



## Pilot Study Report

for

## Z-88<sup>®</sup> Radium Removal Treatment Process



conducted for

**Corinne City, Utah  
Cutler Well**

**January 4, 2016**

## Executive Summary

This radium removal pilot study was conducted for Corinne City, Utah at their Cutler Well treatment facility. Corinne City's water system contains concentrations of radium in excess of the Maximum Contaminant Levels (MCL).

Corinne City selected Water Remediation Technology's (WRT) Z-88<sup>®</sup> Radium Removal Removal Treatment Process as a possible cost effective solution for their radium problem. WRT provided a 0.90 GPM (gallons per minute) treatment system, which was delivered and installed on June 3, 2015.

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

The treatment system successfully met radium compliance at all times during the pilot study. The system was in operation for 111 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 at all times.

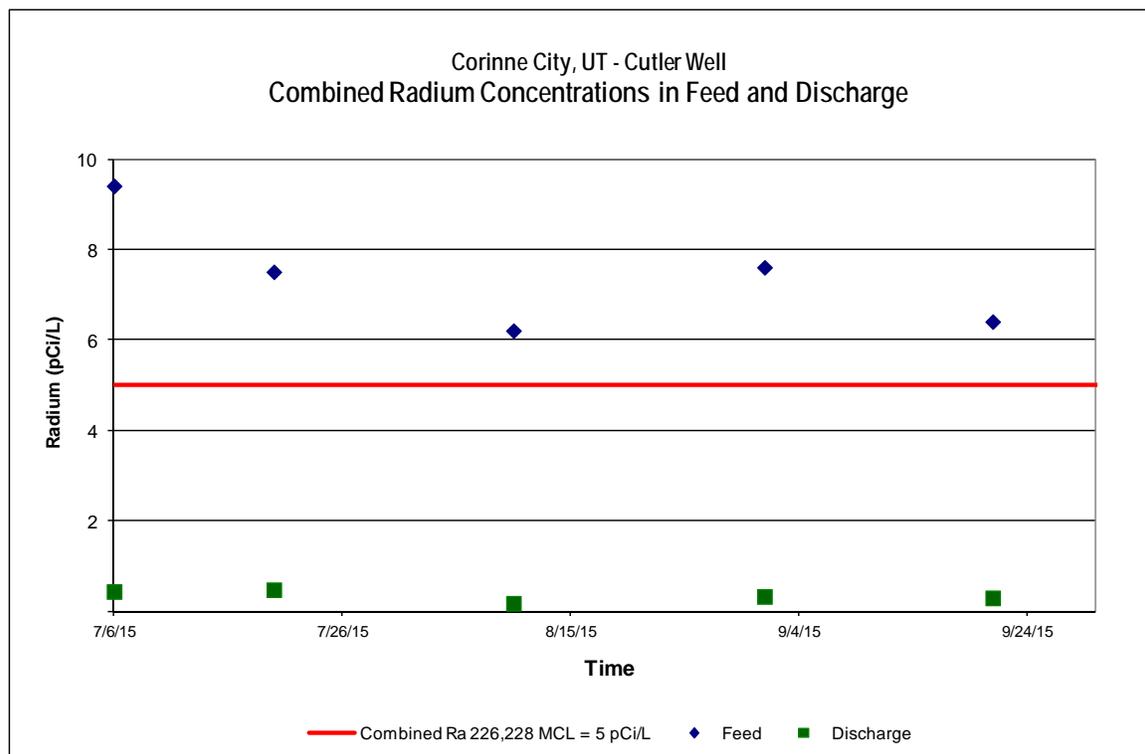


Figure 1

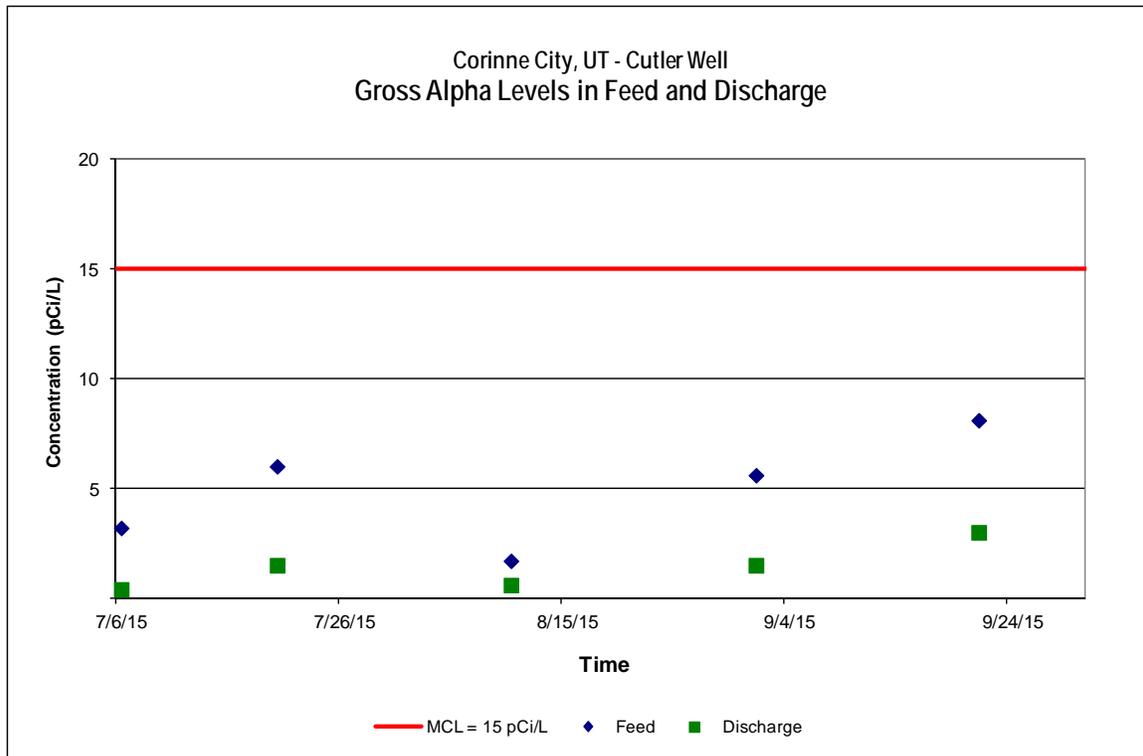


Figure 2

The results are also shown in Table 1. The average feed concentration of combined radium, 7.7 pCi/L (pico Curies per Litre) was reduced to 0.4 pCi/L after column 4 and has not exceeded 0.5 pCi/L. Although the feed water is in compliance with the gross alpha MCL, the average gross alpha level, 4.9 pCi/L, was reduced to 1.2 pCi/L after column 4 and has not exceeded 3.0 pCi/L. Both discharge concentrations are well below their respective MCL's.

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

Combined Radium	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
<b>Combined Ra 226, 228 MCL</b>	—	<b>5.0</b>
Average	7.7	0.4
Highest value	9.4	0.5
Lowest Value	6.2	0.2
Gross Alpha	Feed (pCi/L)	Discharge @ Column 4 (pCi/L)
<b>Gross Alpha MCL</b>	—	<b>15.0</b>
Average	4.9	1.2
Highest value	8.1	3.0
Lowest Value	1.7	0.4



