



Pilot Study Report

for

Z-88® Radium Treatment Process



conducted for

City of New Underwood, South Dakota

January 12, 2009

Executive Summary

This radium removal pilot study was conducted for the City of New Underwood, South Dakota. New Underwood's water system contains concentrations of radium and gross alpha in excess of the Maximum Contaminant Levels (MCL).

New Underwood selected Water Remediation Technology's (WRT) Z-88® Radium Treatment Process as a possible cost effective solution for their radium problem. WRT provided a 1.0 GPM (gallons per minute) treatment system, which was delivered and installed on July 9, 2008.

The purpose of this pilot study is to document the effectiveness of the WRT system on high radium and gross alpha water and to provide information necessary to meet regulatory compliance.

The treatment system successfully met radium and gross alpha compliance at all times during the pilot study. The system was in operation for 117 days prior to writing this report and effectively reduced the level of radium (Figure 1) and gross alpha (Figure 2) to less than the MCL .

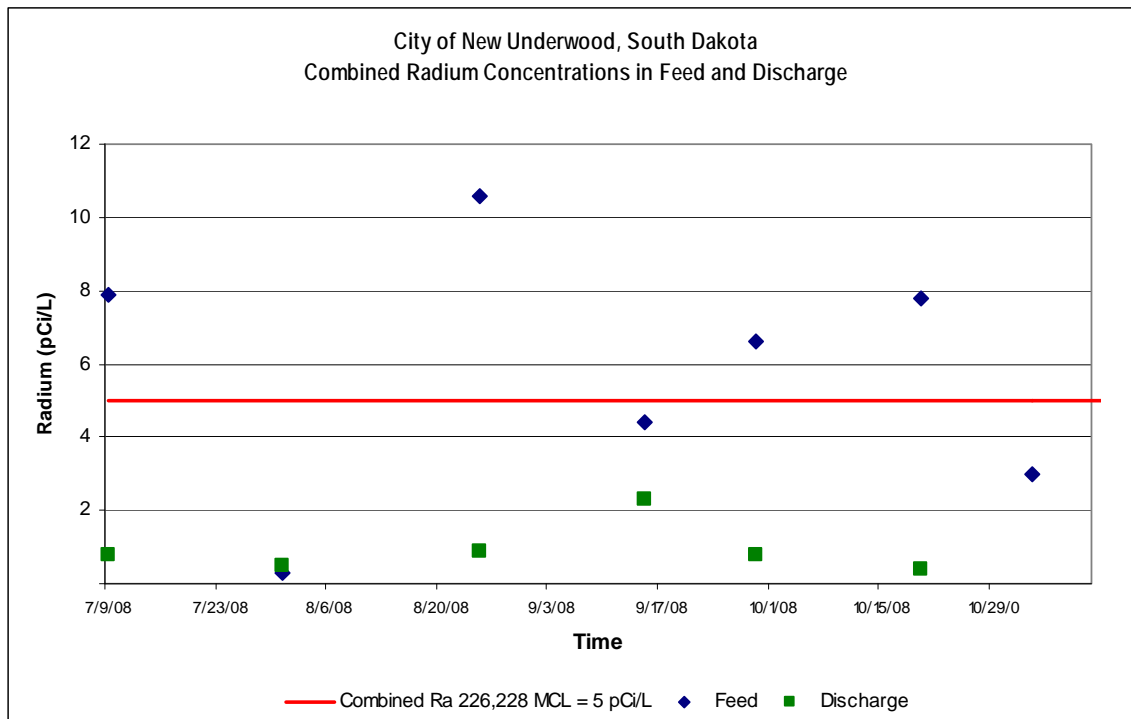


Figure 1

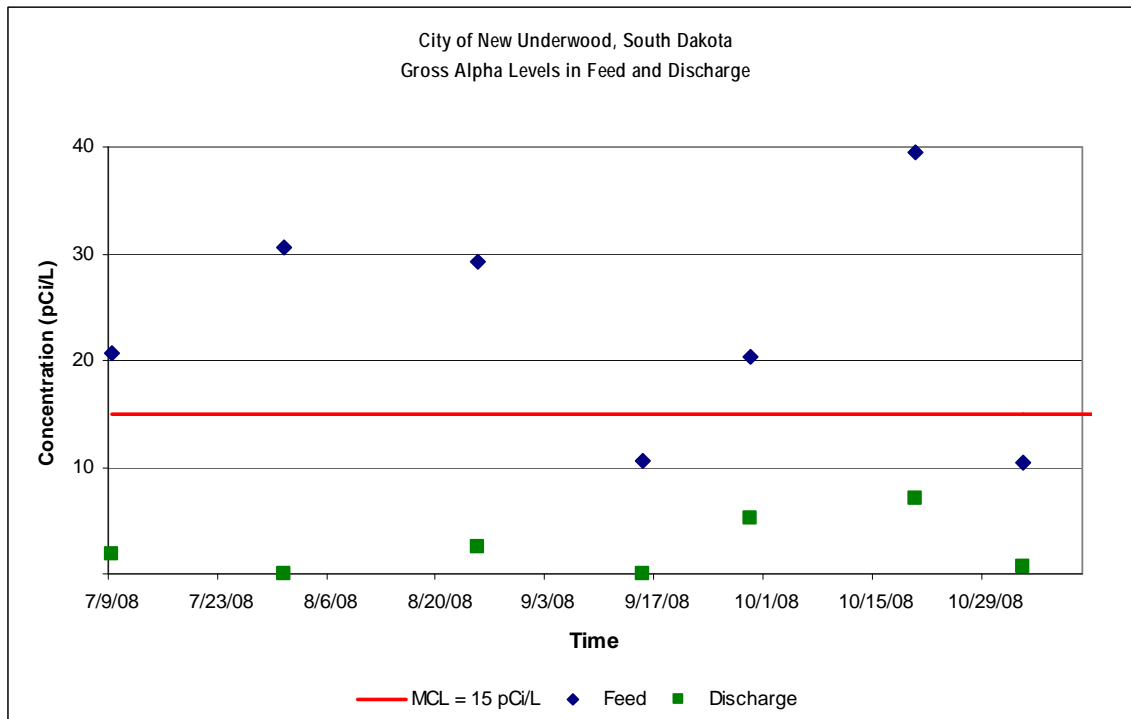


Figure 2

The results are also shown in Table 1. The average feed concentration of combined radium, 5.8 pCi/L, was reduced to an average of 0.9 pCi/L; well below the MCL of 5 pCi/L. The average feed concentration of gross alpha, 23.0 pCi/L, was reduced to 2.5 pCi/L; also well below the MCL of 15 pCi/L.

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

Combined Radium	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
Combined Radium MCL	—	5.0
Average	5.8	0.9
Highest value	10.6	2.3
Lowest Value	0.3	0.4

Gross Alpha	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
Gross Alpha MCL	—	15.0
Average	23.0	2.5
Highest value	39.5	7.1
Lowest Value	10.4	0.0



Application Information

