Pilot Study Report

for

Z-88® Radium Treatment Process

conducted for

City of Bridgeton, New Jersey
Well No. 19

Revised
June 13, 2007

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Executive Summary

This radium removal pilot study was conducted for the City of Bridgeton, New Jersey's Well No. 19 treatment facility. The Bridgeton water system contains concentrations of radium and gross alpha in excess of the Maximum Contaminant Levels (MCL).

The City of Bridgeton selected Water Remediation Technology's (WRT) Z-88® Radium Treatment Process as a possible cost effective solution for their radium and gross alpha problem. WRT provided a 1.2 GPM (gallons per minute) treatment system, which was delivered and installed on March 1, 2007.

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 54 days prior to writing this report and effectively reduced the level of radium (Figure 1) and gross alpha (Figure 2) to less than the State mandated MCL of 5pCi/L.

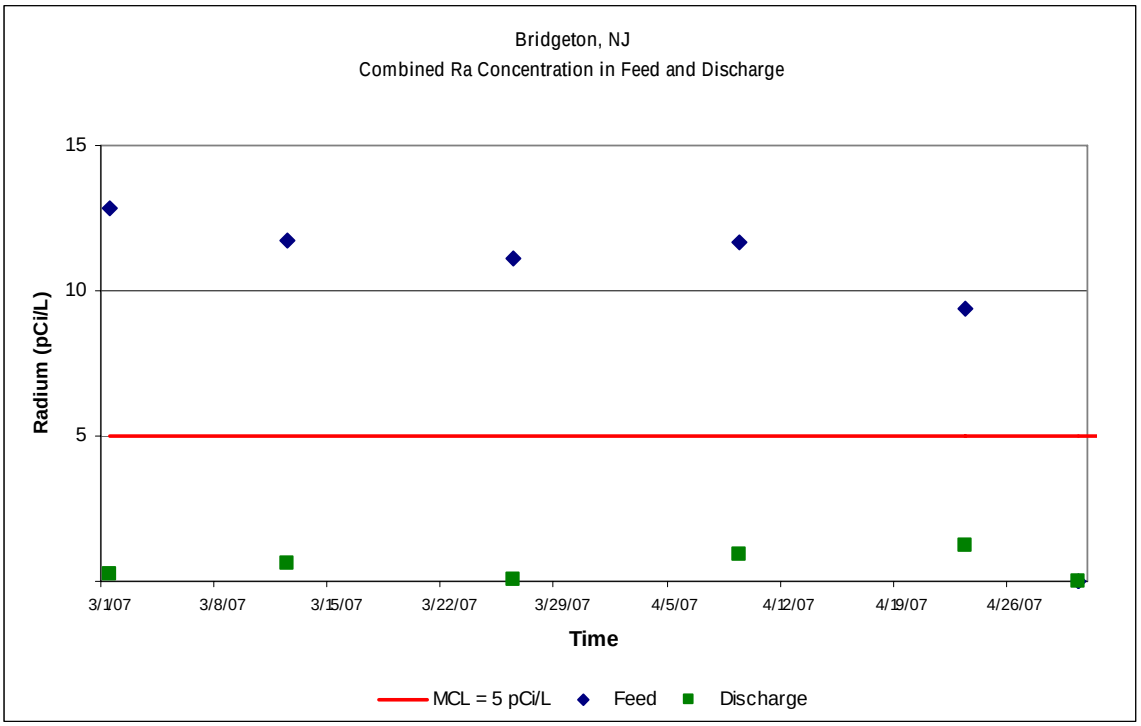

Figure 1

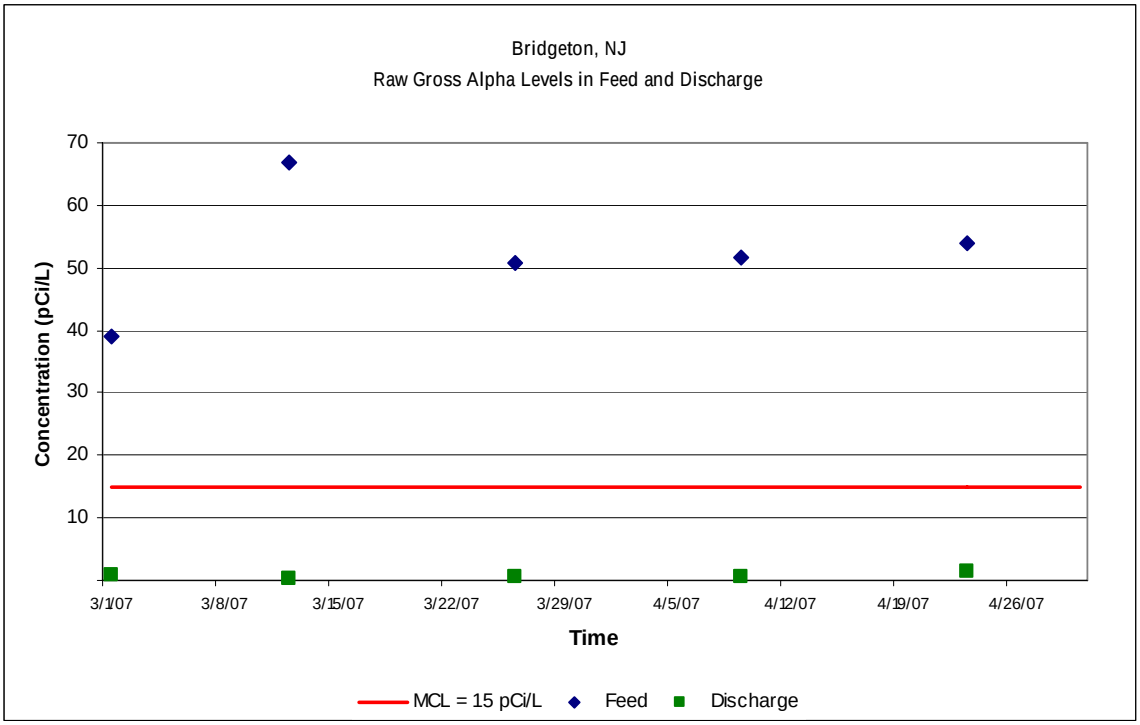

Figure 2

The results are also shown in Table 1. The average feed concentration of combined radium, 11.4 pCi/L, was reduced to an average of 0.6 pCi/L; well below the MCL of 5 pCi/L. The average feed concentration of gross alpha, 52.4 pCi/L, was reduced to 0.7 pCi/L; also 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)
Radium MCL	**—**	**5.0**
Average	11.4	0.6
Highest value	12.8	1.2
Lowest Value	9.4	0.0

Gross Alpha	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
Gross Alpha MCL	**—**	**15.0**
Average	52.4	0.7
Highest value	66.9	1.4
Lowest Value	39.0	0.2

Application Information

