

Pilot Study Report



for

Z-88™ Radium Treatment Process

conducted at the

**Wynstone Property Owners Association
Barrington, Illinois**

March 8, 2004

Executive Summary

The Wynstone Property Owners Association is located in Barrington, Illinois. The drinking water supply for Wynstone is pumped from deep sandstone wells, chlorinated, sent to storage and then to the distribution system. Naturally occurring radionuclides in Wynstone POA's raw water source exceeds current Maximum Contaminant Levels (MCL's) for Gross Alpha Emitters and Combined Radium and Barium.

Wynstone POA selected Water Remediation Technology's (WRT) Z-88™ Radium Removal Process as a possible cost effective solution for these combined problems. WRT provided a one GPM (gallons per minute) pilot plant, which was delivered and installed on December 10, 2003.

The primary purpose of this pilot study is to demonstrate the effectiveness of the treatment process on high radium and gross alpha water, combined with high barium. Secondary purposes were to establish design parameters for the full scale system and meet regulatory piloting requirements.

The pilot unit has successfully met gross alpha and radium at all times during the pilot study. The pilot unit met barium compliance initially, but exceeded the MCL after approximately 28 days of continuous operation. The pilot plant has been in operation for 41 days and continues to effectively reduce the level of radium (Figure 1), gross alpha (Figure 2) to less than the MCL.

