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STATE OF ILLINOIS
Pollution Control Board

BEFORE THE POLLUTION CONTROL BOARD
OF THE STATE OF ILLINOIS

IN THE MATTER OF:	)	
	)	
REVISIONS TO RADIUM WATER	)	
QUALITY STANDARDS: PROPOSED	)	**R04-21**
NEW 35 ILL. ADMIN. CODE 302.307	)	**Rulemaking - Water**
AND AMENDMENTS TO 35 ILL. ADMIN.	)	
CODE 302.207 AND 302.525	)	

NOTICE OF FILING

To: See Attached Service List

Please take notice that on August 11, 2004, we filed with the Office of the Clerk of the Illinois Pollution Control Board, an original and ten copies of the attached **Testimony Of Charles Williams On Behalf Of Water Remediation Technology, LLC** a copy of which is served upon you.

WRT Environmental [Illinois] LLC

By: ____________________
One of Its Attorneys

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TESTIMONY OF CHARLES WILLIAMS
ON BEHALF OF WATER REMEDIATION TECHNOLOGY, LLC

I. INTRODUCTION

My name is Charles Williams. I am the founder and President of Water Remediation Technology, LLC (WRT). Under my direction, WRT has developed proprietary technology for removing contaminants from water and wastewater and is specifically concentrating on helping municipalities comply with the radionuclide rule in a safe and non-polluting manner. I have worked with extractive metallurgical processes for over 30 years and have installed removal technologies for the removal of ammonia, gold, lead, zinc, and silver. For the past four (4) years, I have directed research and development on the removal of contaminants from drinking water, including such contaminants as radium, uranium, arsenic, cadmium, lead, chromium, and selenium. WRT, under my direction, has conducted radium removal pilot plant studies at over 20 sites in six (6) states, 12 of which sites are in Illinois. I am a co-inventor on five (5) patent applications related to contaminant removal from water. WRT currently is constructing five (5) radium removal plants in Illinois; engineering is underway on an additional 20 sites. The WRT process removes radium from drinking water and disposes of the radium-loaded residuals into a low-level radioactive waste facility. My education consists of a B.S. in Geology from North Carolina State University.

II. SUMMARY OF EFFECTS OF PROPOSED REVISIONS TO THE RADIUM WATER QUALITY STANDARDS

The impact of changing the 30-year-old water quality standard for radium, as proposed, is to allow a known carcinogen to be discharged into the waterways of Illinois. The proposed rulemaking effectively eliminates the general use water quality standard for radium – to the detriment of Illinois rivers, streams and lakes. No monitoring of the discharge from a Publicly Owned Treatment Works (POTW) or directly from a water treatment facility would even be required in most cases. In effect, the discharge limit would be changed from the current limit of 1 picocurie/liter (pCi/L) of Radium-226 to an unlimited discharge. It should be remembered that the Maximum Contaminant Level Goal (MCLG) for radium established by the United States Environmental Protection Agency (EPA or U.S. EPA) is zero pCi/L. In other words, any radium in drinking water is undesirable and any level above zero carries a health risk. The apparent reason the Illinois Environmental Protection Agency (IEPA) has requested the rule change is to permit public water systems that remove radium from their drinking water to dispose of the radium-laden residuals into the sanitary sewer or a receiving stream. Neither of these disposal practices is a sound environmental practice.

The removal of the radium discharge standard from the general water quality standard, as proposed, is not necessary or advisable for the following reasons:

a. Treatment technologies are available that remove radium from the drinking water without generating a radium-laden discharge to the sanitary sewer or a receiving stream.

b. All radium removal technologies can be designed to avoid radium release to the sanitary sewer or receiving stream.

c. Treatment technologies that do not discharge radioactive residuals to the sewer are economically competitive with those technologies that do discharge to the sewer or receiving stream.

d. Radioactive residuals that are not discharged into the sewer are disposed of in a Low Level Radioactive Waste Disposal Site (LLRWDS) with long-term maintenance plans and funding.

e. When radium residuals are discharged into the sewer, sewer workers and other public works employees are exposed to higher levels of radiation. Not allowing radium residual discharge to the sewer decreases the exposure of sewer workers to radiation and is consistent with the As Low As Reasonably Achievable (ALARA) radiation control principles.

f. Removing the radium discharge standard, as proposed, will allow low-flow streams where the discharge from the POTW is the principal flow to be many times the drinking water standard. This implies that the life in a stream that is not used for drinking water has no value – fish, birds, and plant life. Testimony from the IEPA is that the majority of affected treatment plants discharge to low-flow or zero-flow streams.

g. There are serious liability issues regarding potential harm to people and the environment that the water treatment plant may be passing to POTWs.

h. The discharge of radium treatment plant residuals into the POTW, which will be allowed by this proposed rule change, will require significant time and resources of government agencies to insure the health and safety of Illinois citizens. Indeed, a significant new workload will be placed on the government agencies to control and monitor sewer worker safety and land-spreading of residuals.

i. The discharge of radium treatment plant residuals into the POTW will create a significant increase in workload for site and worker monitoring and worker training as well as liability for the POTW.

j. Under the proposed rule change, the irony is sludge that is too radioactive for landfills is being permitted for spreading on good Illinois farm fields and open land.

k. Based on the Memorandum of Agreement between the Illinois Department of Nuclear Safety (IDNS) and the IEPA (attached hereto as Exhibit 1), significantly more land than currently utilized will need to be used in land application. Indeed, the limit of a 0.1 pCi/g increase in the soil may require a six- to ten-fold increase in land needed for land application.

l. Common sense says that once you take a carcinogen out of the environment, don't put it back in.

For these reasons, WRT is opposed to this rule change.

As indicated by the IEPA, the source of the radium is natural radium dissolved in the raw water pumped from deep aquifers to supply water to Illinois communities. Virtually no radium is present in the surface waters of the State. Since radium is a known carcinogen and the maximum contamination level goal is zero, any discharge into the Illinois environment should be allowed only after comprehensive studies have been conducted and then only if no other options exist.

Communities that draw water from radium-contaminated aquifers need to understand the requirements, impacts and unintended consequences of radium disposal. They can then make an informed decision on which treatment process to use and be confident that more restrictive discharge limits in the future will not cause a multimillion-dollar treatment facility to become obsolete. Many of the communities with a radium problem are experiencing population growth that requires increased pumping and greater dependence on radium-contaminated aquifers. Oswego, IL, for example, is adding two new 1000 gallon per minute wells during the next year, a 40% increase in capacity. Elburn, IL is adding one well next year, a 50% increase in capacity. Not only must Illinois contend with the current production of radium, it must deal with more and more radium being added to the surface environment each and every year in perpetuity.

Radium in drinking water is a serious and complex issue. To understand all of the ramifications of this proposed rule change, one needs to know where the radium is being generated, the potential disposal options available to the water producer, and the final disposal site of the radium removed from drinking water and, ultimately, how the impact of radium on the environment can be minimized.

Table 1 and Figure 1 indicate radium levels encountered in ground water at sites where WRT has conducted testing.

	FEED			
	Ra-226	Ra-228	Combined	MCL
Woodsmoke Ranch, IL	18.0	4.6	22.6	5
Ken Caryl, CO	17.1	1.6	18.6	5
May Valley, CO	15.3	10.2	25.4	5
Edelstein, IL	12.8	1.5	14.3	5
Richland Springs, TX	12.5	21.4	33.8	5
Elburn, IL	11.6	7.6	19.2	5
Joliet, IL	7.7	4.9	12.6	5
Jamesburg, NJ	11.2	2.0	13.1	5
Cortland, IL	8.4	3.9	12.3	5
IL Prairie Estates, IL	8.1	6.6	14.8	5
Oswego, IL	8.1	9.2	17.3	5
Reddick, IL	5.1	3.5	8.6	5
Breazeale, IL	5.1	3.6	8.7	5
Medina, MN	4.6	3.7	8.3	5
Brookfield, WI	4.0	2.6	6.7	5
Wynstone, IL	3.7	5.3	9.0	5
Sycamore, IL	3.4	3.2	6.6	5
Parkway, NJ	2.7	2.9	5.6	5
Bartlett, IL	2.4	4.8	7.2	5
Average All	8.5	5.4	13.9	
Average Illinois	7.8	4.9	12.8	

Table 1

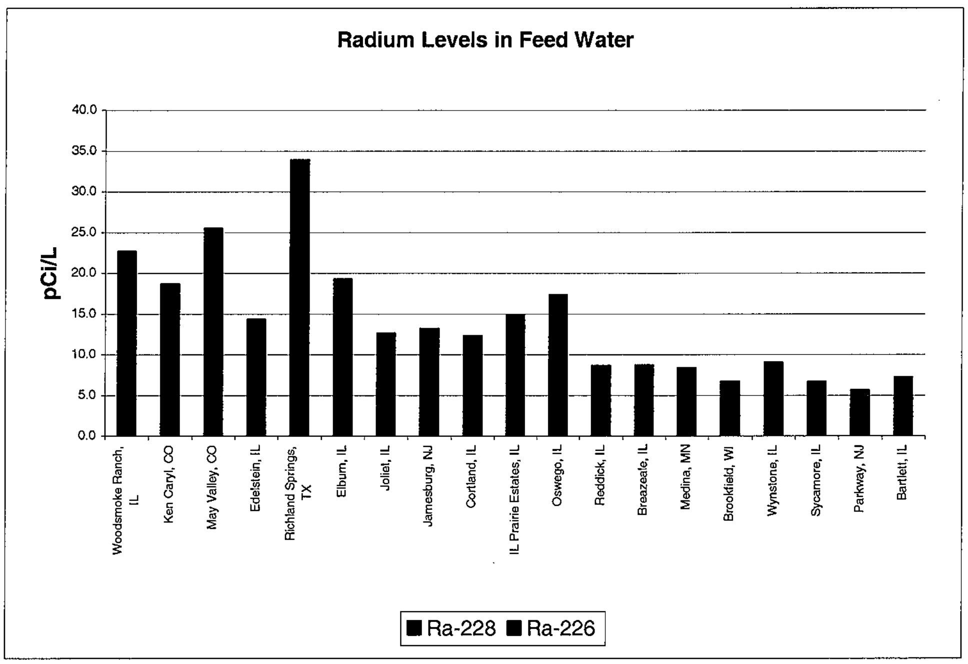

Figure 1

As can be seen from the chart and graph, the average radium level found by WRT in Illinois is 12.8 pCi/L for the combined Ra-226 and Ra-228. In Illinois, the highest level we have tested has averaged 22.6 pCi/L combined. The ratio of Ra-226 to Ra-228 is quite variable and, while not shown on the graph, changes between sampling at individual wells. Some wells are predominantly Ra-226 and some are predominantly Ra-228. The average Ra-226 concentration is 7.8 pCi/L but the highest is Woodsmoke Ranch, IL, which averaged 18 pCi/L Ra-226.

The first decision point is whether or not to treat for the removal of radium. If the raw water contains less than 5 pCi/L Ra-226 and Ra-228 combined, then the water is pumped directly to the consumer without any radium removal required. Since no treatment is required, there is no opportunity to reduce the radium being introduced into the environment.

If the radium content (Ra-226 + Ra-228) is greater than 5 pCi/L, then radium treatment is required. Radium treatment creates radium compliant water (less than 5 pCi/L combined) to be sent to the consumer and radium-enriched residuals, either liquid or solid, to be disposed of. Figure 2 shows the potential disposal options available for radium disposal to the water treatment plant operator. Basically, there are three options for the radium residuals:

1. The radium can be disposed of by discharging the residuals directly to a stream.

2. The residuals can be disposed of by discharging them to a sewer (in which case a portion will be discharged into a receiving stream with the POTW effluent and a portion will be disposed of with the sewage sludge).

3. The radium residuals can be transported to an appropriate LLRWDS with long-term maintenance plans and funding.

Radium Disposal Options for Water Treatment Plants

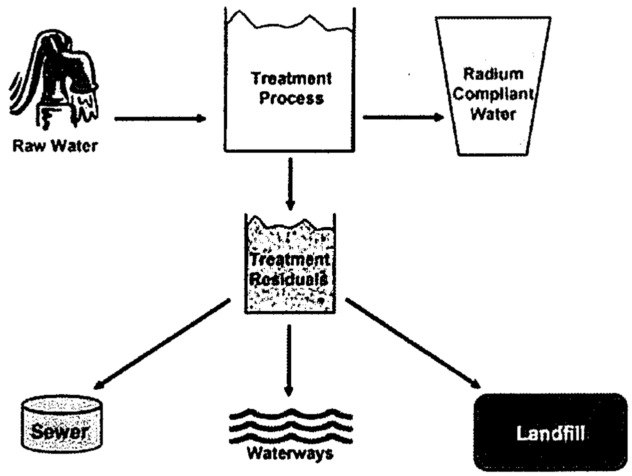

Figure 2

Current Regulations Protect Illinois Waterways

The current general water quality standard of 1 pCi/L effectively protects the citizens of Illinois by preventing the discharge directly into a stream or the discharge of radium into the sewer. Of the three options, only the transport to a LLRWDS of the water treatment residuals keeps the radium out of the Illinois environment and is permissible under current Illinois rules.