The City of Bridgeton is located in southern New Jersey, approximately 40 miles south of Philadelphia. It has a colonial heritage having been first settled by Quakers in 1686. Bridgeton is located in Cumberland County, and is the county seat with a current population of approximately 23,000. When the first bridge was built over the Cohansey River in 1716, the village became known as Cohansey Bridge. Before the Revolutionary War, Cohansey Bridge became known as Bridge Town, which was later mis-spelled as Bridgeton when the first bank opened and issued documents with "Bridgeton" printed on them.

The Well No. 19 treatment facility is one of three wells (the other wells being No. 20 & No. 23) that come together and are connected to Bridgeton's distribution system. The water for Well No. 19 is drawn from the Kirkwood-Cohansey Aquifer (No. 20 from the Kirkwood-Cohansey and No. 23 from the Piney Point Aquifer) and has the highest level of radium between the three wells. The water drawn from the deeper Piney Point Aquifer is essentially radium-free. Well No. 19 is approximately 270 feet deep.

Treatment is proposed to include water from Well No. 19 and from Well No. 18 (which is part of another three well system including Well No. 22, a Piney Point well, and Well No. 21, a Kirkwood-Cohansey well). Well No. 18 is the second highest well for radionuclides. The three well blend for Well Nos. 18, 21 and 22 has recently met the MCL for radionuclides in the latest testing cycle. With treatment on Well Nos. 18 & 19, all points of entry to the distribution system are expected to be in compliance.

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 Bridgeton's Well No. 19 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.

