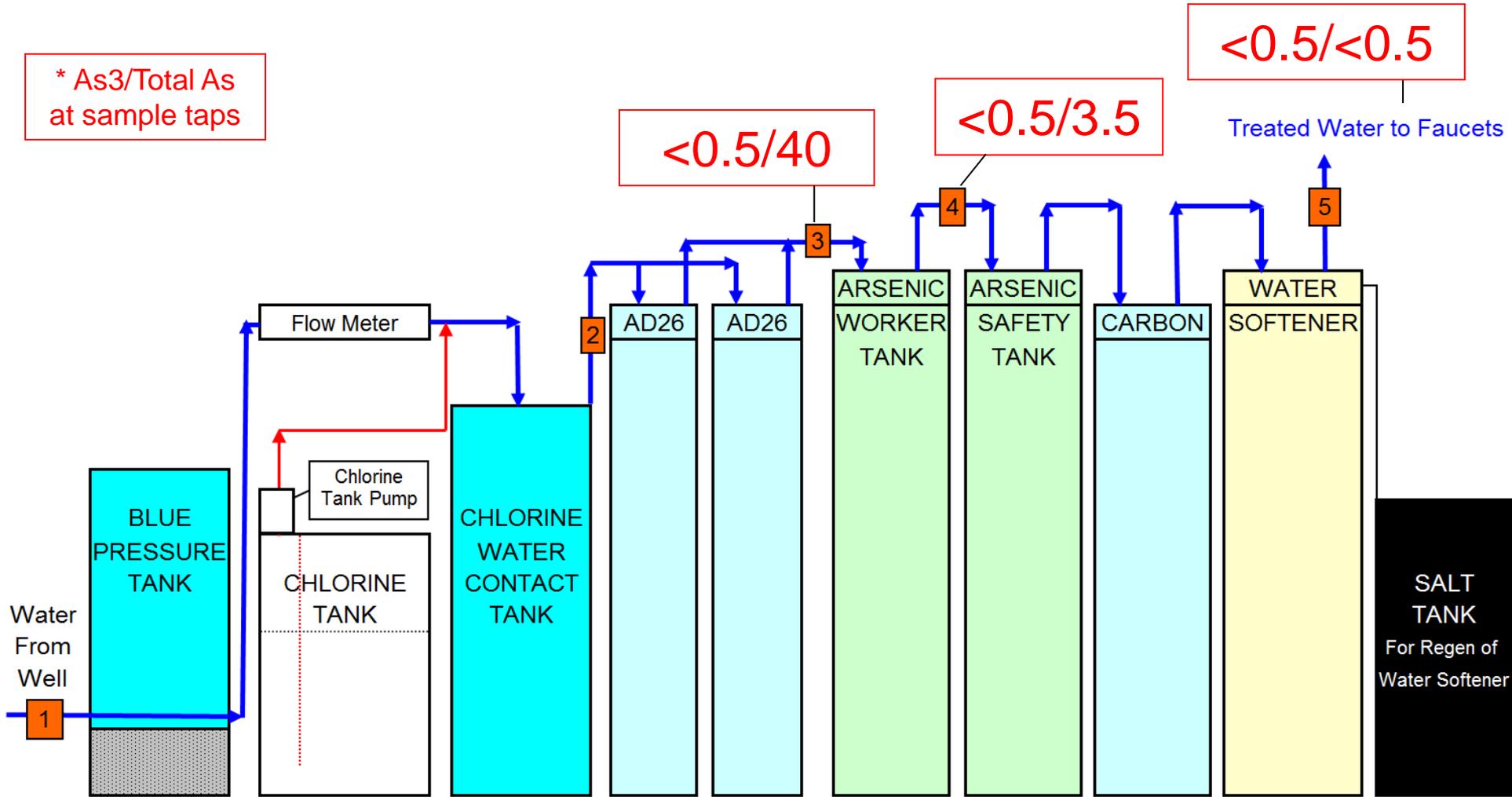
<0.5\*



Raw Water Quality: As3/As=48/48, Fe=1200, Mn=42 ug/L

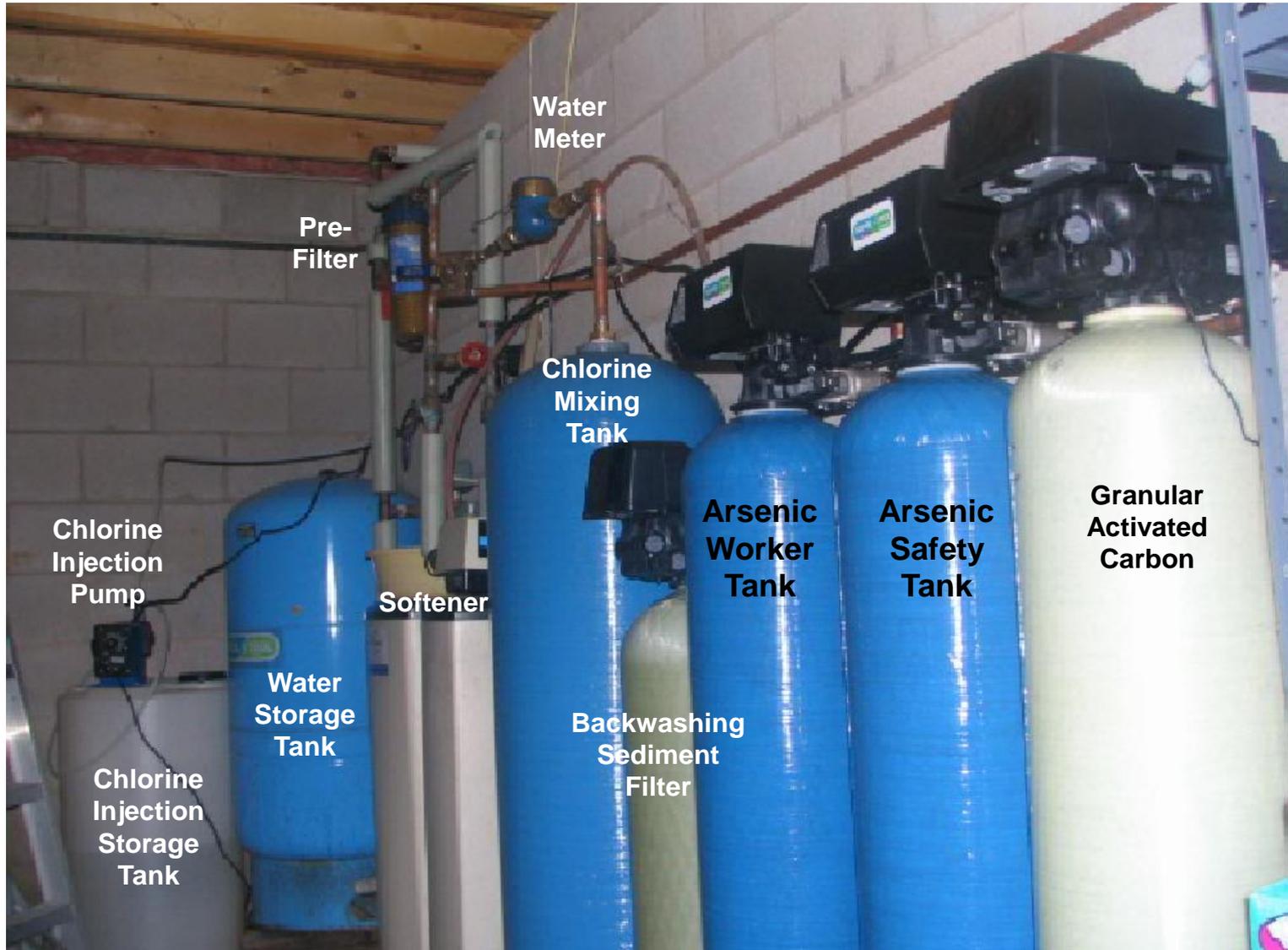
# As3, Fe, Mn, S, Iron Bacteria

\* As3/Total As  