The City of New Underwood, South Dakota is located in Pennington County, approximately 20 miles east of Rapid City. The pilot study was conducted at New Underwood's Well No. 2 treatment facility. This well pumps an average of 190 gallons per minute. New Underwood currently has two operating deep wells. These wells pump approximately 65,000 gallons per day to 750 city and rural residents living in the New Underwood community. The water source for the two wells is the Inyan Kara sandstone aquifer. The Inyan Kara is located from about 2,600 to 2,900 feet below the surface, with the piezometric water surface located at around 350 to 400 feet depth.

Technology Overview

Water Remediation Technology's (WRT) Z-88® Radium Treatment Process utilizes proprietary adsorptive media in a series of up flow treatment vessels to remove radium from drinking water. The water is moved through the treatment system using the water pressure generated from the well source. 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 equipment and media used in the facility. The handling and exchange of new media to replace spent media, as well as the shipping and disposal into licensed disposal sites, is handled by WRT. The treatment media are ANSI/NSF Standard 61 certified for use in drinking water.

Equipment Overview

The pilot equipment was installed in the City of New Underwood's Well No. 2 treatment facility. The treatment train used for this pilot study consists of four 4-inch diameter by 5-foot vertical height columns each containing approximately 25 inches of Z-88® media. The columns in the pilot unit are clear for visual observation of the media and process. The source water enters the unit through a ¾-inch 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 configuration; with the flow exiting the top of the first column, then following the same flow path through columns 2 through 4 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.