It is my belief that discharge of radioactive liquids or solids into either the sewer or the waterways of Illinois is an unacceptable practice for the following reasons:

Rule Change Threatens Illinois Streams, Rivers, and Lakes

Discharge of radium directly from the water treatment plant to a receiving stream will mean the discharge of radium into a receiving stream at many times the current limit of 1 pCi/L and indeed many times the drinking water standard. For example, a municipality that produces water with a radium content of 15 pCi/L and installs a reverse osmosis system, which concentrates the radium into a small percentage of the raw water and then discharges that high radium concentrate water into a receiving stream, would be discharging water into the receiving stream at levels of approximately 100 pCi/L radium. This level is 20 times the drinking water standard and if one-half of the radium is Ra-226, the level would be 50 times higher than the current standard. The proposed rule change would permit just such a discharge.

Open Land is Threatened

Discharge to the sewer creates not only a discharge to the stream of elevated radium but also elevated radium in the sewer sludge, which usually is land-applied to farms. It exposes the sewer workers to unnecessary radiation exposure. It exposes future residents of the land to increased radon exposure (radon is a by-product of radium decay). Indeed, it is my understanding that the level of radium in the sewage sludge will be high enough that the sludge could not be disposed of in any currently permitted Illinois landfill and could only be disposed of out-of-state in specially constructed landfills designed to accept radioactive waste. The proposed rule change will allow discharge down the sewer and the spreading of material on farms that cannot be disposed of in landfills and the unregulated discharge of radium to the streams.

Figure 3 shows the potential disposal sites and the radium limits for each site.

Radium Disposal Options in Illinois

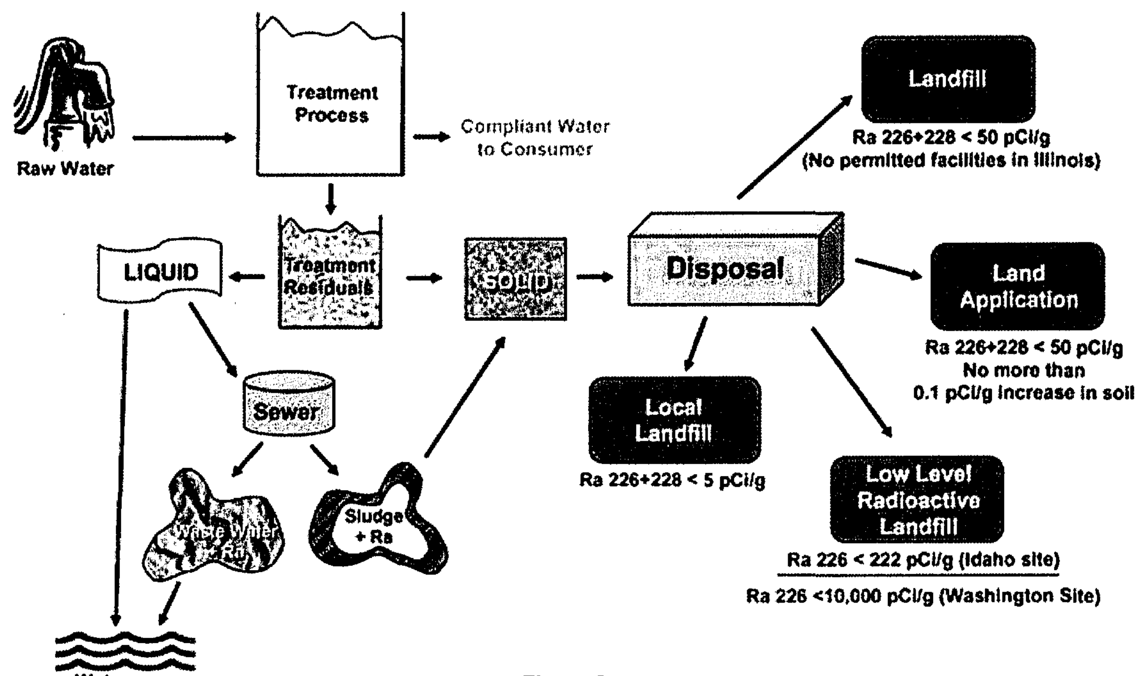

Figure 3

MOA Provides Rules to Protect Citizens

In 1984, the IEPA and the IDNS signed a Memorandum of Agreement that outlined the fate of radium-contaminated sewage sludge. At that time, there were no processes available that avoided radium disposal down the sewer. The Memorandum established three basic parameters:

1. If sewer sludge is over 50 pCi/g then: The disposal method must be approved in advance by the IDNS and the method must limit radon exhalation and provide reasonable assurance against accidental intrusion into the sludge in the future.

2. If sewer sludge is between 5 and 50 pCi/g then: The sludge may be disposed of in an IEPA-permitted landfill with at least 10 feet of overburden.

3. Application of radium-contaminated sludge less than 50 pCi/g as a soil conditioner is allowed to raise the level of radium in the soil by only 0.1 pCi/g.

The impact of these rules is as follows:

Disposal of radium-contaminated sludge should be done only under strict supervision with upper limits on what can be disposed of. In order to minimize impact to future land users, only a very small increase in radium is allowed. The impact of this last rule is very significant. Typically non-radium-bearing sewage sludge application rates are approximately 3 tons/acre. Table 2 indicates the application rates predicted for radium-bearing sludge at the average and high Illinois radium levels. Based on these calculations, the amount of land needed for land application will be increased significantly if radium is in the sludge – **typically 3 to 10 times.**

Anticipated Application Rate of Sewage Sludge with Radium per Memorandum of Understanding

Assumptions	Raw Water Radium Level Ra-226 + Ra-228 pCi/L	Projected Application Rate dry tons/acre
Case 1, 90% recovery in sludge		
Average Illinois Case	12.8	0.49
High Illinois Case	22.6	0.27
Case 2, 50% recovery in sludge		
Average Illinois Case	12.8	0.89
High Illinois Case	22.6	0.49
Case 3, 20% recovery in sludge		
Average Illinois Case	12.8	2.2
High Illinois Case	22.6	1.23

Note – The lower the recovery of radium in the sludge, the higher the level of radium in the effluent to streams.

Table 2

Radium Removal Technologies

I have attached a report entitled "Illinois Summary of Radium Removal Methods and Disposal Issues as They Relate to Radium Removal from Drinking Water" dated May 2004 and prepared by Water Remediation Technology, LLC. (See Exhibit 2.) The report describes the processes for radium removal and advantages and the disadvantages of each system. I would like to only briefly describe the systems here and discuss the potential discharge levels of radium that could be expected to be generated by each system and how the systems could be modified to reduce the discharge of radium into the Illinois environment. **All systems can be modified to significantly reduce or eliminate the disposal of radium removed from drinking water onto the land and into the streams of Illinois.**

Table 3 shows the theory of operation and type of residual generated for each of the radium removal methods.

Radium Removal Method	Theory of Operation	Type of Residual Generated
Reverse Osmosis	Filter out radium ions through high pressure membrane	Liquid Solid (membranes)
Ion Exchange (conventional)	Exchange sodium ion for radium ion on an artificial resin and regenerate with salt brine	Liquid Brine Solid Exchange Media
Hydrous Manganese Oxide (HMO)	Add Iron Manganese chemicals to cause the radium to precipitate	Radioactive Solids of iron-manganese-radium particles
Lime Softening	Add chemicals to precipitate the radium and calcium	Finely divided calcium, radium carbonate
Absorptive medias	Sand-sized particles cause the radium to be collected on the media either by ion exchange or chemical precipitation	Sand-sized particulates containing radium

Table 3

Table 4 below shows the current disposal sites and anticipated levels of radium in the residuals from each of the principal radium removal methods. It is difficult to estimate the radiation content of the residuals because the radiation content is dependent not only on the radium concentration in the raw water but also on the way the radium removal plant is operated.

Radium Removal Method	Current Residual Disposal Site	Anticipated Radium Level of Residuals from Water Treatment Plant
Reverse Osmosis	Streams or sewer	35-150 pCi/L in reject water
Ion Exchange (conventional)	Streams or sewer	1,000 to 6,000 pCi/L in elluate; several hundred pCi/L in rinse + elluate
Hydrous Manganese Oxide (HMO)	Streams or sewer	Solid Component 5,000 to 15,000 pCi/g
Lime Softening	Land-spreading	25 to 50 pCi/g
Absorptive medias	LLRWDS	400 to 3,000 pCi/g

Table 4

According to the U.S. EPA, none of the residuals produced by water treatment plants should be discharged directly to receiving streams or land-applied. (See Theodore G. Adams's Exhibit I which contains relevant excerpts from the "Draft Suggested Guidelines for Handling and Disposal of Drinking Water Treatment Waste Containing Technologically Enhanced Naturally Occurring Radioactive Materials," Office of Ground Water Protection, *EPA November 2000* and "A Regulator's Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies," *EPA August 2004*.) In addition, the level of radionuclides is sufficiently high so that WRT is unaware of any landfills in Illinois licensed to accept these residuals.

Many of the radium removal methods contemplate disposal of the radium-bearing residuals down the sewer assuming that disposal down the sewer will dilute the radium sufficiently so that it is no longer a health hazard. This is a dangerous assumption.

In order to calculate the radium content of POTW sludge and liquid effluent, a number of assumptions must be made. These assumptions apply to all of the methods that dispose of the residuals down the sewer.

These assumptions include:

1. How much of the radium will be contained in the sewage sludge and how much will be contained within the liquid effluent.

2. The total amount of radium sent to the sewage treatment plant will be roughly the same regardless of removal method.

3. The total amount of sludge generated by the sewage treatment plant will be unchanged by the introduction of water treatment residuals.

4. The radium content of the sewer sludge will be dependent on the amount of dilution influent received to the POTW from non-radium-bearing sources such as infiltration, storm drains, and other water treatment plants.

5. Since most of the radium contained in raw water ends up at the POTW, the radium content of the raw water should be an indicator of the radium content of the sewer sludge and liquid effluent from the water treatment facility.

Based on the above assumptions, an estimate can be made for the level of radium to be anticipated in both sludge and liquid effluent. Based on the above assumptions, the following calculations were performed varying the radium in the raw water, amount of dilution, and the percent of the radium reporting to the sludge and to the effluent.

Assumptions*	Radium Level Ra-226 + Ra-228 pCi/L	Sewer Sludge pCi/g	Sewer Liquid Effluent pCi/L
Case 1, 90% of radium in sludge, 10% of radium in effluent, No dilution			
Average Illinois Case	12.8	133	1.3
High Illinois Case	22.6	234	2.2
Case 2, 90% of radium in sludge, 10% of radium in effluent, 50% dilution			
Average Illinois Case	12.8	88	0.4
High Illinois Case	22.6	156	1.5
Case 3, 50% of radium in sludge, 50% of radium in effluent, No dilution			
Average Illinois Case	12.8	73	6.4
High Illinois Case	22.6	130	11
Case 4, 50% of radium in sludge, 50% of radium in effluent, 50% dilution			
Average Illinois Case	12.8	49	2.1
High Illinois Case	22.6	87	7.5
Case 5, 20% of radium in sludge, 80% of radium in effluent, No dilution			
Average Illinois Case	12.8	30	10
High Illinois Case	22.6	52	18
Case 6, 20% of radium in sludge, 80% of radium in effluent, 50% dilution			
Average Illinois Case	12.8	20	6.8
High Illinois Case	22.6	34	12

*Assumes 0.33 grams of sludge/gallon of influent to POTW

Table 5

The conclusion from these calculations is that if water treatment residuals are discharged to the POTW then significant levels of radium can be expected to be found in both the sewage treatment liquid effluent and the sewage sludge. Radium levels in the POTW liquid effluent will range from a low of 0.4 pCi/L total radium to a high of 18 pCi/L total radium or almost four (4) times the drinking water standard. Radium levels in the POTW sludge will range from a low of 20 picocuries/gram (pCi/g) of sludge to a high of over 230 pCi/g in the worst case. **These levels of radium are high enough to cause significant concern for the safety of POTW workers.**

POTW workers normally are not considered radiation workers and are not trained in handling radiation exposure. To my knowledge, no radiation monitoring of sewage workers currently is conducted.

Modifications Required to Avoid Disposal Down the Sewer

As stated earlier, rather simple modifications to these processes can avoid the need to discharge radioactive material down the sewer. Table 6 shows the modifications needed to avoid land and stream pollution with radium.

Radium Removal Method	Modification required to avoid disposal down the sewer	Disposal site after modification
Reverse Osmosis	Precipitate a radium salt in the water treatment plant concentrate stream with barium sulfate, or use an absorptive media such as Layne Christianson or WRT Media to recover the radium.	LLRWDS
Ion Exchange (conventional)	Precipitate a radium salt in the water treatment plant waste brine stream with barium sulfate, or use an absorptive media such as Layne Christianson or WRT Media to recover the radium.	LLRWDS
Hydrous Manganese Oxide (HMO)	Clarify the backwash water to remove the radium precipitants.	LLRWDS
Lime Softening	Not disposed of to sewer. Radium can be removed prior to lime softening using other methods.	LLRWDS or land application
Absorptive medias	Not disposed of to sewer.	LLRWDS

Table 6

Figures 4 through 11 are diagrammatic representations of each of the radium treatment processes and of the modifications that could be made to avoid putting the radioactive residuals into the sewer system.