at sample taps



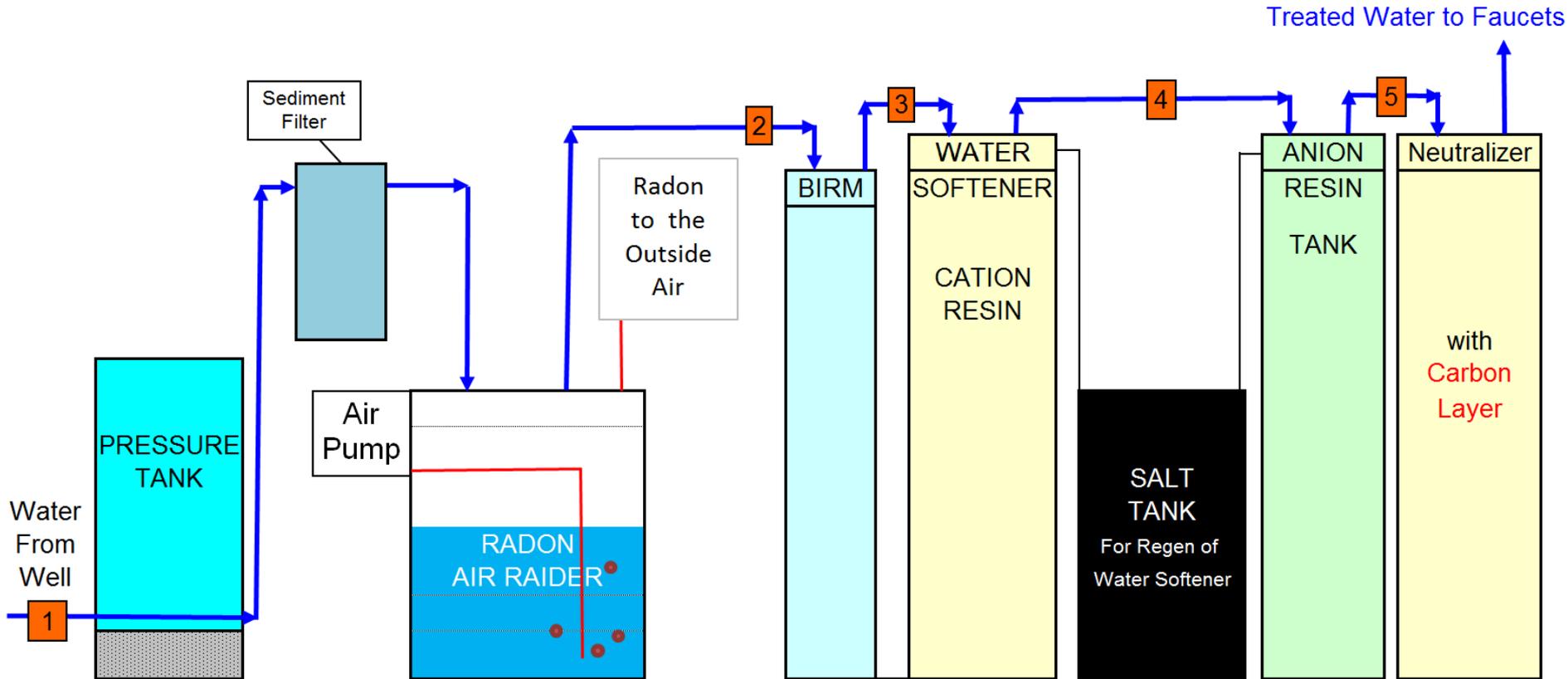
Raw Water Quality: As3/As=80/80, Fe=1170, Mn=216 ug/L

# As<sub>3</sub>, Fe, Mn, S, Iron Bacteria



# As, Fe, Mn, U, Ra, Rn - Phase 1

Problem