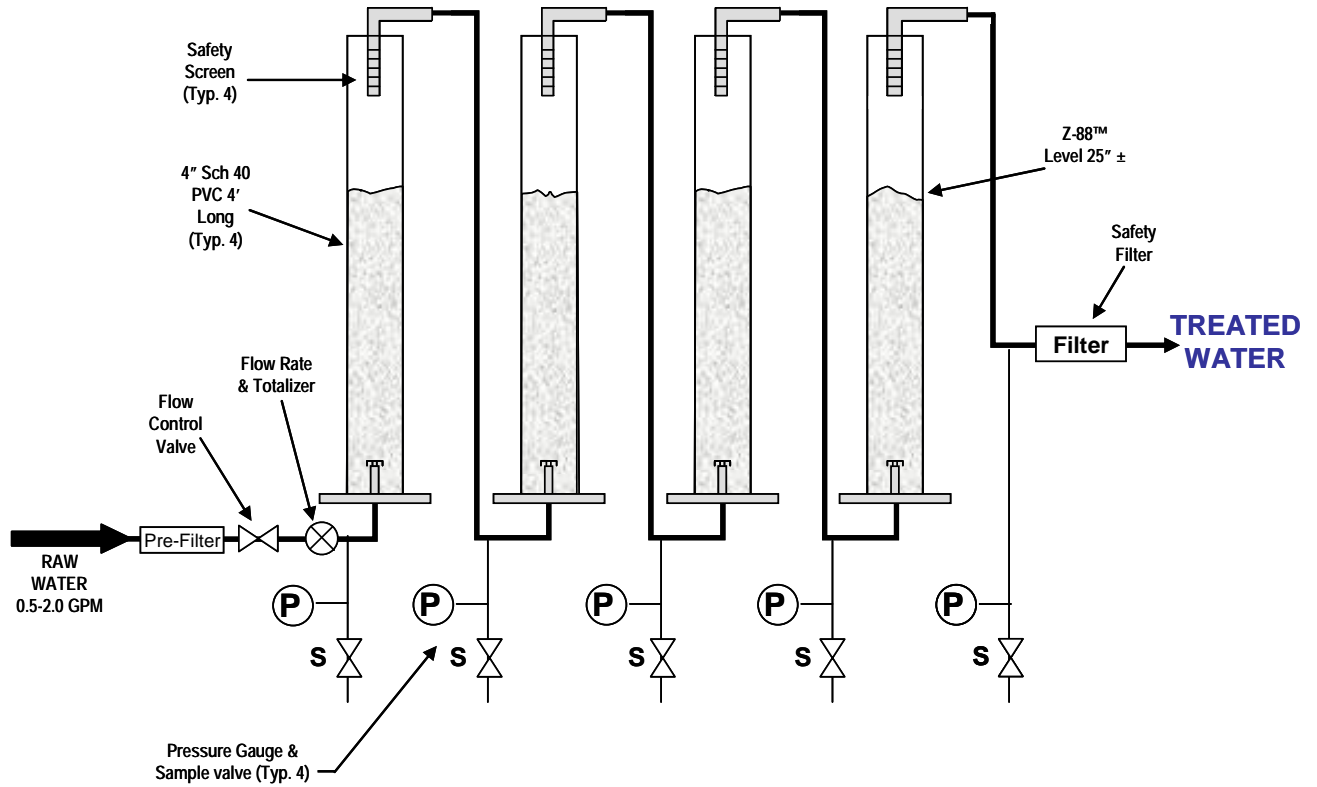


Figure 3. Simplified Process Flow Diagram.

City of New Underwood's Z-88® Radium treatment system.





Statement of Purpose

The combined radium levels in the raw water during the pilot study were as high as 10.6 pCi/L, exceeding the Environmental Protection Agency (EPA) mandated combined radium MCL of 5 pCi/L. The gross alpha water's highest result of 39.5 pCi/L was in compliance of the required MCL of 15 pCi/L.

The purposes of this pilot study are to:

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

Delivery and Installation of the Treatment System

The treatment system was delivered and installed on July 9, 2008. Set up consists of mounting the columns to a frame and connecting the water source and discharge line. The pilot study began the same day. Data was collected for 117 days prior to writing this report.

Operator training for system operation, monitoring and sampling was conducted on the day of installation, and a schedule for sampling was provided by WRT. Samples were collected by the City of Stephenson personnel from sample valves located in the feed line and after discharge from each respective treatment vessel, at pre-determined sample intervals.