As long as radium disposal down the sewer is allowed, the suppliers of these systems have no incentive to develop radium removal systems that do not pollute Illinois waterways and land. The technology exists to modify the systems; the will can be provided by banning disposal down the sewer.

Reverse Osmosis Radium Removal Process

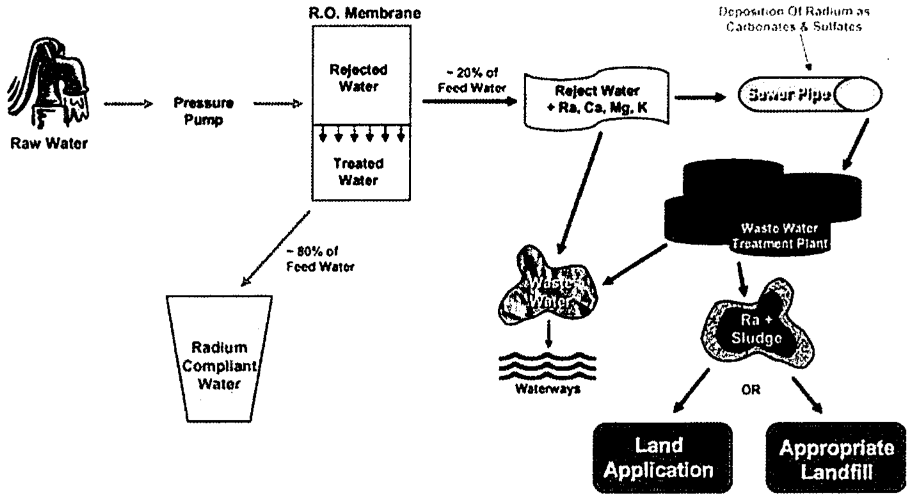

Figure 4

Modified Reverse Osmosis Radium Removal Process

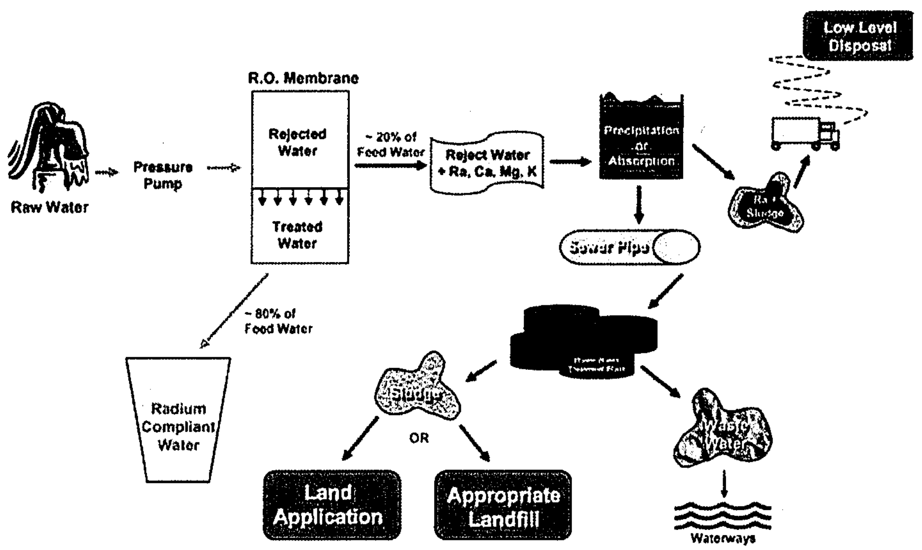

Figure 5

Ion Exchange
Radium Removal Process

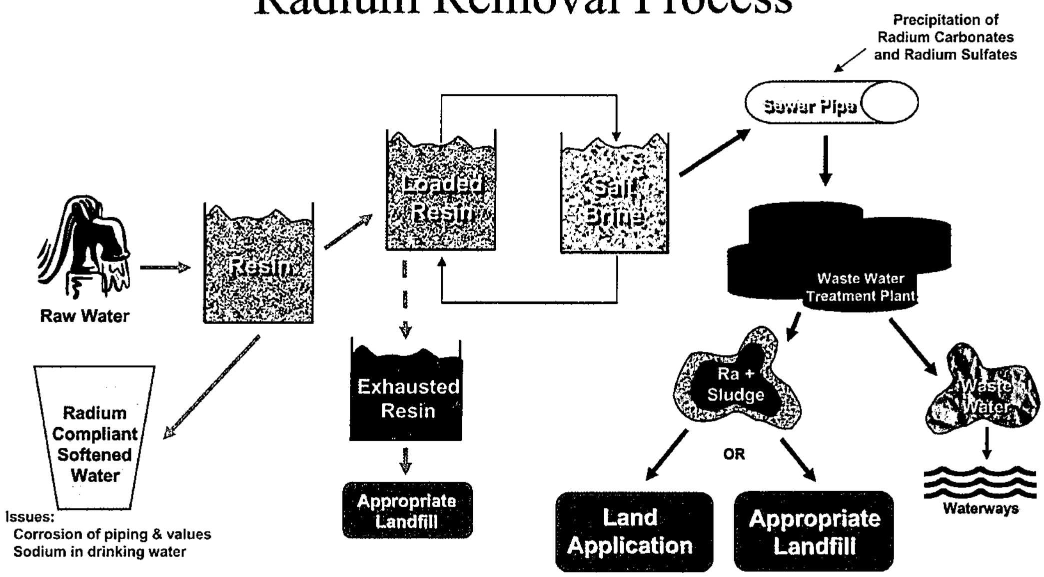

Figure 6

Modified Ion Exchange
Radium Removal Process

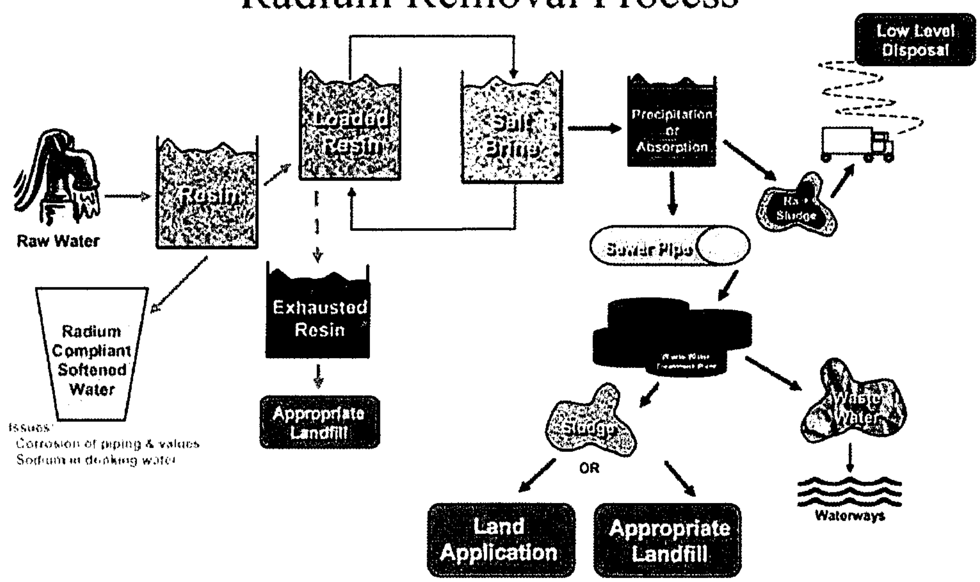

Figure 7

Hydrous Manganese Oxide Radium Removal Process

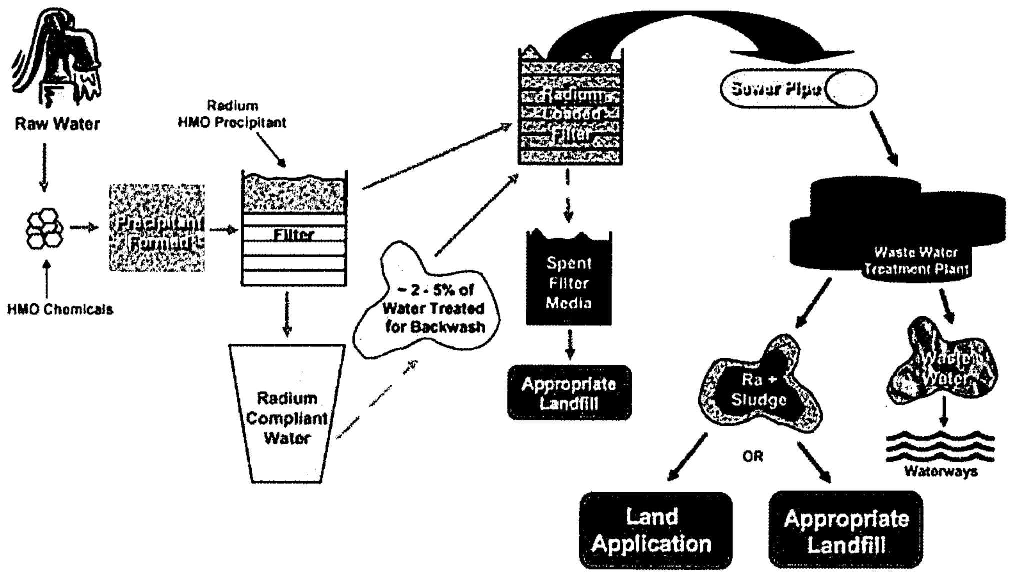

Figure 8

Modified Hydrous Manganese Oxide Radium Removal Process

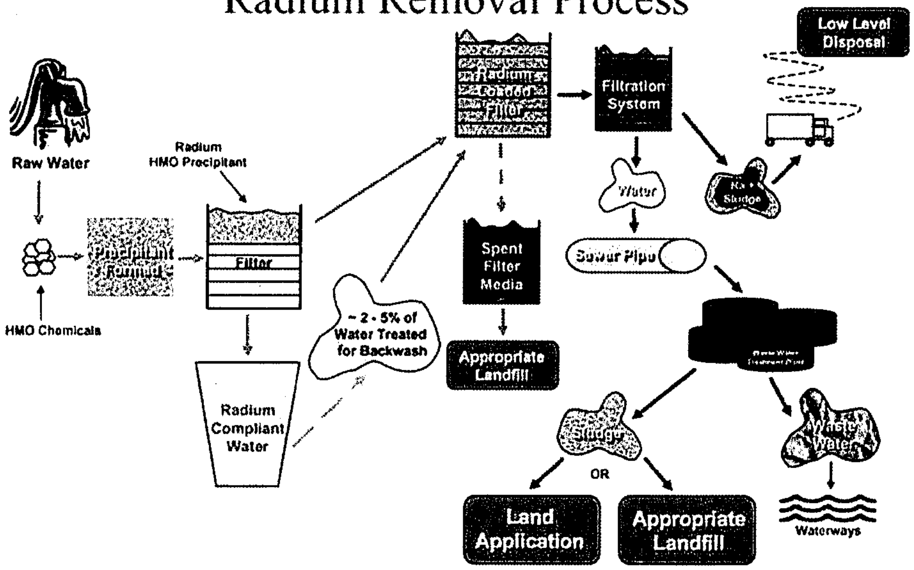

Figure 9

Lime Softening
Radium Removal Process

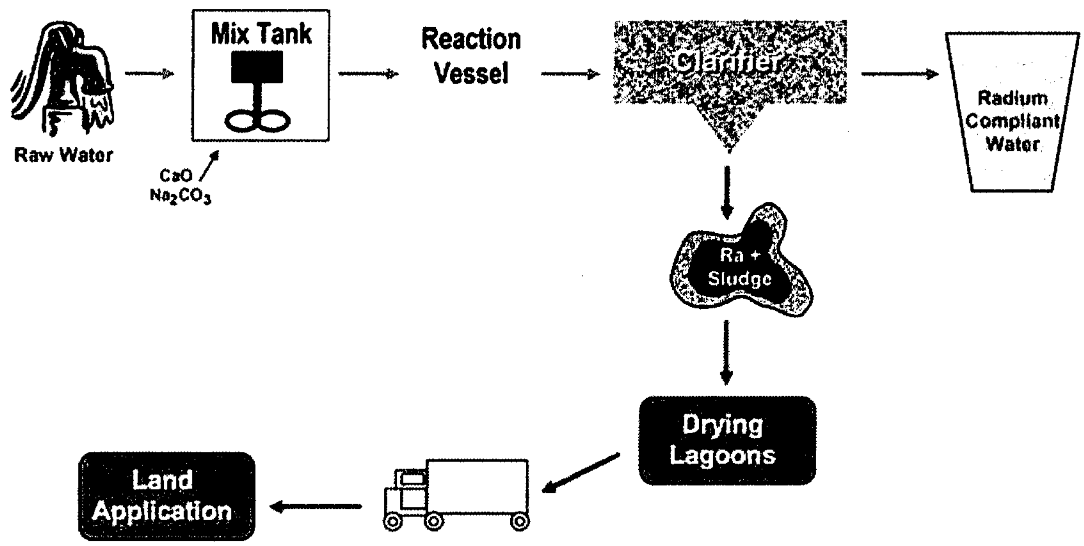

Figure 10

No disposal to sewer required

Absorbent Media
Radium Removal Process

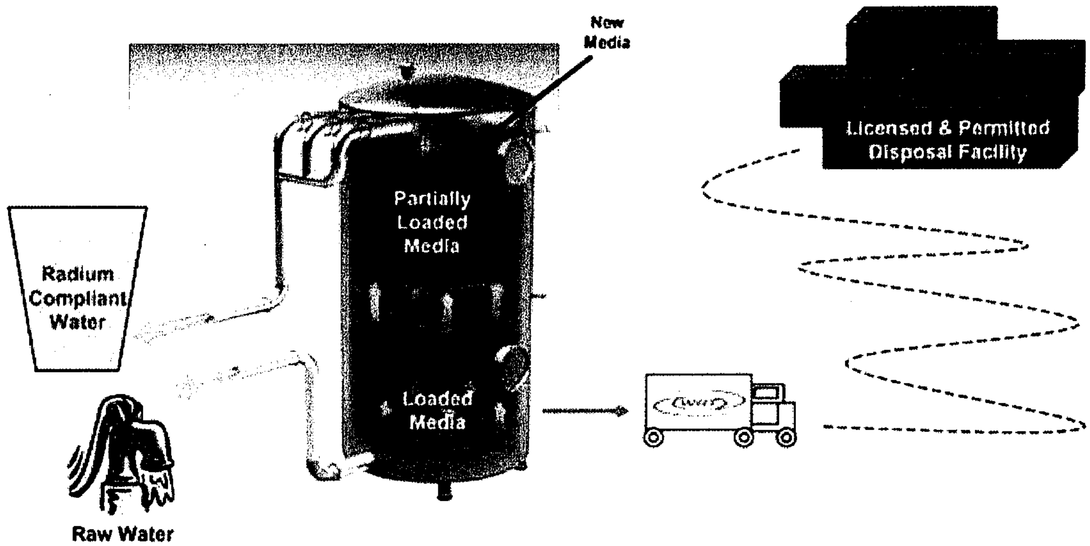

Figure 11

No Modification Needed

Absorptive Media Systems

Two companies, Layne Christianson and WRT, have developed processes that remove the radium from the drinking water without creating a residual to be disposed of down the sewer. Both of these systems use an absorptive media to remove the radium from the drinking water and the loaded media is disposed of in a LLRWDS.

In the case of the WRT technology, WRT provides a complete system consisting of the equipment, media service and disposal to a LLRWDS. Generally, water treatment plant operators have no experience or training in handling radioactive materials. WRT also provides radiation training to our personnel and to the water treatment plant personnel to insure worker awareness of proper procedures. WRT personnel conduct all maintenance and handle all fresh and loaded media. This enables the water treatment plant workers to do their normal jobs without fear of radiation exposure.

Cost of Radium Removal

The cost of the radium removal systems that do not dispose of radium to the sewer or streams is competitive or lower than systems that do. The Mayor of Oswego has stated that selecting WRT saved $2 million over the life of the contract. The mayor of Elburn stated that, by selecting the WRT system, Elburn saved $2.6 million over the life of their contract. (Copies of relevant press articles are attached as Exhibit 3.)

In addition, if the uncontrolled discharge of radium is allowed, when the radioactive contamination is recognized and/or new regulations are enacted or legal suits brought to stop the discharge of radium, the POTWs will have to change their disposal practices. Since it is very difficult, if not impossible, to remove the radium once it is in the POTW system, the POTW would have to:

1. Find an alternate disposal method for its sludge – at great expense.
2. Impose a pre-treatment standard on the water treatment plants that will require retrofitting of the treatment plants – a costly proposition.
3. All parties will have to deal with the resulting litigation as to responsibilities.

III. CONCLUSIONS

- The suggested rule change by the IEPA is ill-advised and could create many more problems than it solves.

- Most significantly, the existing general water quality standard is the one codified rule that effectively prohibits the reintroduction of radium from drinking water to the land and waterways of Illinois.

- Under the existing rule, Illinois is among the national leaders in protecting its streams, rivers and lakes by preventing radioactive carcinogens from being discharged into the waterways. The proposed rule change would turn that upside down.

- The processes that discharge radium into the sewer, as currently allowed, are not environmentally sound, best practices. After going through the sanitary treatment process, the resulting sludge contains concentrated amounts of radium that is then spread on Illinois farmland and open lands, many in the fast-growing collar county areas of Northern Illinois.

- An unintended consequence of sewer disposal is that in the absence of testing, monitoring, and notice, sewer workers are not made aware of their exposure to radiation or trained or equipped to handle it.

- Not only are the absorptive media technologies, such as that of WRT, approved by the agency to provide a total removal in a cost-effective manner, but all of the competing technologies can be re-engineered to provide a similar total solution.

- This total removal approach does not require a new bureaucracy to enforce the regulations governing the discharge of radium particulates into the sewer, the spreading of radioactive sludge on the farmland or the discharge of radioactive carcinogens into the streams and waterways. It does not require the discarding of longstanding state and federal environmental regulations.

- With all due respect to the Board, the result of this proposed rule change will be to allow the unmonitored and unrestricted discharge of large quantities of carcinogenic radioactive material to Illinois streams and the environment.

- We urge the Board to act in the interest of human health and the environment and to protect the long-term interests of the people of the State of Illinois and reject the Agency's proposal.

CERTIFICATE OF SERVICE

The undersigned, an attorney, certify that I have served upon the individuals named on the attached Notice of Filing true and correct copies of the **Testimony Of Charles Williams On Behalf Of Water Remediation Technology, LLC** and First Class Mail, postage prepaid on August 11, 2004.

SERVICE LIST

R04-21

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Exhibit 1

MANAGEMENT OF WATER TREATMENT PLANT SLUDGE

CONTAINING

ELEVATED LEVELS OF RADIUM

Illinois Department of Nuclear Safety

December 1, 1984

MANAGEMENT OF WATER TREATMENT PLANT SLUDGE CONTAINING ELEVATED LEVELS OF RADIUM

I. Introduction

With the promulgation of regulations by the U.S. Environmental Protection Agency (USEPA) requiring the removal of radium from drinking water, a new problem has been created. The resultant sludge from such water treatment plants contains elevated levels of radium.

There are currently no standards or guidelines for the management of such sludges.

The Illinois Department of Nuclear Safety (IDNS) has developed the following plan for the management of sludge containing radium from water treatment plants.

Since water treatment plants and resultant sludges are routinely regulated by the Illinois Environmental Protection Agency (IEPA), IDNS worked with IEPA in developing a Memorandum of Agreement (Attachment A) pertaining to the disposal of sludge containing radium.

II. Objectives

The Memorandum of Agreement (MOA) has five (5) primary technical objectives which serve as the basis for the criteria contained in the MOA. These technical objectives are as follows:

1. Limit the misuse (inadvertent intrusion) of buried sludge for an extended period of time.
2. Limit radon emissions from the surface of buried sludge.
3. Limit external radiation exposure from the buried sludge.
4. Limit the degradation of ground water quality resulting from buried sludge.
5. Limit undue internal radiation exposure resulting from sludge used for agricultural purposes.