Set-UP (BIRM Tank became radioactive)



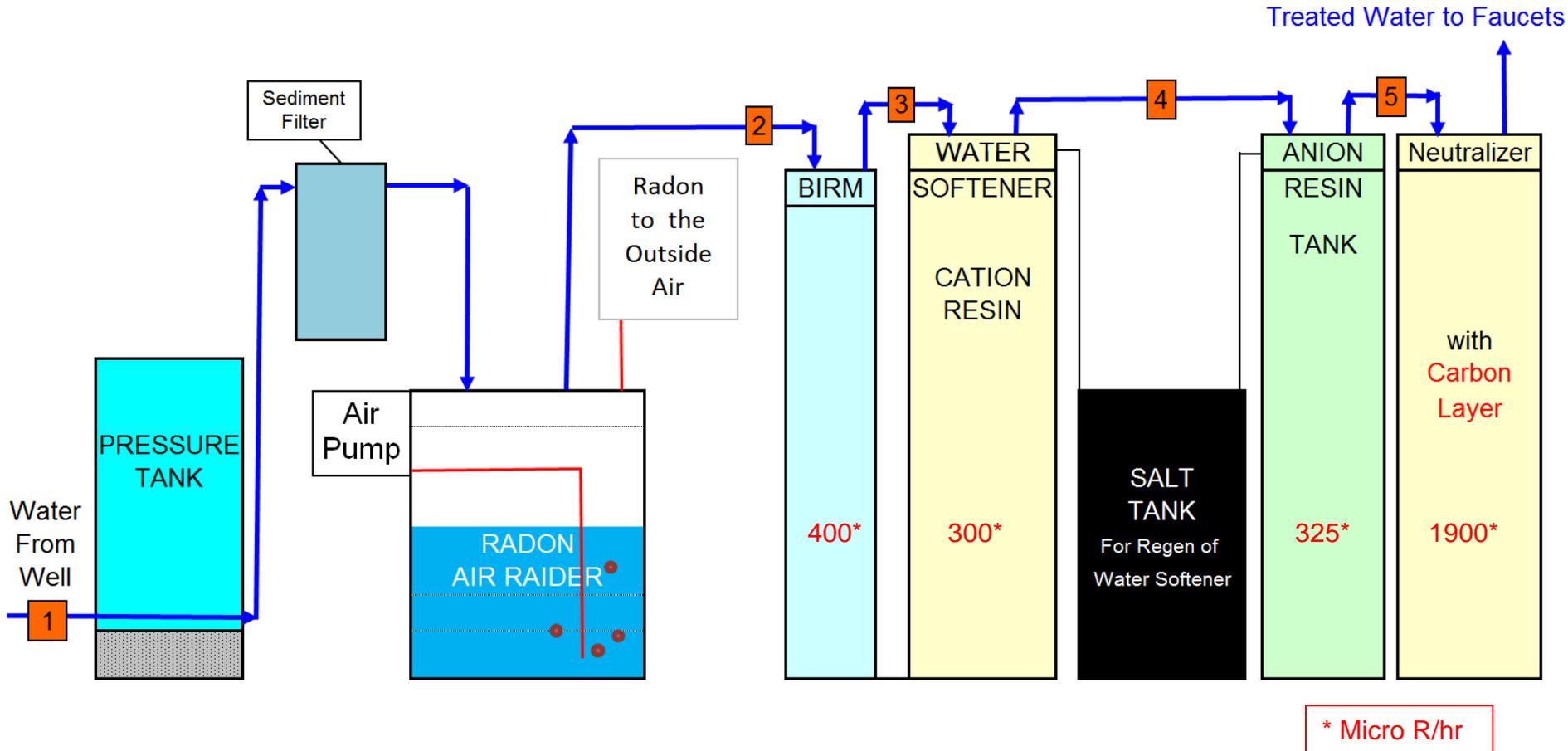
Raw Water Quality: As=26, Fe=190, Mn=3, U=650 ug/L,  
Gross Alpha=800, Ra224=30, Ra226=26, Ra228=3, Rn=90,000 pCi/L