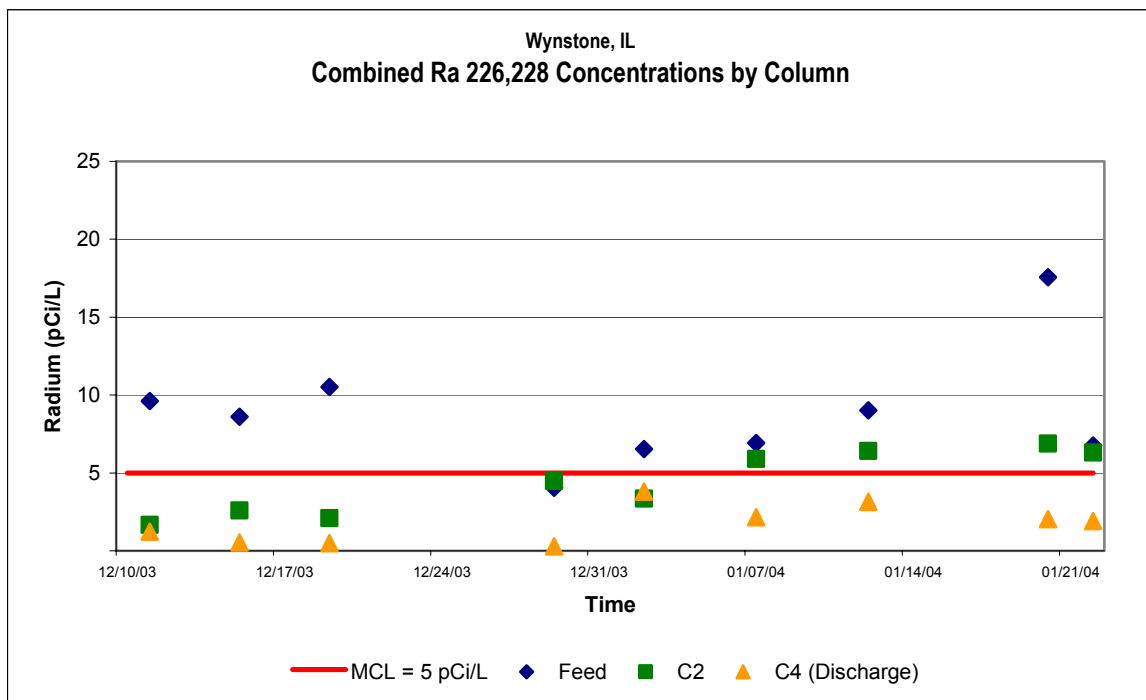


Figure 1

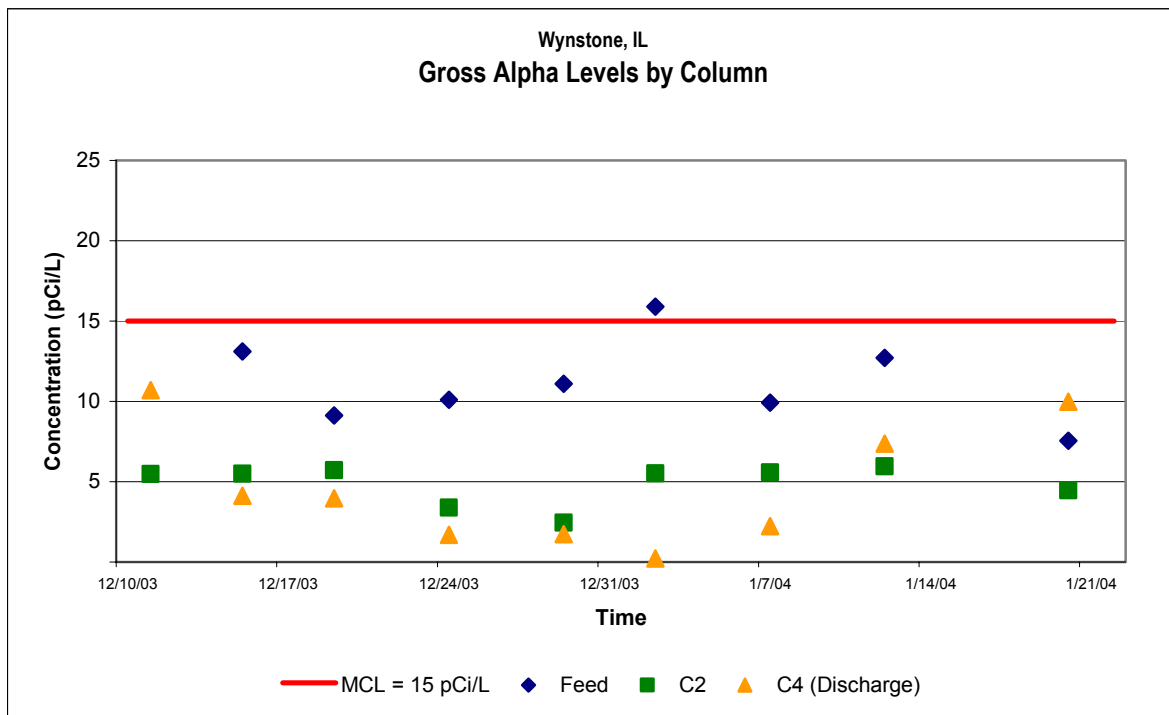


Figure 2

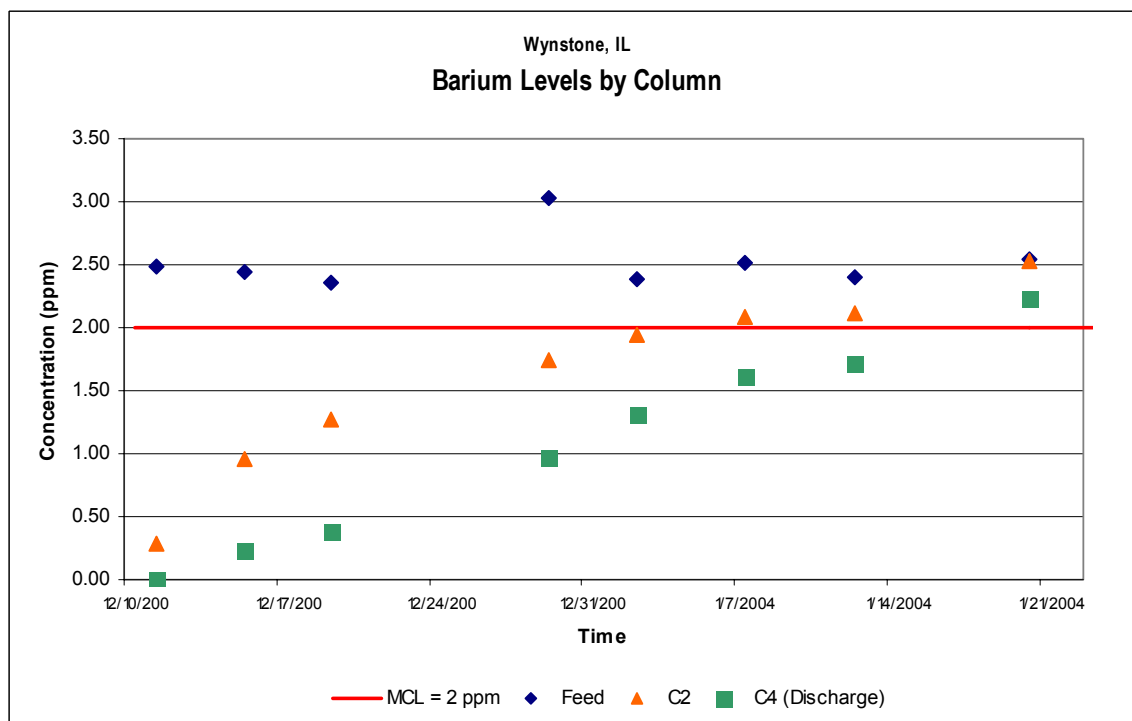


Figure 3



The results are also shown in Table 1. The average feed concentration of radium, 9.1 pCi/L (pico Curies per Litre), was reduced to 1.7 pCi/L after column 4 and has yet to exceed 3.8 pCi/L. Similarly, gross alpha, 13.2 pCi/L was reduced to 4.8 pCi/L after column 4 and has yet to exceed 10.7 pCi/L. The average feed concentration of barium, 2.5 ppm, was reduced to 1.0 ppm after column 4 and has yet to exceed 2.2 ppm. The barium discharge level is increasing, as expected, as the media becomes loaded with barium.

Table 1. Radium, Gross Alpha and Barium levels in feed and discharge water.

	Feed	Discharge @ Column 4
Radium MCL (pCi/L)	NA	5
Average	9.1	1.7
Highest value	17.6	3.8
Lowest Value	4.0	0.3
Gross Alpha MCL (pCi/L)	NA	15
Average	13.2	4.7
Highest value	29.0	10.7
Lowest Value	7.5	0.2
Barium MCL (ppm)	NA	2
Average	2.5	1.0
Highest value	3.0	2.2
Lowest Value	2.3	0.0

Application Information

The Wynstone Property Owners Association is a private water system located in Barrington, Illinois, serving approximately 400 service taps for 1300 residents.



Technology Overview

Water Remediation Technology's (WRT) Z-88™ Radium Treatment Process utilizes Z-88™ patent pending adsorptive media in a series of up flow treatment vessels to reduce gross alpha and remove radium 226 and 228 from drinking water. Barium is removed by the process of ion exchange in a manner similar to radium. The water is moved through the treatment system using the water pressure generated from the well source. Pressure drop through a full-scale system is approximately 10-15 PSI. No chemicals are added to the water for the treatment process. After the media is loaded with radium, it is removed from the circuit and permanently disposed of in a licensed facility. WRT designs, manufactures and provides the facility and produces the media used in the facility. The handling and exchange of new media for spent media, as well as the shipping and disposal into licensed disposal sites, is conducted or arranged for by WRT staff. The Z-88™ process media is ANSI/NSF Standard 61 certified for use in drinking water.

Equipment Overview

The pilot equipment was installed in the well pump house. The treatment train used for this pilot study consists of four 4" diameter by 4' vertical height columns, each containing 25" of Z-88™ process media mounted on a frame within the pump house. The columns in the pilot unit are clear for visual observation of the media and process. The source water enters the unit through a 3/4" diameter hose, passes through a control valve and flow meter, and enters the bottom of the first column. All columns operate in an up-flow mode; with the flow exiting the top of the first column, then following the same flow path through each column in series (see Figure 3). The last component in the system is a safety filter. Sample ports are located prior to the first column, and after each of the columns in the series.