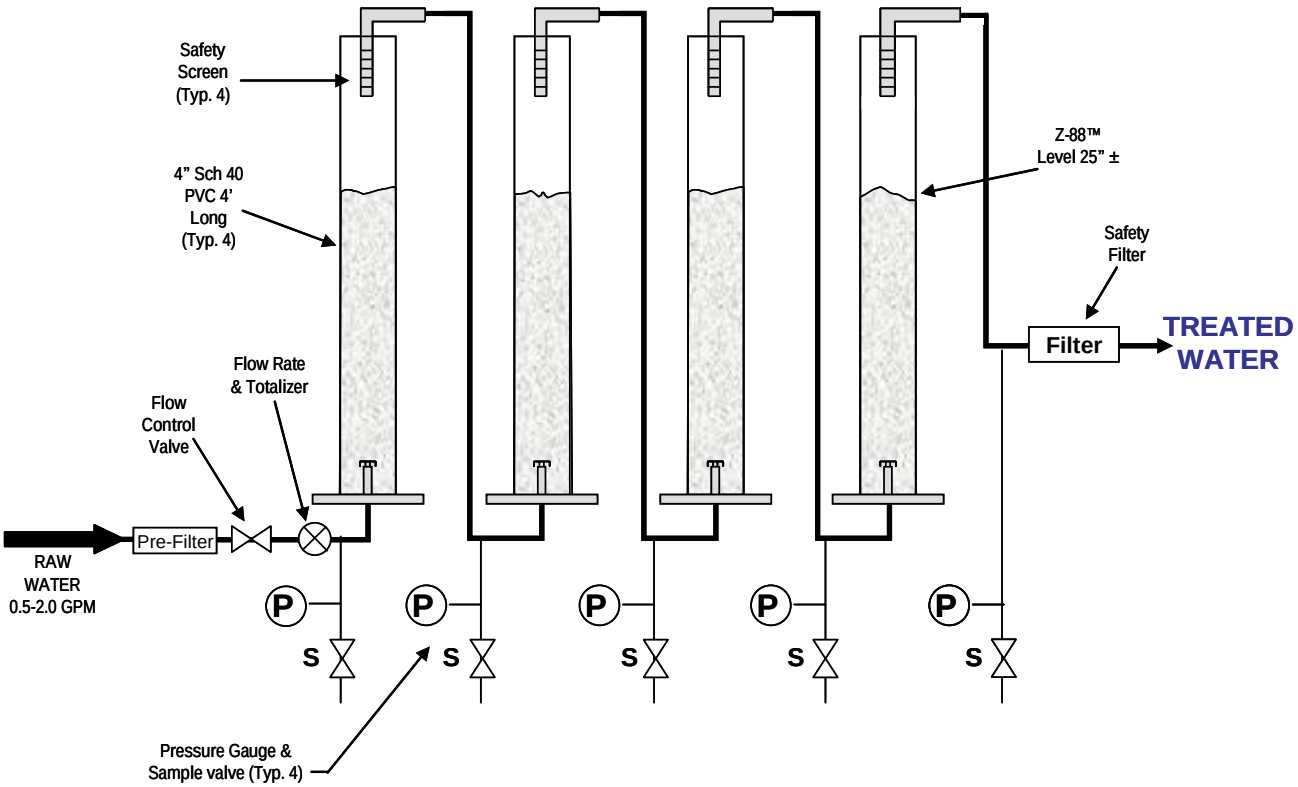

Figure 3. Simplified Process Flow Diagram.

City of Bridgeton's Z-88® Radium treatment system located at Well No. 19.

Statement of Purpose

The combined radium levels in the raw water during the pilot study were as high as 12.8 pCi/L, exceeding the Environmental Protection Agency (EPA) mandated combined radium MCL of 5 pCi/L. Similarly, the gross alpha was as high as 66.9 pCi/L, also exceeding the required MCL of 15 pCi/L for adjusted gross alpha.

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 March 1, 2007. 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 54 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 established. Samples were collected by the City of Bridgeton 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 the Pace Analytical in Madison, Pennsylvania for radium, gross alpha, and uranium. Samples for inorganic water quality analysis were delivered to ACZ Laboratories, Inc. in Steamboat Springs, Colorado. Both laboratories are National Environmental Laboratory Accreditation Program certified laboratories. Methods for analysis were:

Gross Alpha	EPA 900.0
Radium 226	EPA 903.1
Radium 228	EPA 904.0
Uranium	ASTM D5174

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 (C2), and at the discharge point (C4). 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 and gross alpha in the treated water to significantly below the required MCL.