# Consider investing in a Micro R/hr Meter



# As, Fe, Mn, U, Ra, Rn - Phase 1

Problem Set-UP (BIRM Tank became radioactive)



Raw Water Quality: As=26, Fe=190, Mn=3, U=650 ug/L,  
Gross Alpha=800, Ra224=30, Ra226=26, Ra228=3, Rn=90,000 pCi/L

# BIRM Media Analysis After Water Exposure

## June 2009:

Radium: 1,200 pCi/g

Uranium: 68 pCi/g

## July 2010:

Ra226: 1,617 pCi/g

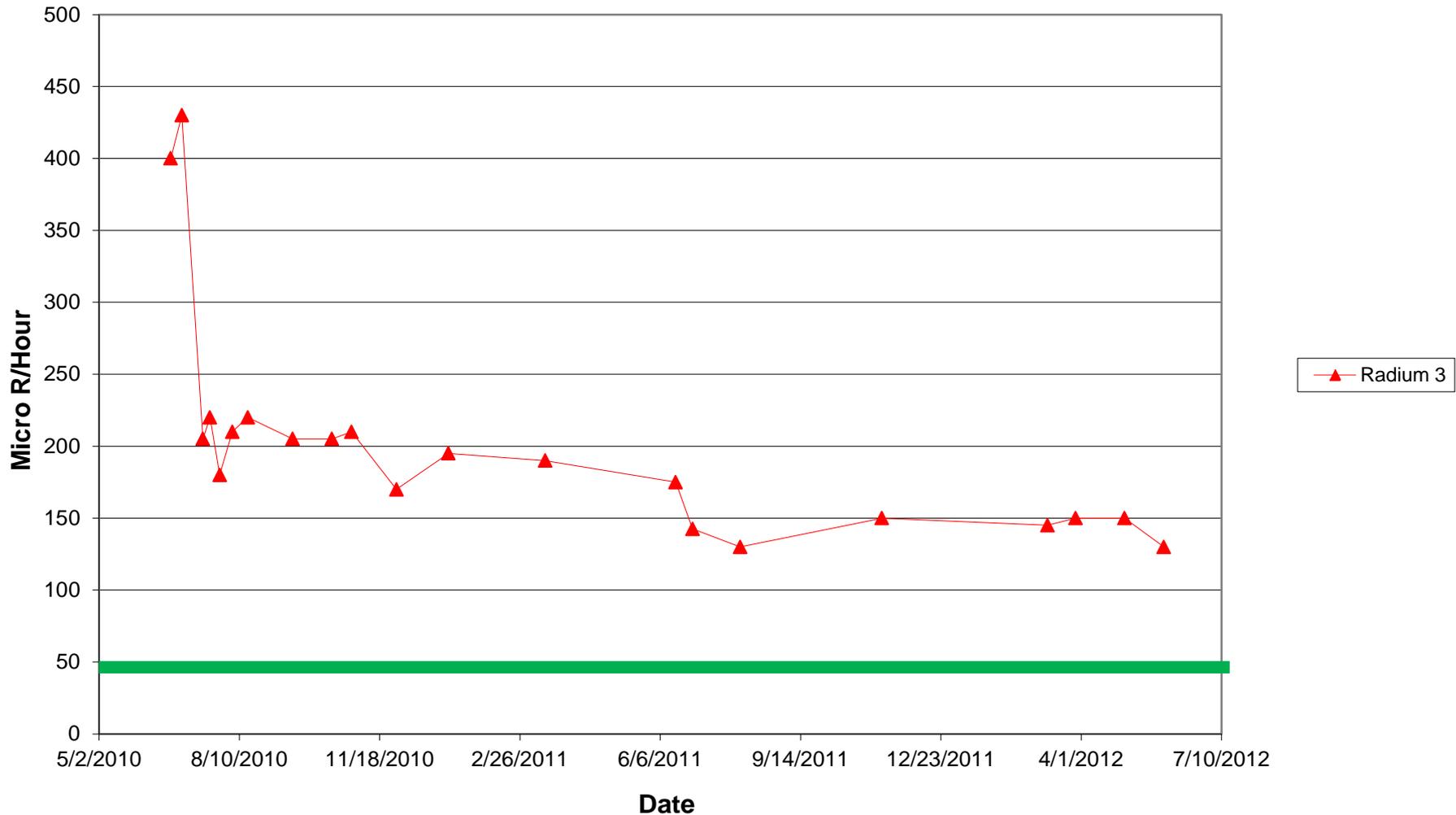