III. Discussion of Criteria

The Memorandum of Agreement outlines four (4) criteria for the management of sludge containing radium. If the sludge meets the conditions of Criteria 1 through 3, the sludge use/disposal will be under the purview of the IEPA in accordance with the Memorandum of Agreement. If Criteria 1 through 3 cannot be met, Criterion 4 states that the disposal of such sludge will be evaluated by IDNS on a case-by-case basis.

Criterion 1

If the level of radium in the sludge is 5 picocuries per gram or less (dry weight), the sludge may be disposed of in a landfill permitted by IEPA to accept such sludge. (Item 4a of Attachment A.)

The USEPA "Standards for Remedial Actions at Inactive Uranium Processing Sites", 40 CFR 192.12, states that the concentration of Radium 226 shall not exceed 5 picocuries/gram (pCi/gm) averaged over the first 15 centimeters (cm) of soil below the surface and shall not exceed 15 pCi/gm averaged over 15 cm thick layers of soil more than 15 cm below the surface. These criteria apply to cleanup of land (away from the tailings piles) where homes could be built.

The Conference of Radiation Control Program Directors, Committee on Natural Radioactivity Problems, Report No. 2, August 1981, states that removal or controls for soil containing up to 3 pCi/gm of Radium 226 would not be mandatory. If the concentration of Radium 226 exceeds 6 pCi/gm, removal or other controls would then be mandatory.

The USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (EPA 520/1-83-008-1, September 1983), indicates that houses built on land with a concentration of 5 pCi/gm radium would be expected to have indoor radon decay product levels of approximately 0.02 Working Level (WL)[1]. ("Working Level" (WL) means any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 1.3 x 10^5 MeV.) The estimated residual risk of lung cancer due to a lifetime exposure to this level is approximately 2 in 100.[2]

The gamma radiation levels (from the sludge) to individuals living above such a concentration of radium would be approximately 80 millirem/year (mrem/yr).[3]

The sludge will be placed in an IEPA permitted sanitary landfill which is designed to have an approximately 5-10 foot thick clay liner to protect against groundwater movement (permeability $<1 \times 10^{-7}$ cm/sec). In addition, the landfill will have a final cover of at least two feet of soil.

The design of such a landfill results in protective measures in excess of those required by the USEPA for cleanup of land containing uranium mill tailings. For example, placing a 24 inch cover of regular soil over the sludge will reduce the radon emanation by approximately 57% (to 0.0086 WL)[4] or approximately 2.2 picocurie/meter^2-second (pCi/m^2-sec), while the external gamma radiation levels would be reduced to less than 3% of original [5], excluding natural background.

Should the final cover be removed in later years, the radium concentration levels would still not exceed 5 pCi/gm.

(NOTE: Calculated values, as presented in this document, may differ from actual values due to varying environmental factors.)

Criterion 2

If the level of radium in the sludge is greater than 5 picocuries per gram (dry weight) but less than 50 picocuries per gram (dry weight), the sludge may be disposed of in an IEPA permitted landfill provided that there is at least ten feet of non-contaminated overburden between the sludge and grade level in order to provide: (1) reasonable assurance that the exhalation rate of radon to the atmosphere, or into a dwelling, will not exceed an average rate of 5 picocuries per square meter per second; and (2) reasonable assurance against accidental intrusion into the sludge in the future. (Item 5a of Attachment A.)

Due to the fact that sludge containing up to 50 pCi/gm of radium may be buried in a "non-radioactive waste" landfill, and one cannot be assured of control of the site for an extended period of time, it is essential that the landfill be designed such that unintentional intrusion into such sludge wastes would be limited. Human activities usually involve excavation to depths of 6 to 8 feet (e.g., utility lines, basements, graves, etc.). Therefore, to prevent casual intrusions into the sludge wastes, as well as to prevent erosion, a final cover of ten feet (below grade level) is stipulated. This is consistent with the USEPA guidance.[6 7] Such a cover is expected to provide excellent stablization with the chance of misuse of the sludge wastes unlikely and erosion avoided for thousands of years.[8]

Using the relationship that soil containing radium with a concentration of 1 pCi/gm has a radon emanation rate of 1 pCi/m^2-sec,[9] a radon emanation rate of 50 pCi/m^2-sec would be expected from the surface of sludge containing radium at a concentration of 50 pCi/gm. Three meters of regular soil cover would reduce the radon emanation rate to approximately 1 pCi/m^2-sec. Such an exhalation rate would be equivalent to average natural background levels as the average concentration of radium in soil is approximately 1 pCi/gm.[10]

This resultant emanation rate is less than that stated in Criterion 1 (5 pCi/m^2-sec). This would allow for accidental removal of a portion of the cover (a little over a meter) before the 5 pCi/m^2-sec level would be exceeded. In the event that an excavation for a basement was made, a significant portion of the "cover" would be removed, resulting in radon emanation rates exceeding 5 pCi/m^2-sec. However, if the cover was designed such that the sludge was capped first with a layer of clay approximately 1.3 feet thick, with the remainder of the cover being regular soil, one could excavate (approximately 8.5 feet) for a basement to within 1.3 feet of the buried sludge without exceeding a resultant radon emanation rate of 5 pCi/m^2-sec. [11]

The external gamma radiation levels would be reduced to less than 0.1% of the initial radiation levels with only 1 meter of soil cover [12] (800 mR/yr x 0.001 = 0.8 mR/yr).

It should be noted that the sludge will again be placed in an IEPA permitted landfill with a clay liner to protect against groundwater movement.

In summary, the objectives of this criterion are to guard against accidental intrusion, limit radon emanation, limit external radiation levels, and protect the groundwater.

Criterion 3

> Sludge with radium levels less than 50 pCi/gm (dry weight) may be used for soil conditioning purposes on agricultural cropland (corn, soybeans) but only if: (1) such use is in accordance with IEPA procedures; and (2) the level of the radium in the sludge is such that after the sludge is mixed with soil (for agricultural use) the incremental increase of the radium concentration in the soil does not exceed 0.1 picocurie per gram (dry weight). The concentration of the radium in the sludge (dry weight) shall be determined by laboratory analysis. The incremental increase of the radium concentration in the soil may be determined by calculations using the previously determined concentration of radium in the sludge and the estimated amount of mixture with soil during application. (Item 4b and 5b of Attachment A.)

The intent of this criterion is to allow sludge to be used for agricultural (soil conditioning) purposes.