Table 2. Radium Test Results

Radium 226	Column Concentrations (pCi/L)			
Date	Feed	C2	C4	MCL
3/1/07	5.0	0.2	-0.2	—
3/12/07	6.1	1.4	0.0	—
3/26/07	6.3	0.1	-0.1	—
4/9/07	7.2	0.4	0.1	—
4/23/07	5.7	1.9	0.4	—
Radium 228	**Column Concentrations (pCi/L)**			
Date	**Feed**	**C2**	**C4**	**MCL**
3/1/07	7.8	0.4	0.4	—
3/12/07	5.7	2.5	0.6	—
3/26/07	4.9	1.0	0.2	—
4/9/07	4.5	1.3	0.9	—
4/23/07	3.6	1.3	0.8	—
Combined Radium	**Column Concentrations (pCi/L)**			
Date	**Feed**	**C2**	**C4**	**MCL**
3/1/07	12.8	0.6	0.2	5.0
3/12/07	11.7	4.0	0.6	5.0
3/26/07	11.1	1.1	0.0	5.0
4/9/07	11.7	1.6	0.9	5.0
4/23/07	9.4	3.2	1.2	5.0

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

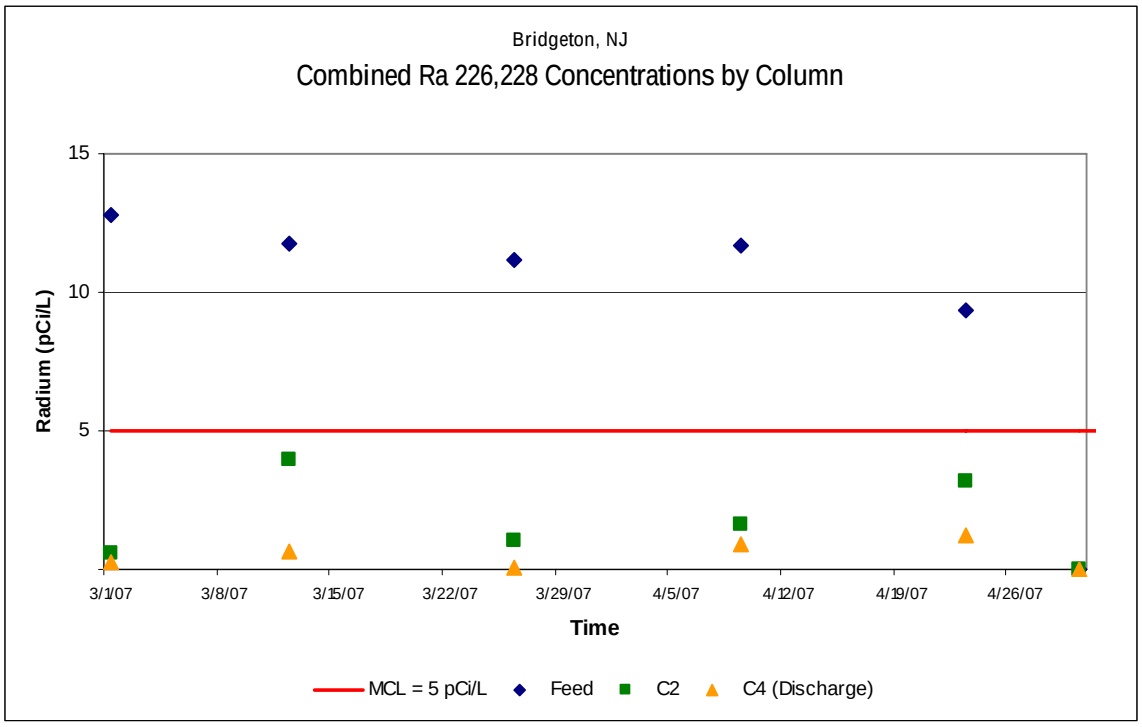

Figure 4

Table 3. Gross Alpha Test Results

Gross Alpha	Column Concentrations (pCi/L)			
Date	Feed	C2	C4	MCL
3/1/07	39.0	0.7	0.9	15.0
3/12/07	66.9	2.3	0.2	15.0
3/26/07	50.8	3.9	0.5	15.0
4/9/07	51.5	3.5	0.6	15.0
4/23/07	54.0	7.3	1.4	15.0