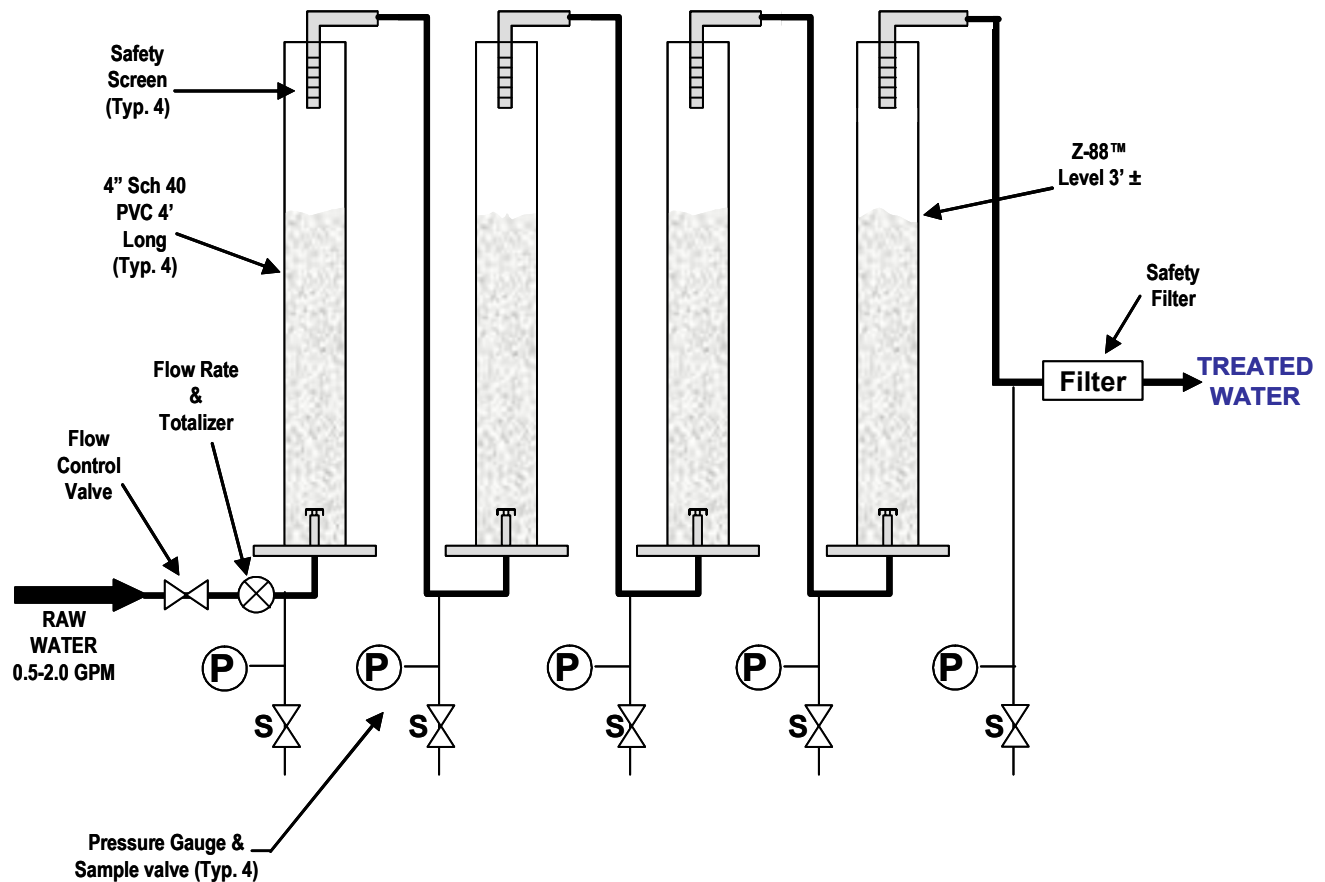


Figure 3. Typical Process Flow Diagram

The pilot unit provides for an Empty Bed Contact Time through four columns of 4.2 minutes. The pilot unit differs from the permanent equipment design as the permanent system utilizes two deep stages of media. The purpose of the short columns in the pilot plant is to allow more data to be collected and faster evaluation of the radium and barium loading on the Z-88™ media.

Statement of Purpose

The levels during the pilot study in the well were as high as 17.6 pCi/L for radium, 29.0 pCi/L for gross alpha, and 3.0 ppm for barium, all exceeding the Environmental Protection Agency (EPA) mandated MCL's.



Pilot unit in operation at the Wynstone Property Owners Association



The purposes of this pilot study are to:

- Demonstrate the ability of the WRT Z-88™ Radium Treatment Process to consistently and effectively reduce the radium, gross alpha and barium content to below the MCL on this specific water.
- Demonstrate the reliability and ease of operation of the WRT Process.
- Comply with regulatory piloting requirements.
- Develop design criteria for the full-scale facility.

Delivery and Installation of Pilot Unit

The pilot unit was delivered and installed on December 10, 2003. Set up consists of mounting the columns to a frame and connecting the water source and a discharge line to a sanitary sewer. The pilot study began the same day. Initial water samples were taken at that time. Data was collected for 41 days prior to writing this report and testing continues to establish optimum media life.

Operator training for pilot unit operation, monitoring and sampling was conducted on the day of installation, and a schedule for sampling was established. Samples were collected from ½" valves located in the feed line and after discharge from each respective test column, at sample intervals prescribed by the Illinois Environmental Protection Agency (IEPA).