The normal concentration of radium in soil is approximately 1-2 pCi/gm. The mean daily intake of radium per day (from foodstuffs) in the United States is approximately 1.4 pCi/day, with an average intake in the Chicago, Illinois, area of approximately 2.1 pCi/day. [13] (Water contributes an additional daily uptake of radium.)

The Illinois Regulations for Radiation Protection, Part C, Schedule A, states an exempt concentration of 1 x 10^{-7} microcurie/milliliter (uCi/ml). Using a conversion of 1 ml/gm, an exempt concentration of 0.1 pCi/gm is derived.

The National Council on Radiation Protection and Measurements, Report No. 77, indicates that agricultural land used to produce crops not directly consumed by humans should not exceed a concentration of 40 pCi/gm of Radium 226 in the soil.

This value is based on a dose limit of 500 mrem/yr to bone (resulting from an average dietary intake of 60 pCi/day of radium) and a plant/soil concentration ratio of 1×10^{-3}. [14]

Using the uptake coefficient of 1 pCi/Kg radium in fresh vegetables per 1 pCi/gm radium in the soil, with an average intake of fresh vegetables of 1.5 Kg/day, one would receive an additional 0.15 pCi of radium per day, or 1.25 mrem/yr, by adding 0.1 pCi/gm radium to the soil. [15]

Agricul. uptake

A U.S. Department of Energy pathway analysis report indicates a source-to-dose conversion factor of 21 (mrem/yr)/(pCi/gm) for Radium 226 in soil. [16] Argonne National Laboratory, utilizing the new dosimetry models described in the International Commission on Radiological Protection publications Numbers 26 and 30, has recalculated this conversion factor to be 28 (mrem/yr)/(pCi/gm) of Radium 226 in soil. As such, an additional 0.1 pCi/gm of radium in soil would result in approximately 3 mR/yr additional dose to an individual based on a worst case scenario. [17]

IEPA has indicated that all sludge application to farmland is regulated by their agency. Sludge applications to land usually would not be more frequent than once every three years. As such, it would take a number of years for the accumulated concentration of radium to increase significantly, and it is unlikely that sludge would be applied to the same fields for an extended period of time. *

Criterion 4

> If the level of radium in the sludge exceeds 50 picocuries per gram (dry weight): (1) the method of disposal of such wastes must be reviewed and a determination must be made in advance by IDNS that there is reasonable assurance that the exhalation rate of radon to the atmosphere or into a dwelling will not exceed an average rate of 5 picocuries per square meter per second and there is reasonable assurance against accidental intrusion into the sludge in the future. (2) the sludge may be used for soil conditioning, subject to the restrictions provided in Criterion 3 and only if an affirmative determination is made in advance by IDNS. (Items 6a and b - Attachment A.)

If the levels of radium in sludge to be buried or applied on land for agricultural use exceed those values stated in Criteria 2 or 3, IDNS believes it is necessary to evaluate the final use/disposal of such sludge on a case-by-case basis.

IV. Summary

The above criteria should provide a mechanism for the practical management of sludge containing radium, while at the same time providing assurance that the five technical objectives of IDNS are fulfilled.

REFERENCES

1. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing"(40CFR192), EPA 520/1-83-008-1, September 1983, Page 9-15.

2. USEPA "Final Environment Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 9-16.

3. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 9-15.

4. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 8-13.

5. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192) EPA 520/1-83-008-1, September 1983, Page 8-12.

6. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 10-10.

7. USEPA "Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites" (40CFR192), EPA 520/4-82-013-1, October 1982, Page 91.

8. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 10-3.

9. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40 CFR192), EPA 520/1-83-008-1, September 1983, Page 3-5.

10. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 3-5.

11. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 8-10.

12. USEPA "Final Environmental Impact Statement for the Control of Byproduct Materials from Uranium Ore Processing" (40CFR192), EPA 520/1-83-008-1, September 1983, Page 8-12.

13. National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States", Report No. 45, November 1975, Page 92.

14. National Council on Radiation Protection and Measurements, "Exposure from the Uranium Series with Emphasis on Radon and its Daughters", Report No. 77, March 1984, Pages 60, 90, 103, 104.

15. National Council on Radiation Protection and Measurements, "Exposure from the Uranium Series with Emphasis on Radon and its Daughters", Report No. 77, March 1984, Pages 61, 104.

16. USDOE, "Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Used MED/AEC Sites", ORO-832(Rev), March 1983, Pages 5-13.

17. Argonne National Laboratory, Letter signed by Thomas L. Gilbert, Senior Physicist, dated 7/24/84.

ATTACHMENT A

MEMORANDUM OF AGREEMENT

This Memorandum of Agreement is entered into by and between the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Nuclear Safety (IDNS). This Memorandum of Agreement is entered into for the purpose of delineating certain responsibilities of IEPA and IDNS regarding the disposal of sludge resulting from treatment of water or sewage and containing radium occurring naturally from ground waters.

WHEREAS, many public water supplies in the State of Illinois draw their raw water from deep wells which contain naturally occurring radium, and

WHEREAS, such radium is removed from the raw water during treatment thereby concentrating it in sludge, and

WHEREAS, IEPA has authority to regulate the management and disposal of said sludge under the Environmental Protection Act, Ill. Rev. Stat., 1983, ch. 111 1/2, pars. 1001 et. seq., and Regulations adopted thereunder, and

WHEREAS, IDNS has authority to require registration of certain installations storing radioactive material under the provisions of Ill. Rev. Stat., 1983, ch. 111 1/2, pars. 194 et seq., and

WHEREAS, IDNS has authority to require the licensure of certain sources of radiation and has authority to promulgate regulations to govern the possession and use of any radiation source under the Radiation Protection Act, Ill. Rev. Stat., 1983, ch. 111 1/2, pars. 211 et seq..

THEREFORE, it is agreed by and between IEPA and IDNS as follows:

1) Pursuant to Ill. Rev. Stat., 1983, ch. 111 1/2, par. 194 et seq. which provides that every operator of a radiation installation must register with IDNS, the following individuals or entities must register directly with IDNS and must comply with the requirements of that statute and implementing regulations:

   a) Owners and operators of facilities or plants which produce sludge resulting from the treatment of water or sewage and containing radium occurring naturally from ground water; and

   b) Owners and operators of IEPA permitted landfills if the sludge is disposed of in such landfills; and

c) Any other person or entity that IDNS determines is required to register under the provisions of Ill. Rev. Stat., 1983, ch. 111 1/2, pars. 194 et seq.

2) Sludge resulting from the treatment of water and sewage and containing radium occurring naturally from ground water will be exempt from the licensure and fee requirements of the Radiation Protection Act (Ill. Rev. Stat., 1983, ch. 111 1/2, pars. 211 et seq.) based on IDNS' finding that such exemption will not constitute a significant risk to the health and safety of the public.

3) Sludge resulting from the treatment of water and sewage and containing naturally occurring radium from ground water may be disposed of in accordance with the provisions of this Memorandum of Agreement and the requirements of IEPA and the Rules and Regulations of the Illinois Pollution Control Board, as implemented by IEPA. Any permit issued by the IEPA pursuant to this Agreement shall contain conditions based on the technical criteria contained herein and in any regulations which IEPA and DNS agree to adopt pursuant to this Agreement.

4) If the level of radium in the sludge is 5 picocuries per gram or less (dry weight):

a) the sludge may be disposed of in a landfill permitted by IEPA to accept such sludge;

b) the sludge may be used for soil conditioning purposes on agricultural crop land (e.g., corn, soy beans) but only if:

(1) such use is in accordance with IEPA procedures; and

(2) the level of radium in the sludge is such that after the sludge is mixed with soil (for agricultural use) the incremental increase of the radium concentration in the soil does not exceed 0.1 picocurie per gram (dry weight). The concentration of the radium in the sludge (dry weight) shall be determined by laboratory analysis. The incremental increase of the radium concentration in the soil may be determined by calculations using the previously determined concentration of radium in the sludge and the estimated amount of mixture with soil during application.

procedures set forth in Paragraph 8) that there is reasonable assurance that the exhalation rate of radon to the atmosphere or into a dwelling will not exceed an average rate of 5 picocuries per square meter per second and reasonable assurance against accidential intrusion into the sludge 'n the future.

8) a) In those cases where a prior determination is needed from IDNS, IEPA will provide IDNS with a copy of the pertinent permit application. IDNS will provide comments to IEPA regarding these permit applications, including its written determination as to whether there is reasonable assurance that the exhalation rate of radon to the atmosphere or into a dwelling will not exceed an average rate of 5 picocuries per square meter per second and reasonable assurance against accidential intrusion into the sludge in the future.

b) In emergencies IEPA and IDNS may meet to discuss the situation and determine acceptable alternatives for temporary resolution of the emergency. IDNS must approve the alternative chosen for temporary resolution. Approval or denial of the method of final disposal of the sludge will be in accordance with procedures described in subparagraph 8(a).

9) All analysis of sludge shall be conducted by a laboratory certified by the United States Environmental Protection Agency to perform radiological analysis, and concentrations of radium will be determined by a method approved by IDNS.

10) Copies of all permits issued by IEPA relating to disposal of sludge containing radium occurring naturally from ground water will be forwarded to IDNS.

11) IDNS agrees to provide IEPA with technical support in any proceeding in which the technical criteria contained in this Memorandum are at issue.

Dated: September 21, 1984

Director
Illinois Environmental
Protection Agency

Dated: September 13, 1984

Director
Illinois Department of Nuclear Safety

Exhibit 2

Illinois
Summary of Radium Removal Methods and Disposal Issues as they Relate to Radium Removal from Drinking Water

May, 2004

WATER REMEDIATION TECHNOLOGY, LLC

Summary of Radium Removal Methods and Disposal Issues as they Relate to Radium Removal from Drinking Water

The U.S. EPA has set a radium maximum contaminate level (MCL) of 5 picocuries (pCi/L) per liter of drinking water. Over 500 communities nationwide do not meet this drinking water standard. The Illinois EPA has the responsibility to insure that the drinking water in Illinois meets all drinking water standards under the Safe Drinking Water Act. The Illinois Emergency Management Agency has the responsibility of insuring safe handling and disposal of all radioactive materials. In Illinois over 100 communities currently do not meet this standard for radium. The EPA and the State are requiring the non-compliant communities to come into compliance. After the deadline for compliance (December 8, 2003), the State can impose fines for non-compliance. Most of the communities have signed compliance consent decrees promising to meet the MCL by a certain date. Currently the communities are conducting pilot plants and engineering studies to bring their community into compliance.

To bring the water systems into compliance the municipalities are investigating five different types of radium-removal systems that can be divided into three categories of waste disposal methods.

1. Systems that dispose of the radioactive water-treatment residues into the sewer system
2. Systems that dispose of the radioactive water-treatment residues directly on the land.
3. Systems that dispose of the radioactive water-treatment residues into landfills/disposal facilities licensed to accept radium-bearing byproducts.

Systems that dispose of the radioactive byproducts into the sewer system

Hydrous Manganese Oxide (HMO)

This process uses the addition of specialty chemicals or manufactured particles to promote the precipitation of radium and iron as insoluble particulates. The precipitated iron, radium, and manganese are then filtered out in a conventional sand filtration system. This sand filter is then backwashed periodically, sending the radioactive filter solids with the backwash water to the sanitary sewer. The system has been used effectively for iron removal for years. Because not all of the precipitant is removed during backwash, the filter media becomes radioactive over a period of time, quite possibly to a concentration that would require disposal to a low level radioactive site. An advantage of this system is that it removes iron as well as radium in the same operation, if both are a concern to a municipality (similar to hardness improvement and radium correction with lime softening).

The principal disadvantage is that the system requires the discharge of radioactive solids down the sewer where they may collect as residue in the collection system. These solids may well be in excess of a radium concentration of 10,000 pCi/g. Because of the high concentration of radium in the solids and the fact that these are discrete particles, disposal down the sewer results in sludge containing discrete particles containing radium in excess of that allowed for disposal at the U.S. Ecology LLRW site in Hanford, Washington and at the Envirocare of Utah site in Utah. Because of the high iron and magnesium content, the density of these particles is greater than typical sludge and segregation/settling of these particles may occur in the sewer system.

Illinois radiation protection regulations, 32 Ill Adm. Code 340.1030 prohibits a licensee from discharging radioactive solids down the sewer. The HMO solids are very high in radioactivity, and these individual particles have the potential for two types of exposure problems – 1) the settling of these radioactive solids in areas of the sewer collection system, resulting in sources of high radiation and exposure; and 2) the periodic backwash and release of a "slug" of highly- radioactive solids may remain as discrete radioactive "hot spots" within the sewage sludge.

This process requires constant chemical feed to maintain the effectiveness of the process. If the chemical feed stops, the radium removal is reduced. The system requires daily operator interaction and frequent expensive radium monitoring to insure compliance. The frequent backwash of the sand- filter waste consumes two to four percent of the water treated. Significant amounts of land will be required for land spreading to meet the maximum increase of 0.1 picocurie per gram on land where sludge will be applied (per IEPA – IDNS MOA, 1984). Local municipal workers are responsible for the maintenance, reagent handling and ultimate disposal.

Additional occupational training and monitoring for radiation exposure of sewer workers in contact with the sludge may be warranted.