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### Application Information

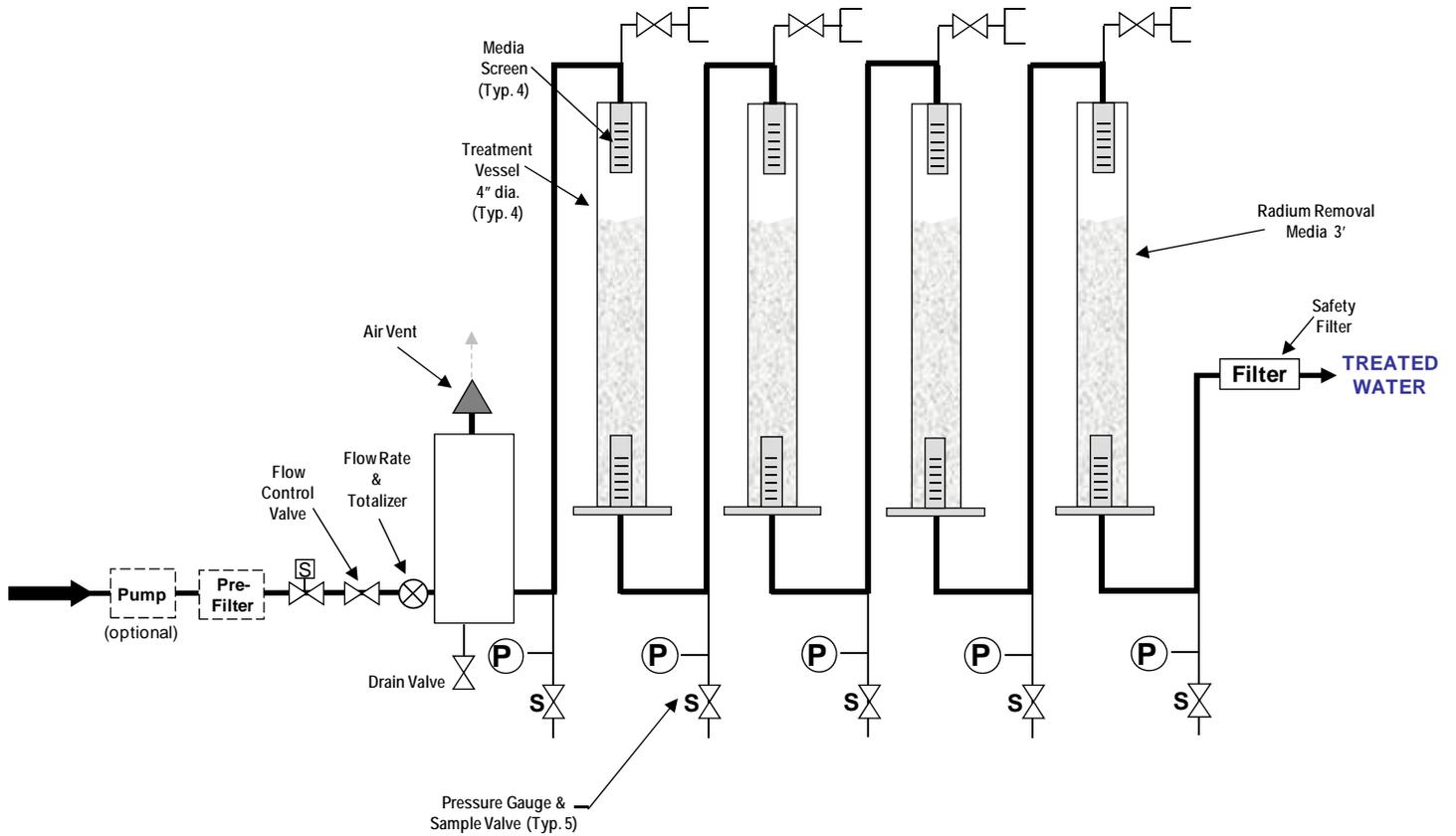
Corinne City is located in southeastern Box Elder County of Utah, approximately 62 miles north of Salt Lake City. The pilot study was conducted at Corinne City's Cutler Well treatment facility. The Cutler Well is one of the community's main water sources, and is blended with spring water prior to being distributed to the residents. Once a permanent solution for treating the elevated radium in the well is finalized, the well water will be treated prior to blending with the spring water. The Cutler Well pumps an average of 200 gallons per minute.