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

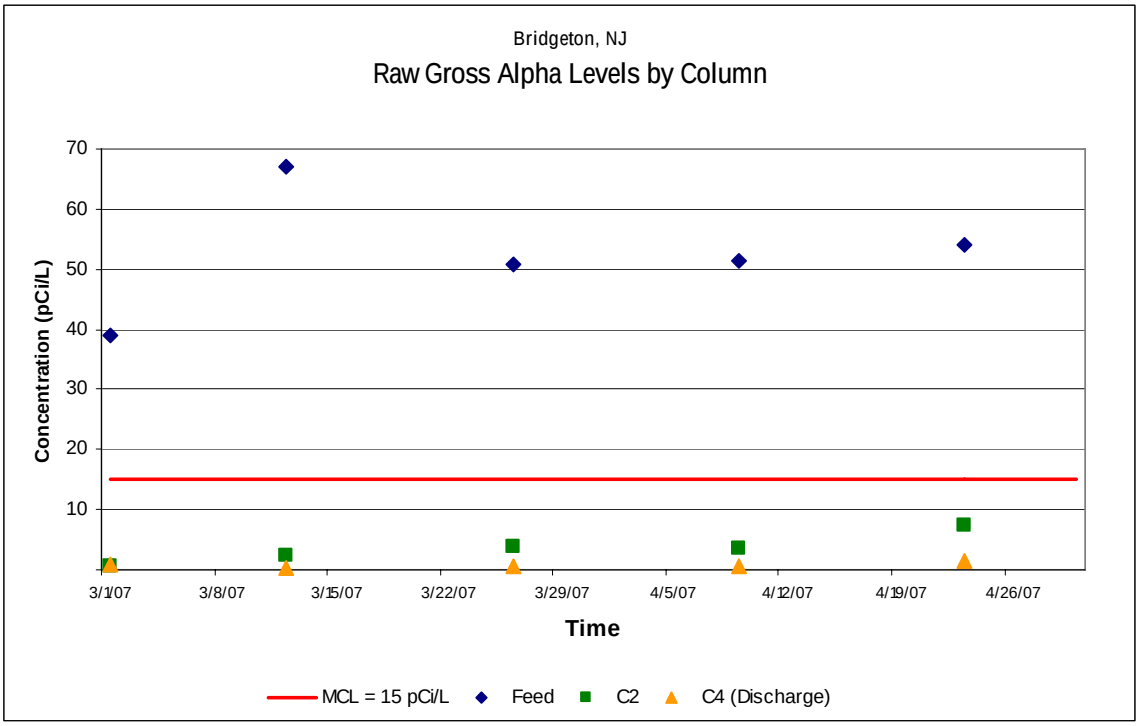

Figure 5

Water Quality

A water quality analysis was performed on feed water to the pilot unit and on treated water exiting the WRT pilot unit to document any changes in water quality through the Z-88® treatment process. The results of those tests are shown in Table 4. Other than the reduction of radium and gross alpha, there is no statistically significant change to the water quality. Support documentation for Table 4 is attached as Appendix B.

Table 4. Water Quality Data entering the WRT treatment process

Bridgeton, NJ Water Quality Data			
Item	**Pre WRT Process**	**units**	**Post WRT Process**
Alkalinity	6	mg/L	ND
Antimony	ND	mg/L	ND
Arsenic	ND	mg/L	ND
Barium	0.0139	mg/L	0.2100
Beryllium	ND	mg/L	ND
Cadmium	0.0003	mg/L	0.0003
Calcium	7.8	mg/L	6.8
Chloride	88	mg/L	88
Chromium	0.0002	mg/L	0.0002
Copper	0.0128	mg/L	0.0164
Fluoride	ND	mg/L	ND
Hardness	46	mg/L	42
Iron	0.13	mg/L	0.18
Lead	0.0037	mg/L	0.0099
Magnesium	6.4	mg/L	6.1
Manganese	0.039	mg/L	0.035
Mercury	ND	mg/L	ND
Nickel	0.08	mg/L	0.05
Nitrate	4.0	mg/L	4.41
Nitrate/Nitrite	4.0	mg/L	4.41
Phosphate	0.03	mg/L	0.06
Phosphorus	0.01	mg/L	0.02
Potassium	3.4	mg/L	2.9
Selenium	0.0002	mg/L	0.0002
Silica	12.1	mg/L	12.2
Sodium	47.9	mg/L	47.7
Strontium	0.05	mg/L	0.06
Sulfate	ND	mg/L	ND
Thallium	ND	mg/L	0.0001
Total Dissolved Solids	190	mg/L	180
Total Organic Carbon	ND	mg/L	ND
Uranium	ND	mg/L	ND
Zinc	0.10	mg/L	0.12

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

The pilot unit operated nominally at 1.2 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
3/1/07	70
3/12/07	19,440
3/26/07	44,142
4/9/07	66,415
4/23/07	90,037

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	Column Concentrations (µg/L)			
Date	Feed	C2	C4	MCL
3/1/07	0.04	0.07	0.10	30.00
3/12/07	0.04	0.03	0.01	30.00
4/9/07	0.06	0.03	0.03	30.00
4/23/07	0.06	0.06	0.05	30.00

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 Bridgeton, and GPM Associates for their cooperation and participation in this study.

Appendices available upon request