Analytical

The samples were delivered to Energy Laboratories, Inc. in Rapid City, South Dakota for inorganic water quality analysis. Samples for radium, gross alpha and uranium were delivered to Energy Laboratories, Inc. in Casper, Wyoming. Both Energy Laboratory locations are National Environmental Laboratory Accreditation Program certified laboratories. Methods for analysis were:

Gross Alpha	E900.0
Radium 226	E903.0
Radium 228	RA-05
Uranium	E200.8



Results

The sampling results are shown in Tables 2 and 3. Feed samples were collected immediately prior to the first treatment vessel. Samples were taken immediately after column no. 2 (C-2), and at the discharge point (C-4). Analytical laboratory certificates are attached as Appendix A. Figures 4, and 5 show combined radium 226 and 228 and gross alpha levels in the feed water entering the pilot unit, and treated water exiting the pilot unit. The graphs show that the pilot unit successfully reduced combined radium in the treated water to significantly below the required MCL.

Table 2. Radium Test Results

Radium 226	Column Concentrations (pCi/L)			
Date	Feed	C-2	C-4	MCL
7/9/08	5.6	-0.2	0.0	—
7/31/08	0.0	0.4	-0.1	—
8/25/08	6.2	-0.1	-0.1	—
9/15/08	2.5	0.3	0.3	—
9/29/08	3.7	1.1	0.8	—
10/20/08	4.4	0.6	0.5	—
11/3/08	2.2	0.3	0.4	—

Radium 228	Column Concentrations (pCi/L)			
Date	Feed	C-2	C-4	MCL
7/9/08	2.3	-0.1	0.9	—
7/31/08	0.3	0.4	0.8	—
8/25/08	4.4	0.3	0.5	—
9/15/08	1.9	0.3	0.6	—
9/29/08	2.9	0.5	1.5	—
10/20/08	3.4	0.8	0.3	—
11/3/08	0.8	0.2	-0.2	—

Combined Radium	Column Concentrations (pCi/L)			
Date	Feed	C-2	C-4	MCL
7/9/08	7.9	0.0	0.9	5.0
7/31/08	0.3	0.8	0.8	5.0
8/25/08	10.6	0.3	0.5	5.0
9/15/08	4.4	0.6	0.9	5.0
9/29/08	6.6	1.6	2.3	5.0
10/20/08	7.8	1.4	0.8	5.0
11/3/08	3.0	0.5	0.4	5.0

Figure 4 below, presents in graph format, the data in Table 2.