Ion Exchange

This process removes radium by exchanging sodium for calcium, magnesium and radium on a resin. When the calcium is no longer effectively removed, the resin is then stripped of the collected elements by exposing the resin to a sodium chloride brine. The resin is then rinsed and reused. The sodium chloride brine bearing the radium, calcium, and magnesium is then discharged to the sewer followed by disposal of the rinse water. When the resin is no longer efficient at removing the radium the resin is replaced. The life of the resin is determined by the water chemistry but can be expected to be between two and seven years. When replaced, the spent resin, even after a final stripping operation, will likely contain radium in a concentration well above the limit for surface land application, requiring it to be disposed of in an appropriate landfill or Low Level Radioactive Waste (LLRW) disposal site. Advantages to the system include softening of the water while removing radium and a relatively low capital cost.

Disadvantages to the system include the addition of sodium and chlorides to both the drinking water and the sewer system. Increase in the corrosivity of the water may lead to the need to bypass and blend with untreated water to avoid dissolution of heavy metals and corrosion of the distribution system. This bypass of untreated water will raise the level of radium in the potable water, and communities with high radium may find that this bypass prohibits the use of the ion-exchange system. The discharge of the rinse water and the eluant brine to the sewer can result in scale formation with significant radium content in the sewer pipeline. Within the sewer plant, it is expected that the majority of the radium will end up concentrated in the sewage sludge. In communities where all or most of the drinking water that reports to a wastewater treatment plant is above the MCL, some level of training and monitoring for radiation exposure of sewer workers in contact with the sludge may be warranted.

Significant amounts of land will be required for land spreading to meet the maximum allowable increase of 0.1 picocurie per gram on land with sludge applied. The anticipated level of radium in the eluant water will be dependent on the frequency of regenerations and the original level of radium in the feed water but can be expected to be between 3,000 PCi/L to 6,000 pCi/L (based on recent analysis of eluant brine at an ion-exchange treatment plant in New Jersey). Dilution with rinse water may reduce this concentration to several hundred pCi/L. On a dry-weight basis, the concentration will be in excess of 100,000 pCi/g. Local municipal workers are responsible for the maintenance, reagent handling, and ultimate disposal. Calculations of radium content in the brine and eluant may be performed using the SPARRC Program [1]

Reverse Osmosis

Reverse osmosis is a very fine filter system where water containing contaminates is pressurized and pushed through a permeable membrane sized to prohibit passage of the undesirable elements. The process produces approximately 80 percent of the feed water as finished water. The 20 percent reject water contains the majority of the contaminants and is then disposed of as a liquid waste to the sanitary sewer. Since the concentration ratio of reject water to feed water is 5:1, the radium concentration in the reject water will be 5 times that of the original feed water, e.g., a feed concentration of 15 pCi/L would result in 75 pCi/L discharged to the wastewater treatment facility. The advantage of this system is that very high quality water is produced.

Disadvantages include high capital and operating costs, perhaps $1.50 to $2.50 per 1,000 gallons produced. The loss of 20 percent of the feed water will be a problem for some communities. Within the sewer plant it is expected that the majority of the radium will end up concentrated in the sludge. Significant amounts of land will be required for land spreading to meet the maximum increase of 0.1 picocurie per gram on land with sludge applied. Local municipal workers are responsible for the maintenance, reagent handling and ultimate disposal. In communities where all or most of the drinking water that reports to a wastewater treatment plant is above the MCL, some level of training and monitoring for radiation exposure of sewer workers in contact with the sewage sludge may be warranted.

Systems that dispose of the radioactive byproducts directly on the land

Lime Softening

The addition of chemicals such as lime and soda ash causes the calcium, magnesium and also radium to precipitate as carbonate compounds, thereby softening the water and removing radium in the same operation. The sludge generated by this process is usually sent to dewatering lagoons and later removed for land application. An advantage to this system is that, if the municipality wants to soften the water, this will occur at the same time the radium is removed, and the treatment residue generated by this process is often used on low-pH soils for soil conditioning.

Disadvantages to this system include high capital and operating costs. Significant amounts of land will be required for land spreading to meet the maximum allowable increase of 0.1 picocurie per gram on land where sludge is applied. Radon exposure levels of lime softening workers may need to be monitored. It is anticipated that the radium activity or concentration of the treatment residue on a dry weight basis would be less than 25 picocuries/g. Local municipal workers would be responsible for the maintenance, reagent handling and ultimate disposal.

Systems that dispose of the radioactive byproducts into landfills licensed to accept radium bearing waste.

Adsorptive media

The radium is collected on a disposable long-lived media that requires changing every one to several years. Because backwashing is not required, there is no water wasted. Chemical addition is not required. The media is exchanged when it no longer removes sufficient radium to meet the MCL. The exchange and transportation is contracted to experienced personnel. In addition, the spent media will be exchanged while the concentration of radium is low enough to permit safe and economic transportation and disposal.

One advantage is the simple operation of the system (no backwashing or chemical additions); only operational monitoring of the equipment is required of the utility operators. This simpler operation results in these workers having little exposure to radiation, estimated at less than 10 mrem/year. The radium-bearing media is disposed of in a licensed disposal site with long term maintenance and monitoring plans.

What are the repercussions of radium being disposed of into the sewer system?

Radium removal systems that discharge into the sewer either discharge the radium as a liquid (Ion Exchange or Reverse Osmosis) or as a solid (Hydrous Manganese Oxide). When discharged as a liquid the biological treatment concentrates the radium into the sewage sludge. The degree of concentration in the solids is not well documented but has been estimated by the New Jersey EPA to be in excess of 90 percent.

The discharge by a licensee of radioactive solids into the sewer system is not allowed by Illinois law but is being pursued by some municipalities. Virtually 100 percent of these solids would end up in the sewer system or the sewage sludge.

Discharge of solids or liquids into a sewer system introduces some potential impacts that need to be investigated. Some of these are:

1. What is the possibility of contaminating the sewer collection system, specifically considering the probability of the scale buildup within the piping and the possible settling out of radioactive solids in areas of low flows? Even Ion Exchange and Reverse Osmosis has the potential for radioactive solids to be precipitated within the collection system as scale when the water is mixed with air (CO_2 forming radium carbonates) and water (forming both radium sulfates and radium carbonates).
2. What is the potential for sewer worker exposure throughout the sewer system? The ISCORS[2] report indicates a reasonable expectation that sludge handlers could be exposed to levels that would require training as radiation workers and monitoring even if the radioactivity of the sludge is at relatively low levels. The exposure to these workers could exceed that of a nuclear power plant worker, at wastewater treatment facilities that accept water with radium concentrations above the MCL. (See ARS Report[3])
3. What is the long term impact of the decay of radium and the release of radon gas on land where houses may be built in the future? Who will bear the cost if radon mitigation is needed?
4. What is the impact of radium on the flora and fauna of the area where the sludge is being spread especially in the case of HMO where discrete highly radioactive particles are being spread?
5. What are the possibilities of the radium being spread on the farmland leaching into the near surface aquifer endangering aquifers that currently have no radium?
6. What precautions are being taken to ensure that runoff from land application is not endangering waterways?
7. Who is going to be responsible for the long term monitoring of sites where radium contaminated sludge is spread? Is there a mechanism so that future land owners will be informed that radium has been spread on the land.
8. How many communities have enough land available for land application at application rates far below what is currently practiced?

What are the potential repercussions of landfill disposal?

While all removal systems remove roughly the same amount of radium in a year, adsorptive media has a longer life between disposals than other methods dictating that more radium is held on site prior to disposal. The concentration of radium, however, on a dry weight basis (picocuries / gram) is less than any other method other than lime softening. Transportation of radioactive materials is completed under established Department of Transportation regulations. Because of the granular nature of the media and the low level of radiation contained within the loaded media, clean up in the event of a spill consists of collecting/vacuuming and repackaging any spilled media. The media, by its very nature, removes radium from water and does not allow it to leach back into the water, making the possibility of water contamination very minimal. Disposal occurs in a licensed landfill appropriate for the level of radium contained. Each of these landfills has long term care plans, maintenance plans and funding in place. Long term contracts for disposal are in place for the Water Remediation Technology System insuring a disposal site until 2040. Removal, transportation, and disposal of the media are performed by workers specifically trained in the handling of radioactive material. Municipal workers are not required to perform any of the servicing or maintenance of the equipment.

Decommissioning of sites

Each of the radium removal processes are intended for long term use but there will come a time when every system must be decommissioned. Each system will require an in-depth evaluation of decommissioning requirements, but some general observations can be made for each system.

Hydrous Manganese Oxide

The filter media will have to be disposed of in an appropriate landfill or disposal site and the equipment will have to be decontaminated. The sewer line will have to be surveyed and appropriate clean up undertaken. Elevated levels of radium in the pipe scale should be expected. Special care should be given to the surveying and decommissioning of the sewer line.

Ion Exchange

The ion exchange media will have to be disposed of in an appropriate disposal site. The vessels and pipelines will have to be surveyed and decommissioned if needed. The sewer line will have to be surveyed and appropriate clean up undertaken. Elevated levels of radium in the pipe scale should be expected.

Reverse Osmosis

The equipment and sewer line will have to be surveyed and decontaminated if necessary.

Lime Softening

The vessels and pipelines will need to be decommissioned. The most problematic area for decommissioning will be to reclaim the drying lagoons, which may be extensive. Depending on the allowed level of radium in soil underlying the lagoons, they may have to be over-excavated and the soil hauled to an appropriate disposal site. This system has the largest footprint of any system.

Adsorptive Media

The filter media will have to be disposed of in an appropriate landfill or disposal site and the equipment will have to be surveyed and decontaminated if necessary. The equipment is stainless steel.

Notes/References:

1. SPARRC Program Version 1 (Software Program to Ascertain Residuals Radionuclide Concentrations July 2003 – website location for downloading the software application Website www.npdespermits.com.sparrc. This is also available directly from WRT.
2. ISCORS Technical Report 2003-03 – *ISCORS Assessment of Radioactivity in Sewage Sludge: Modeling to Assess Radiation Doses*, Nov 2003. This is also available directly from WRT.
3. American Radiation Services, Inc. report – *Total Effective Dose Equivalent (TEDE) Calculations for Radium-Bearing Sewage Sludge Under Various Exposure Scenarios*, Jan 26, 2004. This report describes potential radiation exposure for sewer workers. It is available directly from WRT.

Reference #1

SPARRC - Software Program to Ascertain Residual Radionuclide Concentrations

Download and comments su

HOME | Download SP/

Welcome to the SPARRC Download and Comments Submission Site

What is SPARRC?

Several radionuclides such as radon, radium, alpha emitters, and beta and photon emitters are regulated by the US Environmental Protection Agency under the Safe Drinking Water Act. When water treatment plants remove these contaminants from drinking water sources, the contaminants are transferred from feed water to other media including treatment plant process residuals such as backwash water, brine, and sludge. The presence of radionuclides in treatment plant wastes, depending on the concentration and or load specified in allowable limits, may restrict the use of inexpensive disposal options for those residuals, increasing treatment costs. Residuals may be classified as hazardous under RCRA depending on the concentration of co-contaminants present. The cost of residuals disposal is also a function of the volume and/or mass of the residuals. Therefore, it is important to estimate the quantities as well as the concentrations of radionuclides and co-contaminants in residuals generated by water treatment plants.

SPARRC is a desktop software application that enables users to analyze the potential concentrations of radionuclides in residuals from drinking water process streams.