### Technology Overview

Water Remediation Technology's (WRT) Z-88<sup>®</sup> Radium Removal Treatment Process utilizes proprietary adsorptive media in a series of down-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 sufficiently loaded with radium contaminant, 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 Corinne City's Cutler Well treatment facility. The treatment train used for this pilot study consists of four 4-inch diameter by 3-foot, 6 inch vertical height columns. The columns contained approximately 25 inches of Z-88<sup>®</sup> 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 top of the first column. All columns operate in a down-flow configuration; with the flow exiting the bottom 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.**

Corinne City's Z-88<sup>®</sup> Radium treatment system for the Cutler Well.





Statement of Purpose

The combined radium levels in the raw water during the pilot study were as high as 9.4 pCi/L, exceeding the Environmental Protection Agency (EPA) mandated combined radium MCL of 5 pCi/L. The gross alpha water's highest result of 8.1 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<sup>®</sup> Treatment Process to consistently and effectively reduce the radium and gross alpha 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 June 3, 2015. 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 111 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 Corinne City's 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 Chemtech-Ford Laboratories in Sandy, Utah for radium, gross alpha, uranium and inorganic water quality analysis. This laboratory is a National Environmental Laboratory Accreditation Program certified laboratory. Methods for analysis were:

Gross Alpha	EPA 900.0
Radium 226	EPA 903.1
Radium 228	EPA 904.0



## 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 and gross alpha in the treated water to significantly below the required MCL.

**Table 2. Radium Test Results**

<b>Radium 226</b>	<b>Column Concentrations (pCi/L)</b>			
<b>Date</b>	<b>Feed</b>	<b>C-2</b>	<b>C-4</b>	<b>MCL</b>
6/3/15	2.5	0.1	0.0	—
7/6/15	2.3	0.1	0.1	—
7/20/15	2.0	0.1	0.1	—
8/10/15	1.9	0.1	0.0	—
9/1/15	1.6	0.0	0.1	—
9/21/15	1.8	0.1	0.1	—

<b>Radium 228</b>	<b>Column Concentrations (pCi/L)</b>			
<b>Date</b>	<b>Feed</b>	<b>C-2</b>	<b>C-4</b>	<b>MCL</b>
6/3/15	6.5	1.0	0.4	—
7/6/15	7.1	0.2	0.4	—
7/20/15	5.5	0.2	0.4	—
8/10/15	4.3	0.3	0.1	—
9/1/15	6.0	0.1	0.2	—
9/21/15	4.6	0.4	0.2	—

<b>Combined Radium</b>	<b>Column Concentrations (pCi/L)</b>			
<b>Date</b>	<b>Feed</b>	<b>C-2</b>	<b>C-4</b>	<b>MCL</b>
6/3/15	9.0	1.1	0.4	5.0
7/6/15	9.4	0.3	0.4	5.0
7/20/15	7.5	0.3	0.5	5.0
8/10/15	6.2	0.4	0.2	5.0
9/1/15	7.6	0.1	0.3	5.0
9/21/15	6.4	0.5	0.3	5.0