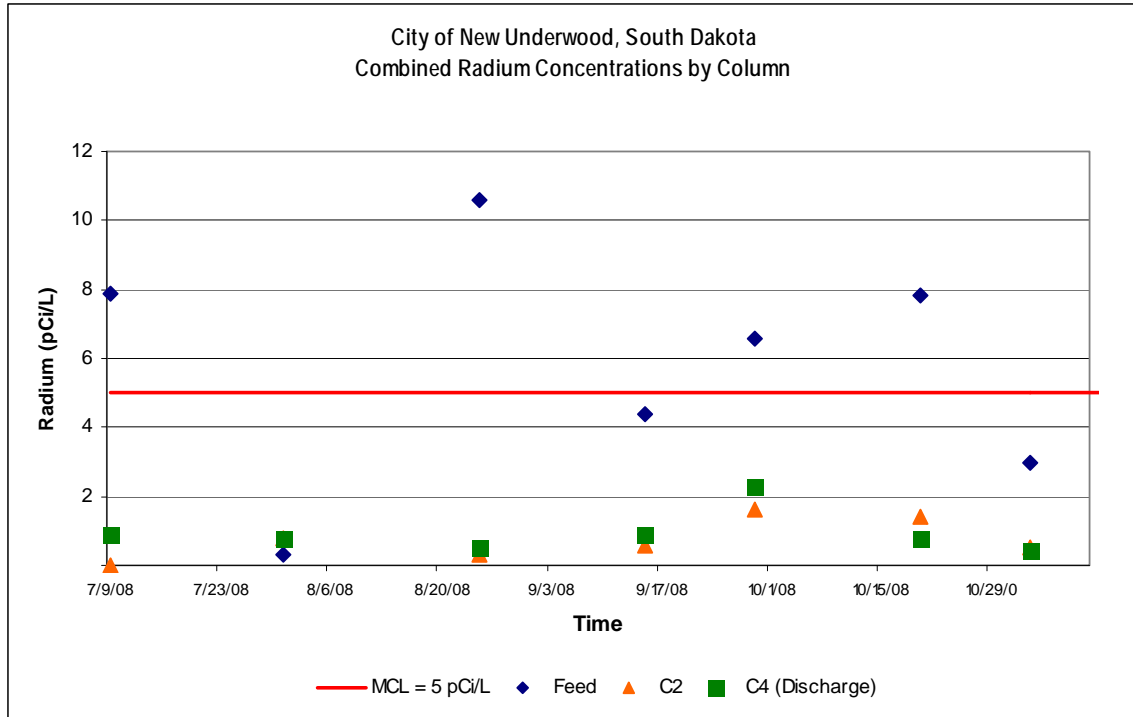


Figure 4

Table 3. Gross Alpha Test Results

Gross Alpha Date	Column Concentrations (pCi/L)			
	Feed	C-2	C-4	MCL
7/9/08	20.6	0.7	1.9	15.0
7/31/08	30.6	-0.07*	-2.0*	15.0
8/25/08	29.2	0.4	2.6	15.0
9/15/08	10.6	1.7	-0.5*	15.0
9/29/08	20.3	4.0	5.2	15.0
10/20/08	39.5	5.2	7.1	15.0
11/3/08	10.4	1.8	0.7	15.0

* Count is below background level, or ND (non-detectable level).

Figure 5 below, presents in graph format, the data in Table 3.

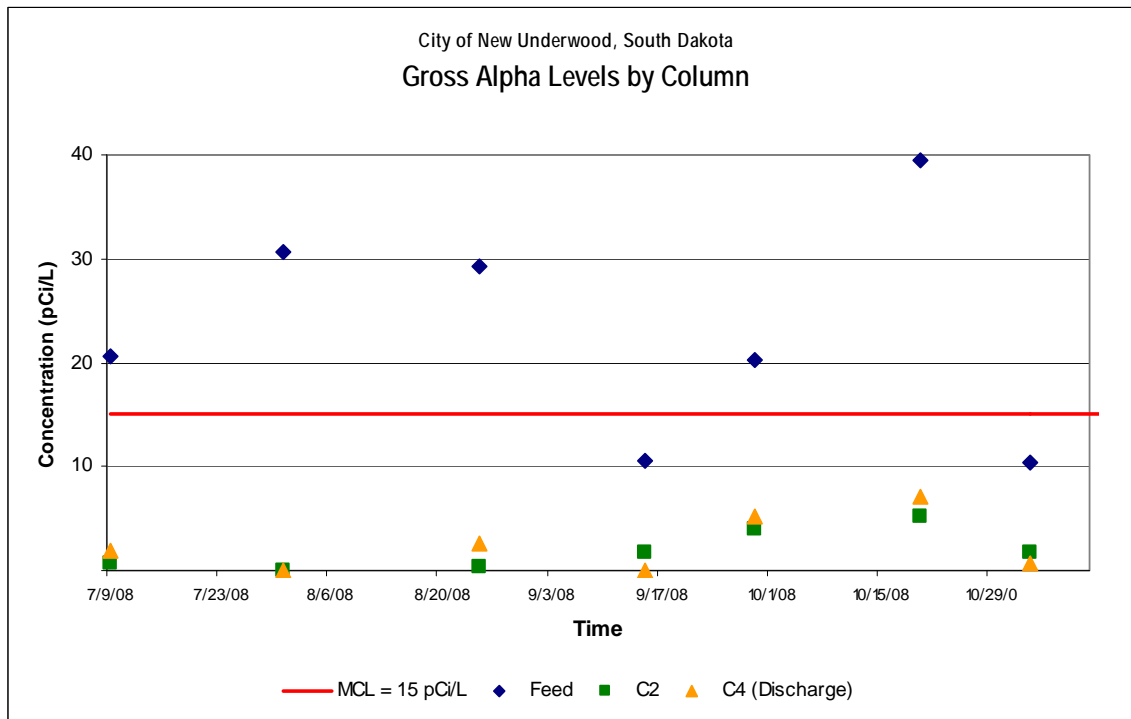


Figure 5

Water Quality

A water quality analysis was performed on the feed water to the treatment system. The results of those tests are shown in Table 4. Support documentation for Table 4 is attached as Appendix B.