Ra228: 53 pCi/g

U234: 43 pCi/g

U238: 31 pCi/g

# BIRM Micro R/hr Readings

Micro R/Hour in Disconnected Tank of BIRM  
After Exposure to Radium, Uranium, and Radon



Other Manganese Oxide medias are likely to be affected by radium similar to what we have seen with the BIRM.

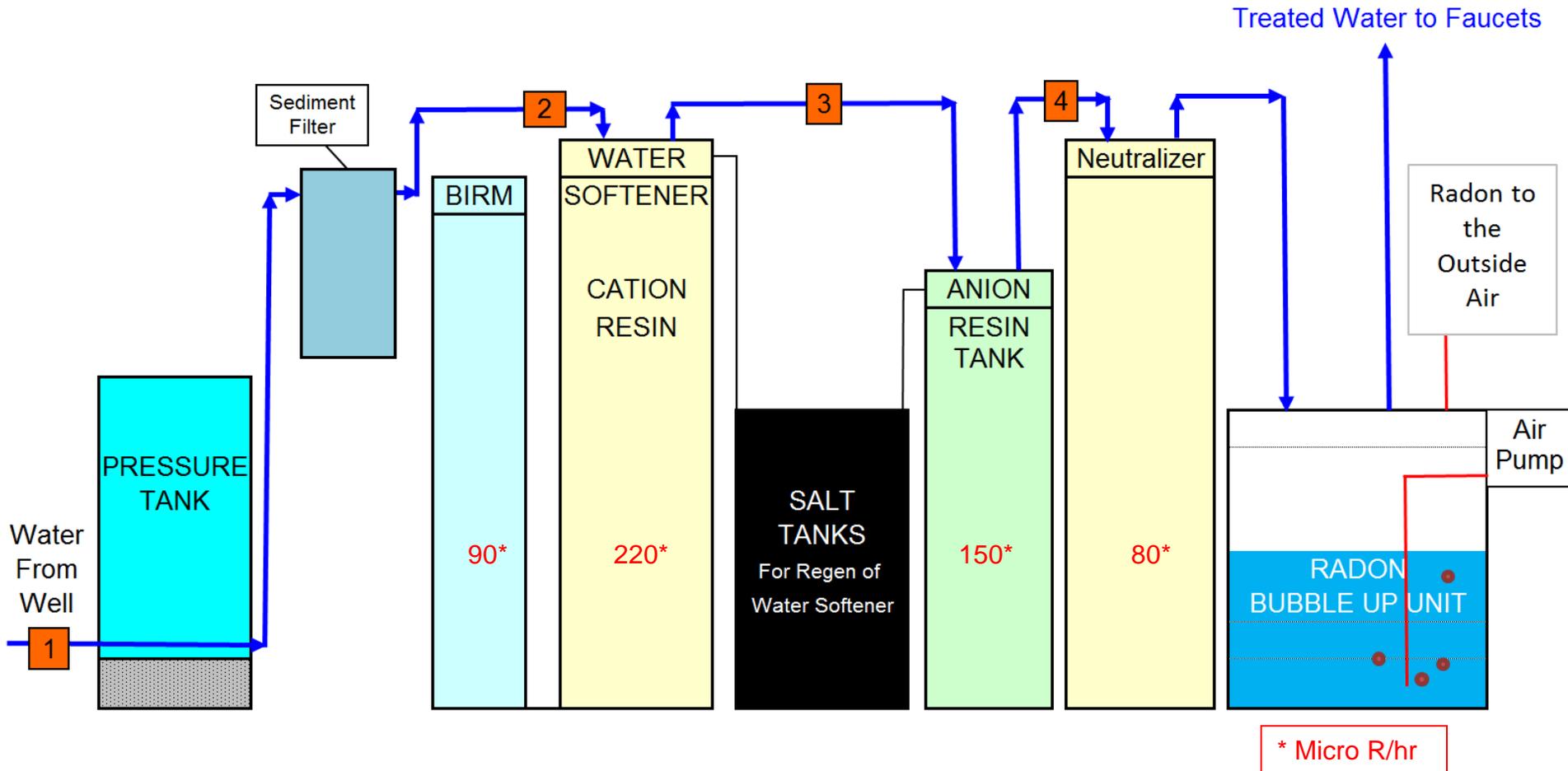
NJDEP is also seeing elevated radium in Greensand used with water containing radium.