Analytical

The samples were sent to ACZ Laboratories, a National Environmental Laboratory Accreditation Program certified laboratory, for analysis. Methods for analysis were:

Gross Alpha	EPA 900.0
Radium 226	EPA 903.1
Radium 228	EPA 904.0
Barium	M200.8 ICP-MS

Results

The sampling results are shown in Tables 2, 3 and 4. Feed samples were collected immediately prior to the first column of Z-88™. Samples C2 and C4 were taken after each respective column, prior to discharge. Analytical laboratory certificates are attached as Appendix A for radium and gross alpha, and Appendix B for barium. Figures 1, 2 and 3 show combined radium 226 and 228, gross alpha and barium levels in the feed water entering the pilot unit, and treated water exiting the pilot unit. The graphs clearly show that the pilot unit successfully reduced the combined radium and gross alpha to levels below their MCL's. Barium was reduced to a level below the MCL of 2 ppm during the initial portion of the pilot study. However, the barium level at the discharge point did exceed the MCL as the media's capacity for barium was exhausted by the end of this test.

Table 2. Radium Test Results

Ra-226	Column Concentrations (pCi/L)		
Date	Feed	C2	C4
12/10/03			
12/11/03	4.4	0.2	0.1
12/15/03	3.8	0.5	0.0
12/19/03	4.2	0.9	0.1
12/29/03	0.5	2.4	0.3
1/2/04	3.1	1.3	0.3
1/7/04	4.1	2.2	0.6
1/12/04	4.0	2.4	1.1
1/20/04	5.7	3.2	1.5

Ra-228	Column Concentrations (pCi/L)		
Date	Feed	C2	C4
12/10/03			
12/11/03	5.2	1.5	1.1
12/15/03	4.8	2.1	0.5
12/19/03	6.3	1.2	0.4
12/29/03	3.5	2.0	0.0
1/2/04	3.4	2.1	3.5
1/7/04	2.8	3.7	1.6
1/12/04	5.0	4.0	2.1
1/20/04	11.9	3.7	0.5

Ra Combined	Column Concentrations (pCi/L)		
Date	Feed	C2	C4
12/10/03			
12/11/03	9.6	1.7	1.2
12/15/03	8.6	2.6	0.5
12/19/03	10.5	2.1	0.5
12/29/03	4.0	4.5	0.3
1/2/04	6.5	3.3	3.8
1/7/04	6.9	5.9	2.2
1/12/04	9.0	6.4	3.1
1/20/04	17.6	6.9	2.0

Table 3. Gross Alpha Test Results

Gross Alpha	Column Concentrations (pCi/L)		
Date	Feed	C2	C4
12/10/03			
12/11/03	29.0	5.5	10.7
12/15/03	13.1	5.5	4.1
12/19/03	9.1	5.7	4.0
12/24/03	10.1	3.4	1.7
12/29/03	11.1	2.5	1.7
1/2/04	15.9	5.5	0.2
1/7/04	9.9	5.6	2.2
1/12/04	12.7	6.0	7.4
1/20/04	7.5	4.5	10.0

Table 4. Barium Test Results

Barium	Column Concentrations (ppm)		
Date	Feed	C2	C4
12/10/03			
12/11/03	2.5	0.3	0.0
12/15/03	2.4	1.0	0.2
12/19/03	2.4	1.3	0.4
12/24/03	2.3	1.6	0.7
12/29/03	3.0	1.7	1.0
1/2/04	2.4	2.0	1.3
1/7/04	2.5	2.1	1.6
1/12/04	2.4	2.1	1.7
1/20/04	2.5	2.5	2.2

Figures 1, 2 and 3 show discharge levels indicative of a full-scale treatment system. The pilot plant provided for an Empty Bed Contact Time of 4.2 minutes after column 4. The full scale system is designed with a longer EBCT which will effectively capture more radium, gross alpha and barium than the pilot. The data at column 4 demonstrates the performance of a typical full-scale treatment system. Treatment through column 4 successfully reduced the radium level to below the MCL of 5 pCi/L throughout the duration of the pilot study.

Water Quality

A water quality analysis was performed on feed water to the pilot unit and on treated water exiting the WRT pilot unit treatment process to document any changes in water quality through the Z-88™ treatment process. The results of those tests are shown in Table 7. Other than barium, there is no significant change to the water quality other than the desired reduction of gross alpha and radium. Support documentation for Table 5 and 7 are attached as Appendix B.