Distribution of SPARRC

SPARRC Version 1.0 is in the public domain and may be copied and distributed freely. We ask that you:

1. Report any errors or bugs or provide comments.

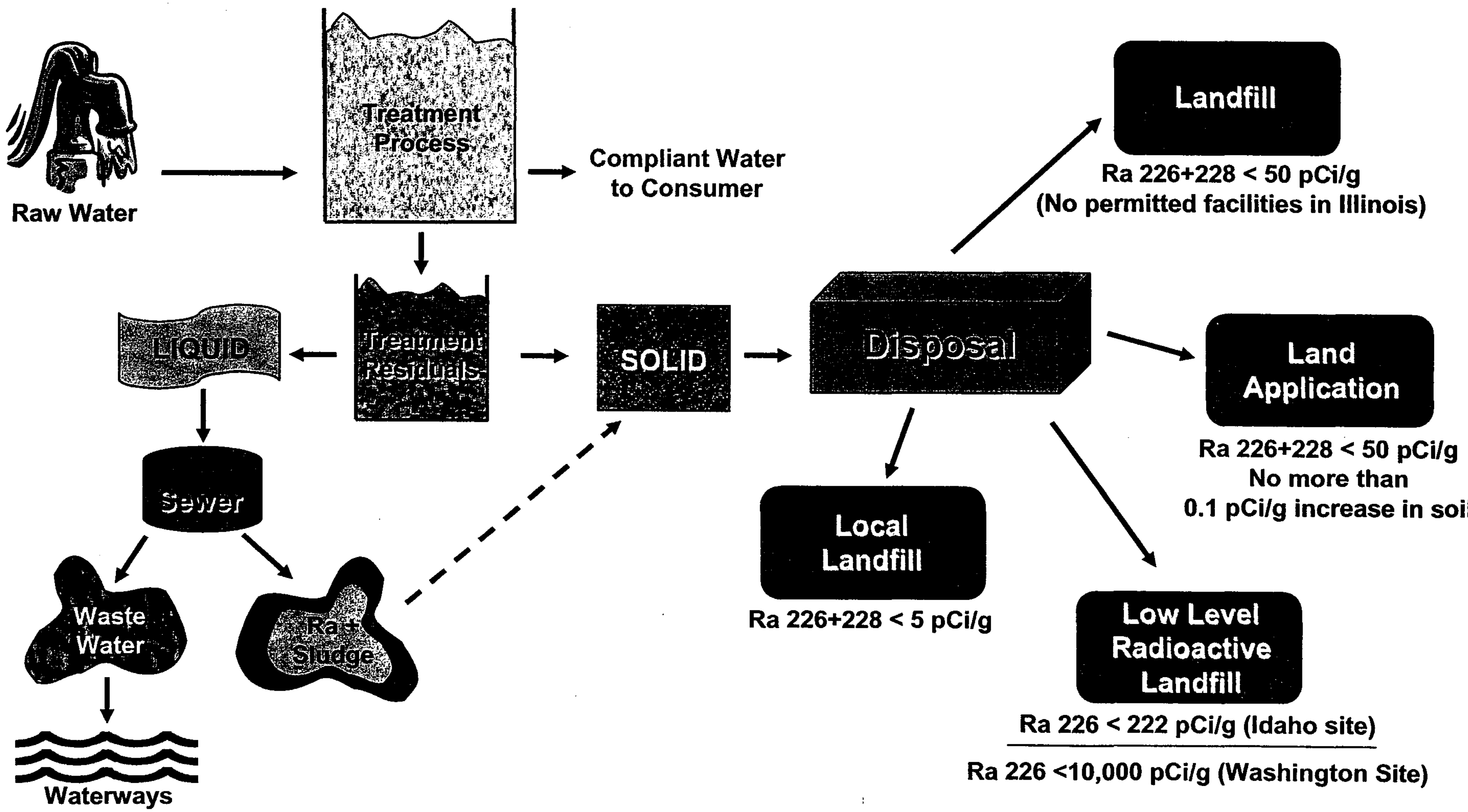
2. When distributing this program, make sure that all documentation files are included.

What would you like to do?