Warning labels may be needed for this type of media.

**Do not use with water  
that contains radium.**

**Using this media with water that  
contains radium may create  
technologically enhanced naturally  
occurring radioactive materials that  
may be a hazard.**

# As, Fe, Mn, U, Ra, Rn – Phase 2



Raw Water Quality: As=26, Fe=190, Mn=3, U=650 ug/L,  
Gross Alpha=800, Ra224=30, Ra226=26, Ra228=3, Rn=90,000 pCi/L

## Video Presentation

Click outside the text box on this page to start a two-minute video showing measurements of MicroR/hr readings on water treatment system tanks.

You may be asked to “Trust” this file. After “Trusting” re-click the page to start the video.

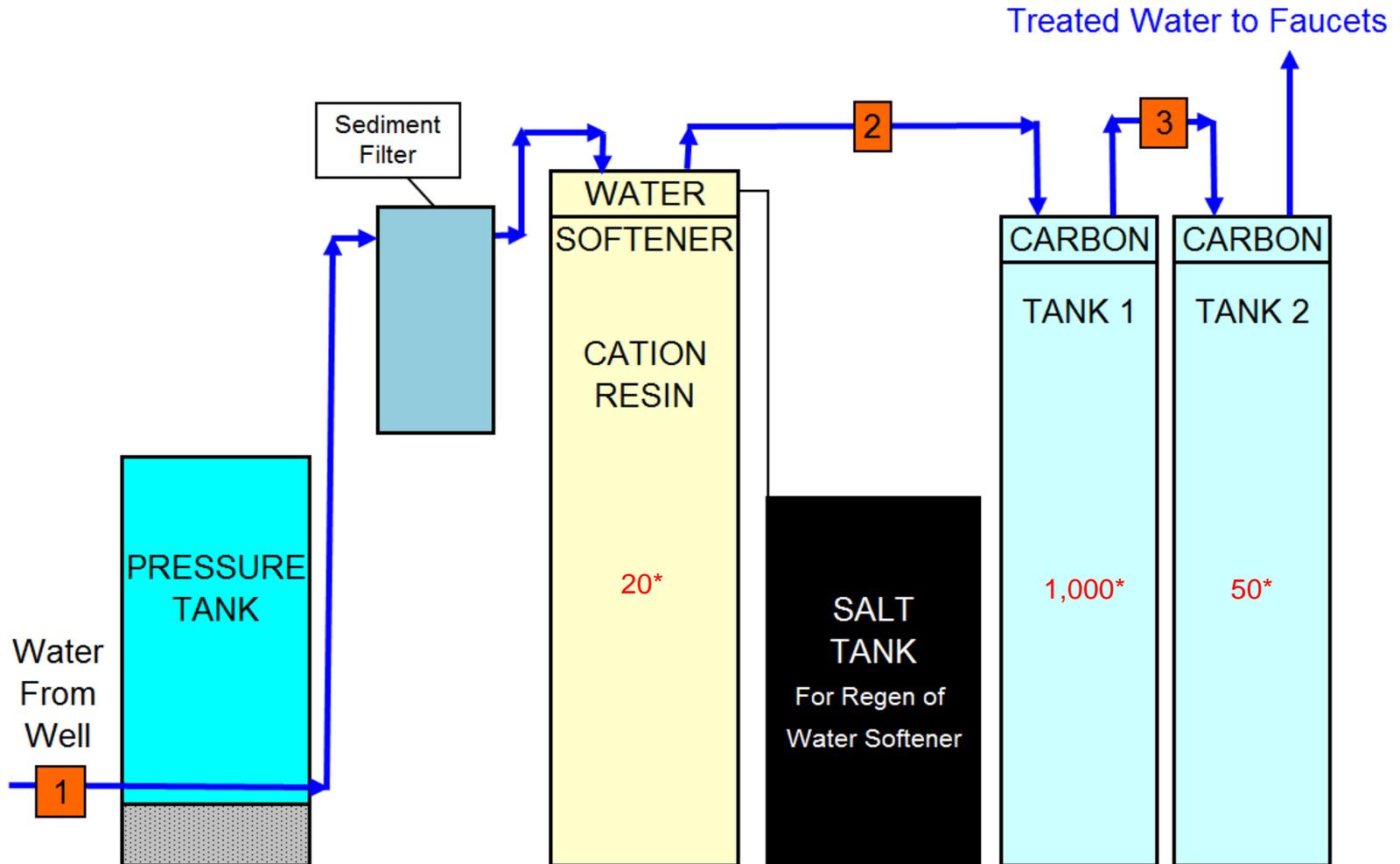
Depending on your computer’s speed, allow up to one minute for video to start.