Table 5. Barium Test Results

	Feed (ppm)	Discharge @ Column 4 (ppm)
Barium MCL	NA	2
Average	2.5	1.0
Highest value	3.0	2.2
Lowest Value	2.3	0.0

Hydraulic Loading Rate

The flow rate during the pilot test period averaged 1.29 GPM, which equates to 14.5 gallons per minute per square foot hydraulic loading rate. Table 6 shows the total treated flow by sample date. Data for Table 6 can be found in Appendix C. The full scale system is designed at a lower hydraulic loading rate, 9 gallons per minute per square foot, a longer EBCT of 5.8 minutes per stage, and has two stages of treatment. This design more than doubles the amount of media in the full scale system as compared to the pilot.

Table 6. Cumulative treated flow in gallons

Sample Data	Treated Flow in Gallons
12/10/03	0
12/11/03	1,832
12/15/03	9,046
12/19/03	16,480
12/24/03	25,720
12/29/03	35,018
1/2/04	42,441
1/7/04	51,520
1/12/04	61,389
1/20/04	76,193

Table 7. Water Quality Data entering and exiting the Z-88™ treatment process

Wynstone, Illinois – Water Quality Data			
Item	Pre WRT Process	units	Post WRT Process
Alkalinity	270	mg/L	269
Antimony	<	mg/L	<
Arsenic	<	mg/L	<
Barium	2.32	mg/L	1.72
Beryllium	<	mg/L	<
Cadmium	<	mg/L	<
Calcium	56.8	mg/L	58.7
Chromium	<	mg/L	<
Chloride	13	mg/L	11
Copper	<	mg/L	<
Fluoride	1	mg/L	1
Hardness	218	mg/L	226
Iron	0.16	mg/L	0.13
Lead	<	mg/L	<
Magnesium	18.6	mg/L	19.3
Manganese	0.016	mg/L	0.015
Mercury	<	mg/L	<
Potassium	9.8	mg/L	10.5
Selenium	<	mg/L	<
Sodium	23.2	mg/L	23.6
Sulfate	20	mg/L	10
Thallium	<	mg/L	<
Total Dissolved Solids	304	mg/L	296
Uranium	<	mg/L	<
Zinc	<	mg/L	<

Note: < is below detection levels

Radiation Safety

The initial long term radium pilot studies conducted by WRT consisted of a detailed radiation safety plan which was prepared and implemented for the course of the pilot study to insure the safety of plant staff and the general public. The safety plan includes radiation level monitoring, logging each time people entered and exited the pilot trailer, radiation level monitoring badges assigned to staff personnel that would frequently enter the pilot trailer and emergency procedures and equipment. Data from this safety plan was monitored by the WRT Radiation Safety Officer during the pilot studies to ensure compliance to internal WRT standards.

The total amount of radiation that members of the public can be exposed to is 2 mrem per hour and 100 mrem over the course of a year.



As part of the long term pilot tests, a monitoring badge was attached to the bottom of Column 1, the point of highest radiation level, and a monitoring badge was placed far away from the pilot unit, in a safety equipment locker located greater than 50 feet from the test unit.

Data collected after 9 months of continuous operation, showed that the highest radiation level measured at the base of column 1, which contains the highest loaded media, was 0.2 mrem per hour, or approximately 10% of the permitted hourly exposure level. At a distance of 3 feet from the equipment, no discernable difference from background levels could be detected.

The dosimeter located on column 1 averaged 0.14 mrem per hour exposure after nine months of operation. The average exposure over the course of this 9 month pilot study was 0.06 mrem per hour.

Based upon WRT's experience with this and other long term radium pilot studies and the long term radiation data collected from those studies, it was concluded that an abbreviated pilot study of less than 180 days does not require dosimetry badge monitoring.

Any full-scale system will include equipment and personnel monitoring radiation dosimetry badges, and a corresponding safety plan to monitor that information.

Operational Results

An operation log was maintained during the pilot study, and is attached as Appendix C. The pilot unit effectively removed radium and gross alpha to acceptable levels throughout the course of this test without any significant operating problems.

Conclusion

The WRT Z-88™ Radium Treatment Process consistently produced gross alpha and combined radium 226 and 228 discharge levels below the EPA mandated MCL of 15 pCi/L and 5 pCi/L respectively. While this pilot test successfully removed the radium, the high barium level in this water eventually exhausted the media from a barium standpoint. The expected media life for this application has been estimated based upon the barium level. Full scale plant design parameters, such as media loading rate, EBCT and number of stages required, have been interpreted from the pilot study data collected and incorporated into the basis of design.

WRT would like to thank the personnel and staff of the Wynstone Property Owners Association for their cooperation and assistance during this test.



Appendices available upon request.