Note: Negative results are recorded as 0.0

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

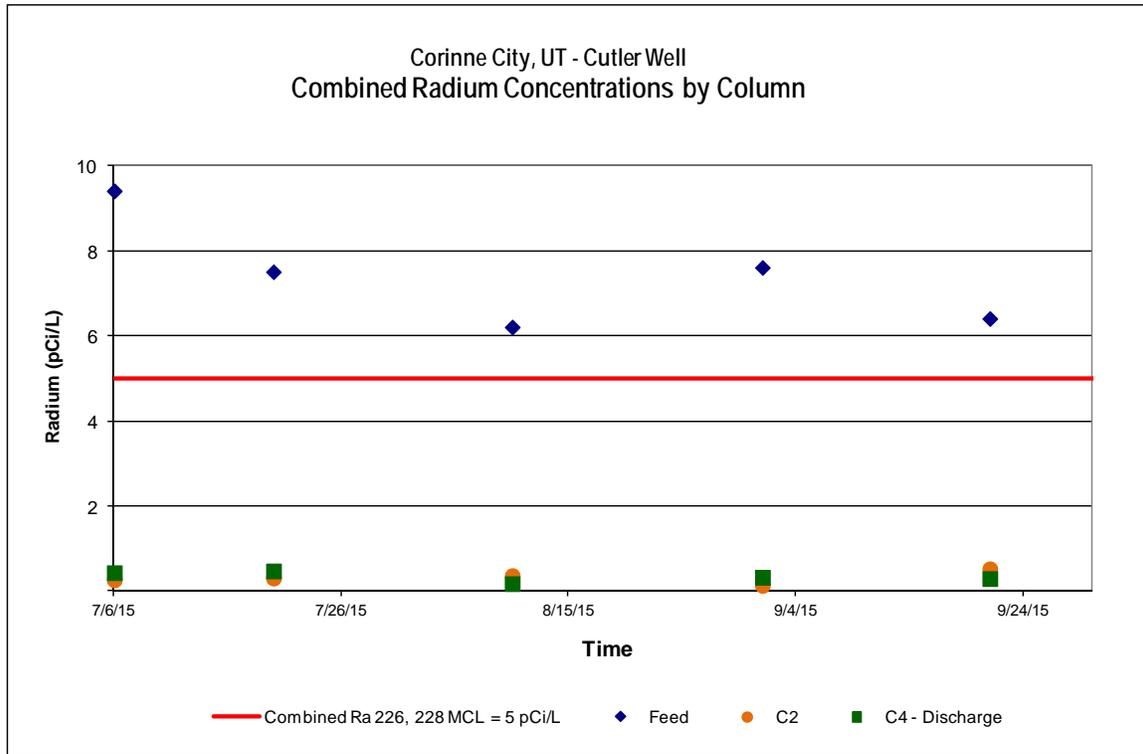


Figure 4

**Table 3. Gross Alpha Test Results**

Gross Alpha Date	Column Concentrations (pCi/L)			
	Feed	C-2	C-4	MCL
6/3/15	4.8	0.0	0.4	15.0
7/6/15	3.2	0.9	0.4	15.0
7/20/15	6.0	1.0	1.5	15.0
8/10/15	1.7	3.0	0.6	15.0
9/1/15	5.6	2.0	1.5	15.0
9/21/15	8.1	0.7	3.0	15.0