After the video, advance the slide presentation using the down arrow.

# USGS Staff Collaborating With Raw Water Sampling



# Ra, Rn, U, Mn



Raw Water Quality: As <1, Fe=ND, Mn=50, U=5 ug/L, Gross Alpha=50-112, Ra224=3, Ra226=16, Ra228=3, Rn=3,400-5500 pCi/L  
Total Ra = 21 pCi/L

\* Micro R/hr

# Radon (3,400-5,500)

New System Installed approx 12/6/2010

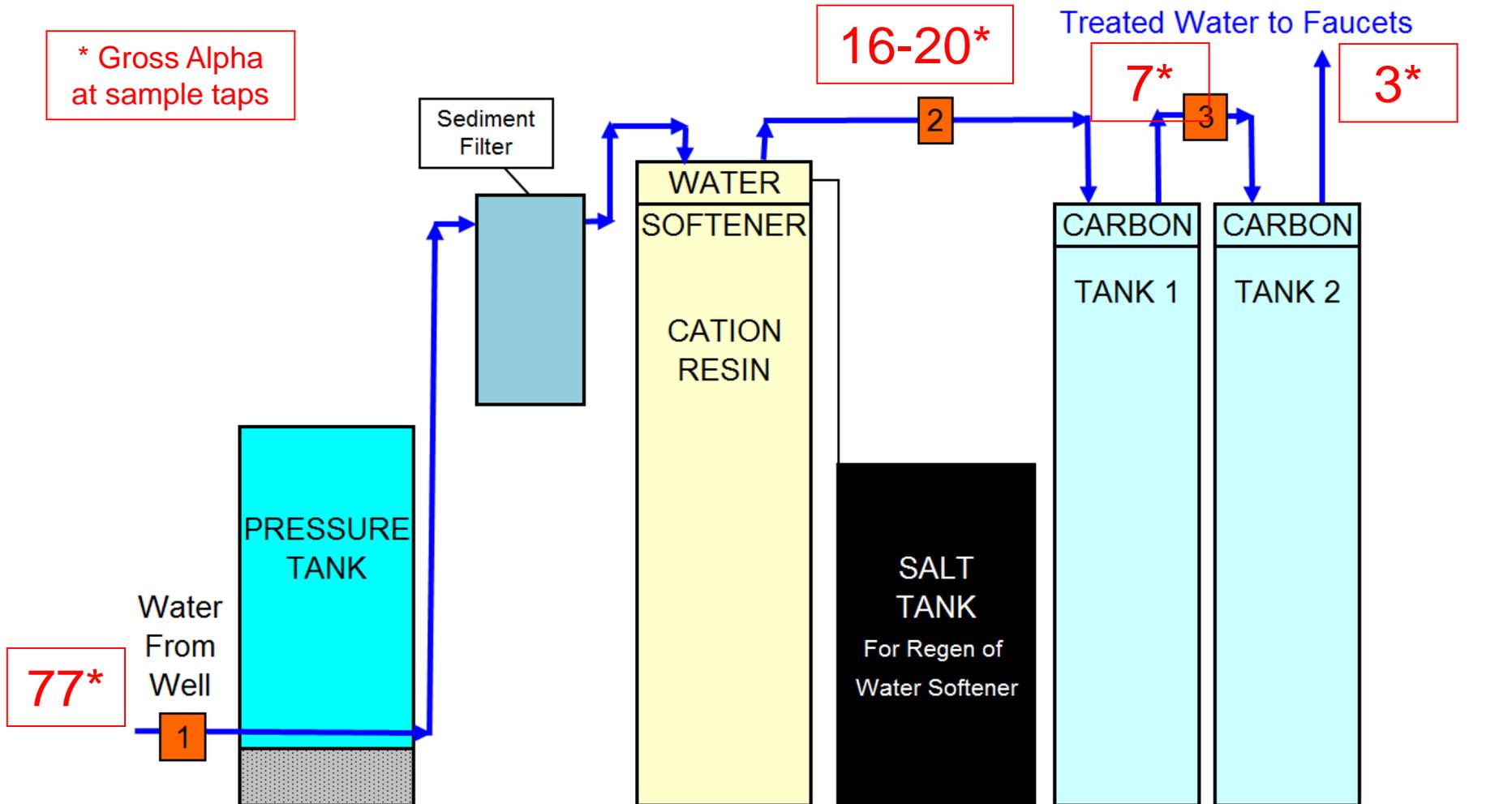
(Ra Calib Meter)	*	*	*
Data Micro R/hr	<u>1/6/2011</u>	<u>2/17/2011</u>	<u>3/17/2011</u>
<u>New Water Softener</u>	18	15	13
	20	18	16
	18	14	14
	15	10	10
<u>Carbon Tank #1</u>	140	120	100
	1500	1000	400
	250	600	100
	37	500	20
<u>Carbon Tank #2</u>	25	18	18
	44	30	47
	32	18	35
	18	13	10
<u>Wall Behind Tank</u>	130	160	120
<u>Closest Chair #1</u>	17	13	9
<u>Closest Chair #2</u>	11	8	7
<u>Closest Chair #3</u>	7	6	6
<u>Closest Chair #4</u>	6	5	4