Table 4. Water Quality Test Results

City of New Underwood, South Dakota – Water Quality Data		
Item	Pre WRT Process	units
Alkalinity	210	mg/L
Antimony	ND	mg/L
Arsenic	ND	mg/L
Barium	ND	mg/L
Beryllium	ND	mg/L
Bicarbonate as HCO ₃	260	mg/L
Calcium	17	mg/L
Carbonate as CO ₃	ND	mg/L
Chloride	5.0	mg/L
Chromium	ND	mg/L
Copper	ND	mg/L
Fluoride	1.8	mg/L
Hardness	54	mg/L
Hardness as CaCO ₃ - Grains	3.1	grains/gal
Iron	0.18	mg/L
Lead	0.001	mg/L
Magnesium	3	mg/L
Manganese	0.04	mg/L
Mercury	ND	mg/L
Nickel	ND	mg/L
Nitrogen, Nitrate as N	0.1	mg/L
Nitrogen, Nitrite as N	ND	mg/L
pH	8.1	s.u.
Phosphorus	ND	mg/L
Potassium	3	mg/L
Selenium	ND	mg/L
Silica	13.2	mg/L
Silicon	6.15	mg/L
Sodium	191	mg/L
Sulfate	285	mg/L
Thallium	ND	mg/L
Total Dissolved Solids	670	mg/L
Total Organic Carbon	0.1	mg/L
Uranium	ND	mg/L
Zinc	0.02	mg/L

Note: ND is non-detectable levels.

Hydraulic Loading Rate (HLR) and Empty-bed Contact Time (EBCT)

The pilot unit operated nominally at 1.1 gallons per minute, for a HLR of 12.6 gallons per minute per square foot. The pilot unit ran continuously during this test. The total gallons treated during the pilot study are summarized in Table 5 and Appendix C.

The EBCT at this HLR through four columns, each containing 25 inches of media, is 4.9 minutes.

Table 5. Cumulative treated flow in gallons

Sample Data	Treated Flow in Gallons
7/9/08	61
7/31/08	10,049
8/25/08	21,605
9/15/08	35,251
9/29/08	54,661
10/20/08	80,762
11/3/08	100,000

Uranium

Samples were collected during this study to evaluate the general level of uranium in the product water. Table 6 contains the uranium test results taken during the pilot study. The WRT Z-88® process is not designed to remove uranium. Supporting documentation for Table 6 is attached as Appendix A.

Because the uranium levels in the initial water analysis were well below the MCL, uranium removal was precluded as a target contaminant in reducing gross alpha. Uranium levels remained below detection limits in the feed water and discharge throughout the pilot testing.

Table 6. Uranium Test Results

Uranium Date	Column Concentrations (µg/L)			
	Feed	C-2	C-4	MCL
7/9/08	ND	0.8	1.5	30.0
7/31/08	ND	ND	ND	30.0
8/25/08	ND	ND	ND	30.0
9/15/08	ND	ND	ND	30.0
9/29/08	ND	ND	ND	30.0
10/20/08	ND	ND	ND	30.0
11/3/08	ND	ND	ND	30.0

Note: ND is non-detectable levels.



Radiation Safety

The pilot unit is designed to collect naturally occurring radioactive material while in operation. Because of this action, it gradually becomes radioactive during normal operation. WRT both predicts and monitors the level of radiation present in the treatment system.

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. WRT's maximum measured activity is less than half of the hourly exposure limit. Due to the limited amount of operator attention necessary for the pilot test, the annual exposure limit is also readily met.

WRT has prepared a safety plan for its tests that includes radiation level monitoring, logging time spent in proximity to a test unit, emergency procedures to be followed and an introduction to radiation safety for operators. Operators are instructed in radiation safety before the pilot test is started.

Any full scale system will include appropriate equipment, radiation level monitoring, and a corresponding safety plan approved by regulatory authorities.

Operational Results

An operation log was maintained during the pilot study, and is attached as Appendix C. The treatment system operated easily and reliably during the study.

Conclusion

The WRT Z-88® Radium Treatment Process consistently reduced the combined radium 226 and 228 and gross alpha discharge to levels well below the required MCLs.

WRT would like to thank the personnel and staff of the City of New Underwood for their cooperation and participation in this study.



Appendices available upon request