Note: Negative results are recorded as 0.0

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

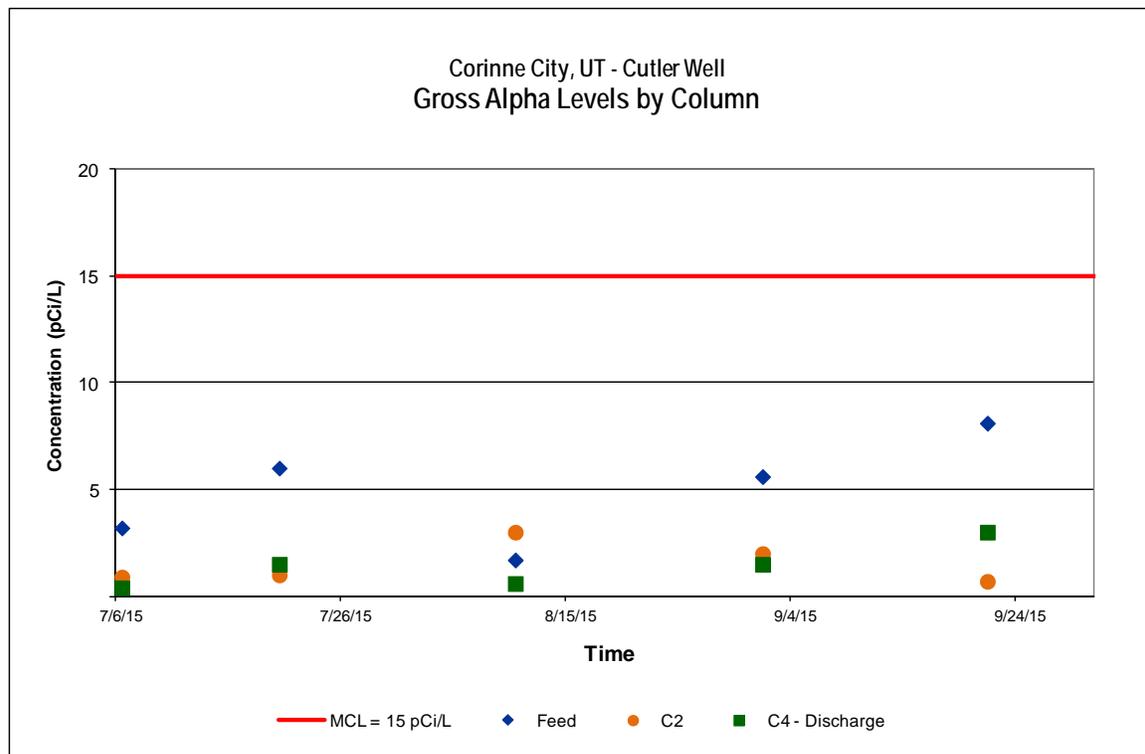


Figure 5

Water Quality

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

**Table 4. Water Quality Test Results**

<b>Corinne City, Utah - Cutler Well</b>			
<b>WATER QUALITY DATA</b>			
<b>Item</b>	<b>Pre WRT Process</b>	<b>units</b>	<b>Post WRT Process</b>
Alkalinity - Bicarbonate (HCO <sub>3</sub> )	267	mg/L	268
Alkalinity - Carbonate (CO <sub>3</sub> )	ND	mg/L	ND
Alkalinity - CO <sub>2</sub>	204	mg/L	213
Alkalinity - Hydroxide (OH)	ND	mg/L	ND
Alkalinity - (CaCO <sub>3</sub> )	219	mg/L	220
Antimony	0.0006	mg/L	0.0007
Arsenic	ND	mg/L	ND
Barium	0.092	mg/L	ND
Beryllium	ND	mg/L	ND
Calcium	43.9	mg/L	36.2
Chloride	8	mg/L	9
Chromium	0.0005	mg/L	0.0007
Copper	0.0088	mg/L	0.0011
Floride	ND	mg/L	ND
Hardness, (CaCO <sub>3</sub> )	239	mg/L	201
Iron	0.03	mg/L	ND
Lead	0.0034	mg/L	ND
Magnesium	31.4	mg/L	26.9
Manganese	ND	mg/L	0.007
Mercury	ND	mg/L	ND
Nickel	0.0367	mg/L	0.0082
Nitrate as N	ND	mg/L	ND
Nitrite as N	ND	mg/L	ND
Phosphate, ortho as P	ND	mg/L	ND
Potassium	1.4	mg/L	3.8
Selenium	ND	mg/L	0.0005
Silica (SiO <sub>2</sub> )	10.4	mg/L	9.3
Sodium	7.8	mg/L	7.2
Sulfate	27	mg/L	27
Thallium	ND	mg/L	ND
Total Dissolved Solids (TDS)	220	mg/L	220
Total Organic Carbon	ND	mg/L	ND
Uranium	0.0022	mg/L	0.0022
Vanadium	ND	mg/L	ND
Zinc	ND	mg/L	ND

Note: results reported as ND is non-detected levels



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

The pilot unit operated nominally at 1.0 gallons per minute, for a HLR of 11.5 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 or 1 minute-14 seconds per treatment column.

**Table 5. Cumulative treated flow in gallons**

Sample Data	Treated Flow in Gallons
6/3/15	48
7/6/15	5,356
7/20/15	9,388
8/10/15	13,653
9/1/15	18,293
9/21/15	22,583



### 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<sup>®</sup> 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 Corinne City for their cooperation and participation in this study.