# What's Wrong with this Picture?



# Ra, Rn, U, Mn



Raw Water Quality: As <1, Fe=ND, Mn=50, U=5 ug/L,  
Gross Alpha=50-112, Ra224=3, Ra226=16, Ra228=3, Rn=3,400-5,500 pCi/L  
Total Ra = 21 pCi/L

# Uranium-238

Seeking Source of Unaccounted for Gross Alpha

# Protons

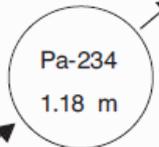
92

Uranium



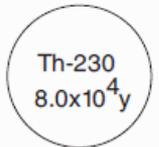
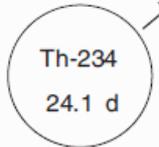
91

Protactinium



90

Thorium



88

Radium



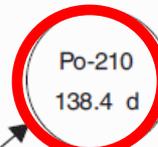
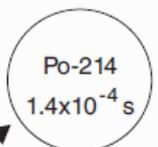
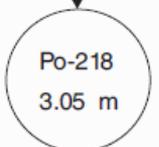
86

Radon



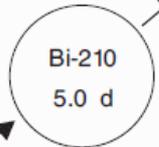
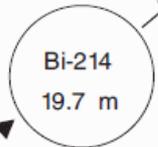
84

Polonium



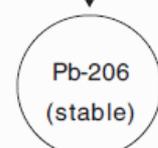
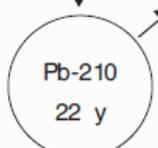
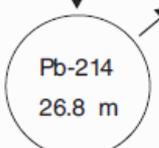
83

Bismuth

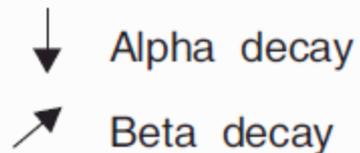


82

Lead



## EXPLANATION



# May be Found in a Well Near You

Along with Arsenic, Iron, and Manganese:

Sodium, Lithium, and Boron

The last two are very difficult to treat.

# Take Home Messages

- Characterize the water (As, Fe, Mn, Gross Alpha, Ra, U, Radon).
- For As, Fe, and Mn, use oxidation systems (Chlorine, Air, and/or MnO<sub>2</sub> media) for more efficient and cost effective treatment, BUT not in the presence of Radium.
- If Radium is present, remove it first with a cation water softener.
- If there is Radon in the water, keep GAC away from living areas or use aeration to remove the Radon.
- Look out for unaccounted for Gross Alpha.

# Multiple-Contaminant Private Well Water Treatment Arsenic, Radionuclides, and More

Steve Spayd, PhD, MPH, PG  
Research Scientist - Hydrogeologist  
New Jersey Geological and Water Survey  
New Jersey Department of Environmental Protection  
PO Box 420  
Trenton, New Jersey 08625

email: [steve.spayd@dep.state.nj.us](mailto:steve.spayd@dep.state.nj.us)  
phone: 609-633-1039