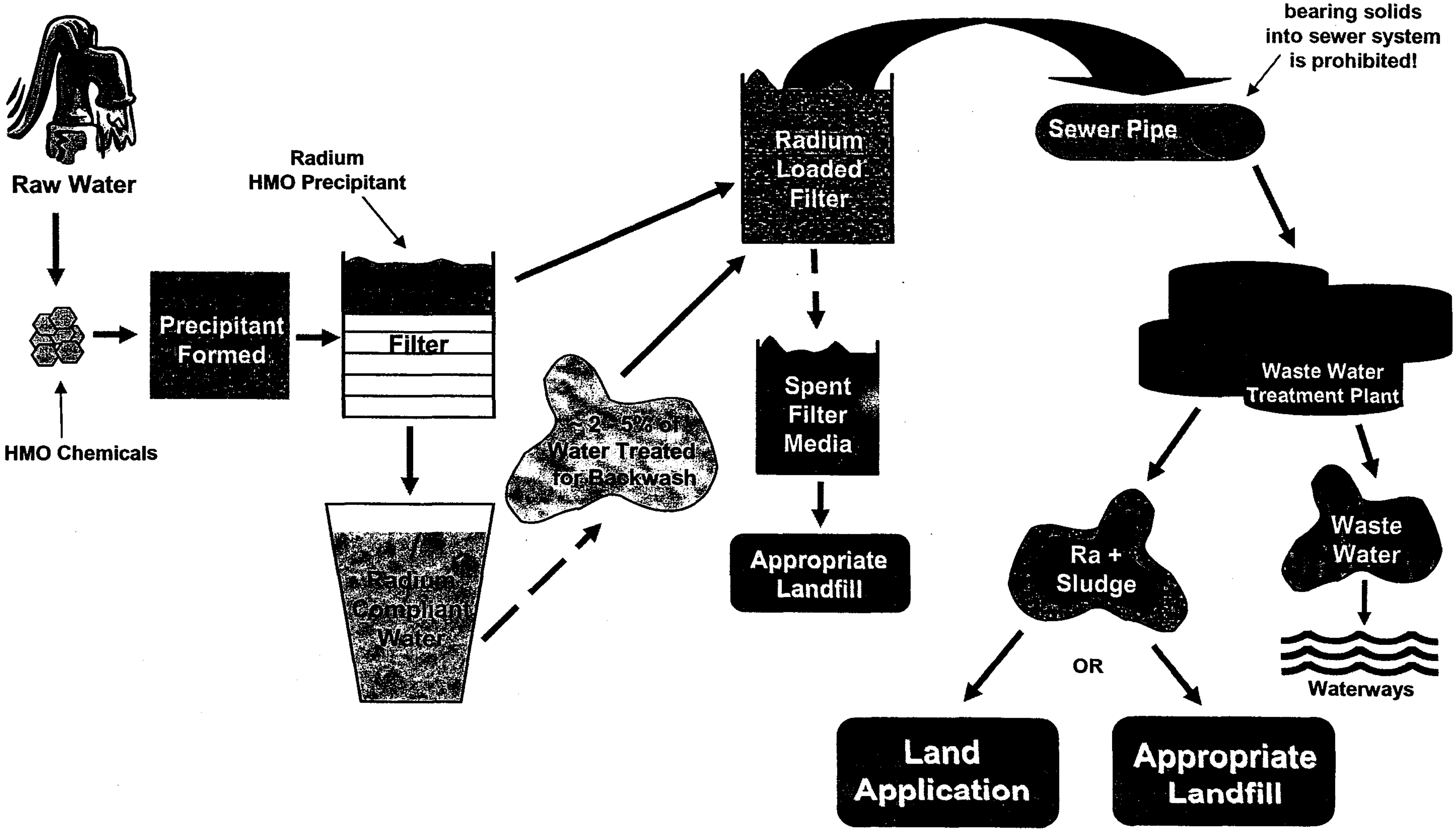
Download and Install SPARRC

Submit comments on SPARRC

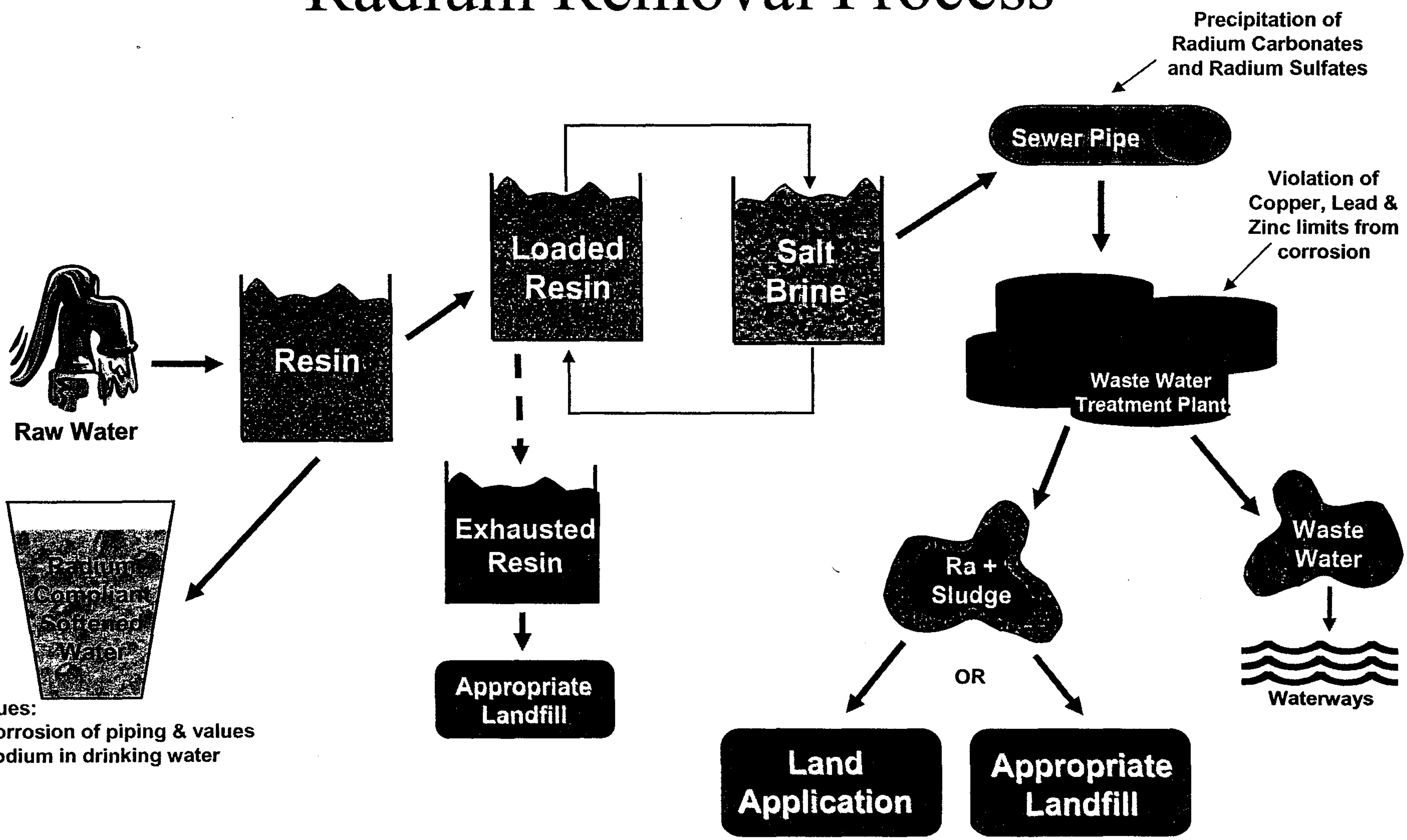
Radium Disposal Options in Illinois



Hydrous Manganese Oxide Radium Removal Process

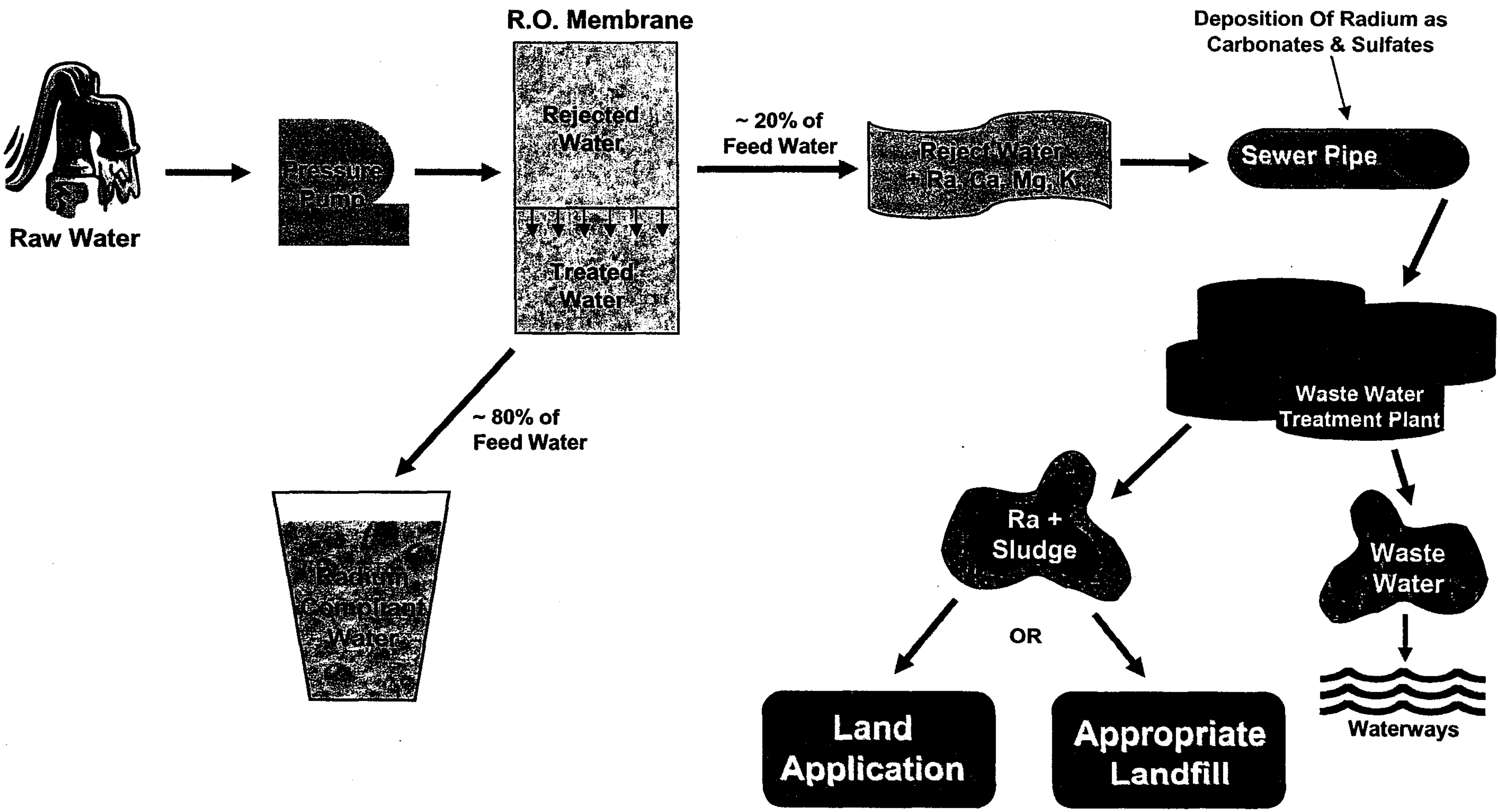


Ion Exchange
Radium Removal Process

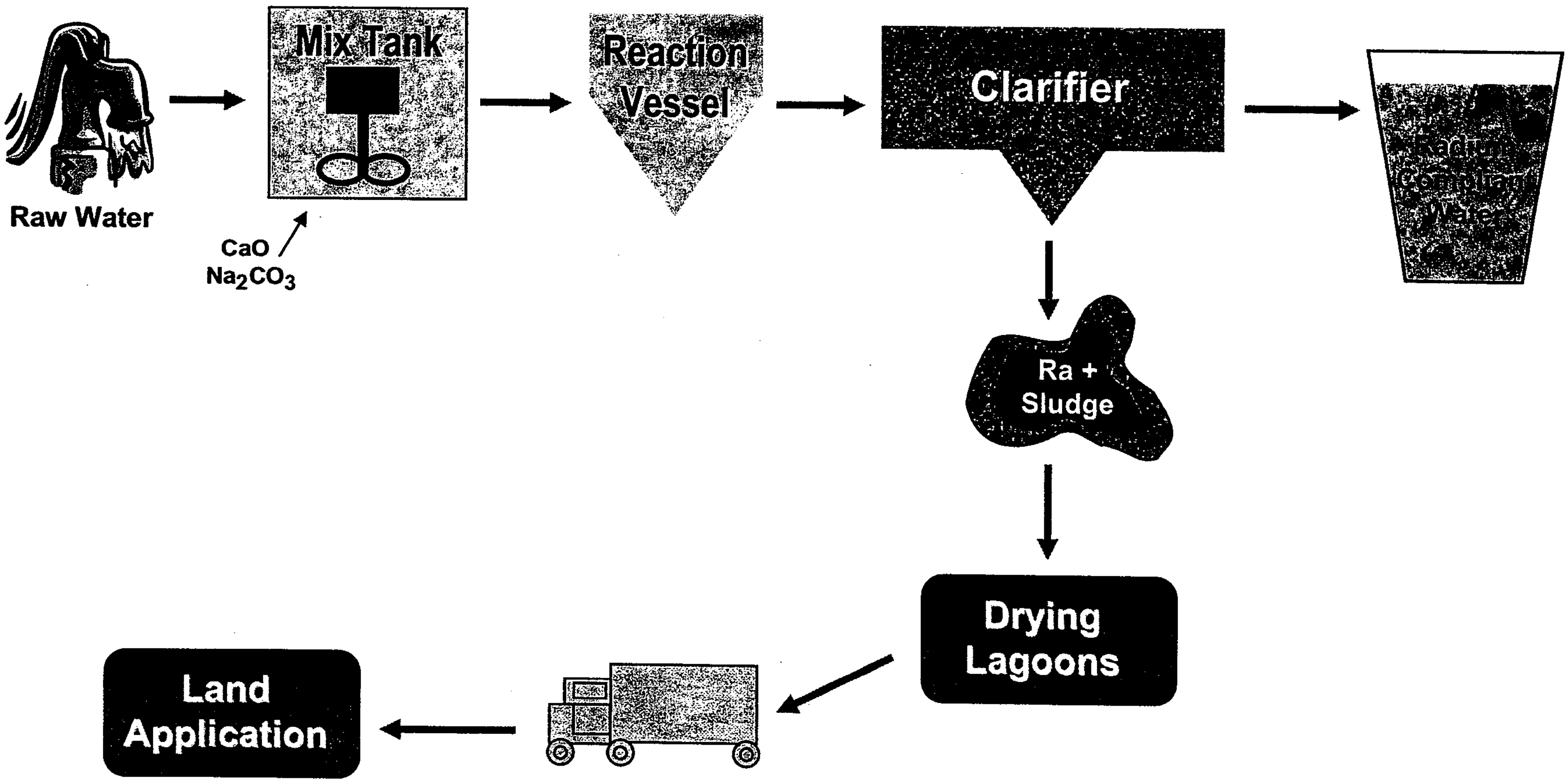


Issues:
Corrosion of piping & values
Sodium in drinking water

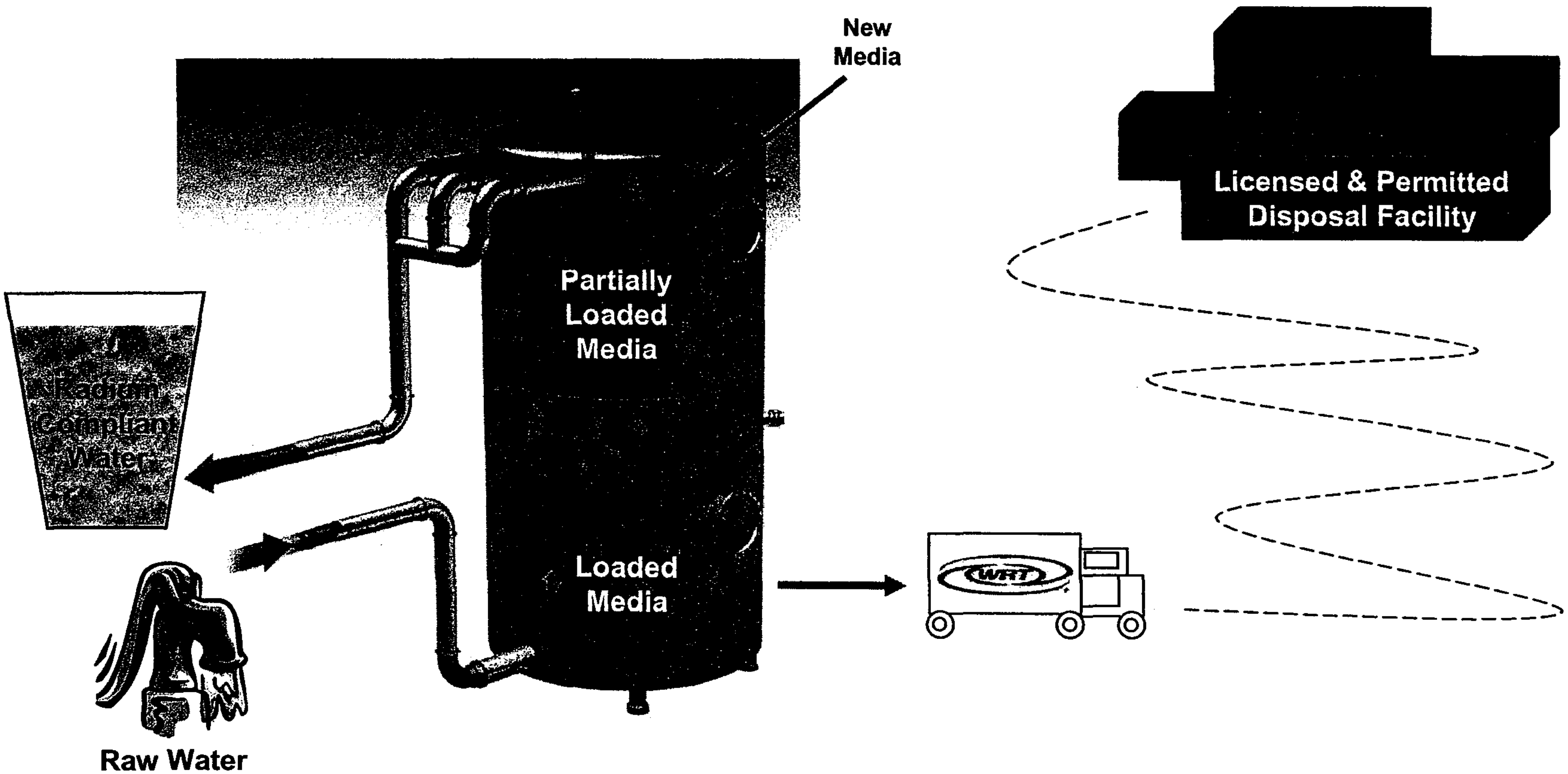
Reverse Osmosis
Radium Removal Process



Lime Softening
Radium Removal Process



Absorbent Media
Radium Removal Process



Summary of Memorandum of Agreement between IEPA and IDNS

1. If sludge is less than 50 pCi/g then land application is permitted.
2. If sludge is land applied it may not increase the radioactivity of the soil by more than 0.1 pCi/g
3. If sludge is > 5pCi/g but<50 pCi/g sludge may go to a IEPA landfill with a minimum of 10 foot of cover being placed over the radium bearing material.
4. If sludge is above 50 pCi/g then IDNS must approve disposal method and site.

Sewer Sludge Application Parameters

Coding:
required input numbers:
numbers that are calculated but should be input if available:
comments:

Drinking water parameters		
Level of total radium in water	15	pCi/L
gallons per day pumped	500,000	Typical well pumped at 1000 gpm 35% of the time
gallons per year pumped	182,500,000	gallons/ year
Picocuries radium in water per year	10,402,500,000	pCi/ Year
Sludge recovery parameters		
Dilution factor	1.6	Adjustment for infiltration
Gallons of water / day treated in waste water facility	[redacted]	This number is higher than pumped to allow for infiltration
Radium in sewer influent	[redacted]	Reflects dilution of radium in raw water from infiltration
gallons of water / year	292,000,000	
grams of sludge/ gallon of effluent	0.40	(Low of .23 High is .8)
Tons of sludge produced per year dry weight	[redacted]	From sewage treatment plant reports
Grams sludge produced / year	116,800,000	grams
Picocuries radium in sewage influent / year	10,402,500,000	
% radium reporting to sludge	[redacted]	
% radium remaining in water	5%	
Anticipated radium content in sludge (Picocurie/ gram)	84.6	Per MOU limit is 50 pCi/g
Anticipated radium content of water effluent	0.47	Picocuries / liter
Land Application Parameters		
Allowed radium increase in soil (picocuries/ gram)	0.1	Per MOU
grams of soil needed for mixture	98,823,750,000	grams of soil
Pounds dry weight per cubic foot of soil	[redacted]	(based on Catepillar Performance Handbook 1977)
grams of soil / cubic ftsoil	26,899.50	g/ cubic ft.
cubic ft of soil needed / year	3,673,814	cubic ft.
Acres / year if mixed in top 6 inches	168.7	acres needed / year
Application rate (tons/ acre)	0.76	tons / acre

Exhibit 3

The Beacon News

October 22, 2003

Oswego will pay $2.8 million to remove radium from water

By Ed Fanselow
STAFF WRITER

OSWEGO – The process of removing radium from the village's water supply should begin this winter, after contract negotiations were completed this week with the company that will do the work.

Village Board members this week approved a $2.8 million contract with Colorado-based Water Remediation Technology Inc. to rid the water of radium, a naturally occurring yet potentially harmful element.

In 2000, the Illinois Environmental Protection Agency found that Oswego was one of 130 Illinois communities with higher-than-normal levels of radium in their water, and mandated that they either correct the problem or have a plan in place to do so by this December.

"It's the most environmentally sound and most cost-effective way to do what we need to do."
–Village Administrator Carrie Hansen

Village officials originally estimated that it would cost more than $5 million to complete the task through filtering or softening, but later discovered that a process called ion exchange would do the job more efficiently and for almost half the price.

"It's the most environmentally sound and most cost-effective way to do what we need to do," Village Administrator Carrie Hansen said.

On average, the village's five water wells contain about 6.5 units of radium per liter, 1.5 units higher than the EPA allows. Once the removal process begins, however, levels should be almost undetectable, officials say.

Studies have shown that water with high levels of radium can cause bone cancer if consumed in mass quantities and over a long period of time.

Oswego board members agreed to give the job to WRT last May, but recurring disputes over the wording of the contract stalled the process until this week.

"... WRT's $2.8 million price tag ... was far lower than any other offer the village received."

– Mayor Craig Weber

But Mayor Craig Weber said the wait was well worth it.

He said WRT's $2.8 million price tag – about a third of which will be paid with federal grant money – was far lower than any other offer the village received.

Still, trustees are considering a "slight" increase to the village water rates to help defray the cost, Weber said.

"This was something that we simply needed to do," he said. "It's going to provide us with safe drinking water and (contracting with WRT) is going to save us more than $2 million in the process. I think we're all pleased with this agreement and ready to get the process started."

Other local communities, including Elburn and Sycamore, also have used the WRT technology with good results, officials from those communities said.

In January, officials in Yorkville approved a $10 million contract with another company to remove radium using a method called "cat ion exchange."

Batavia and Geneva are among other Fox Valley cities where radium-removal procedures are also under way.

THE ELBURN HERALD

Independently Serving the Kaneland Community – Since 1908

June 17, 2004

Elburn considers first water rate increase in 18 years

New rate will help pay for radium removal project, other infrastructure costs

By Jennifer DuMont

While Elburn residents may pay 34.5 percent more for water, village officials pointed out Monday that the residents' glasses are still half full.

Elburn's water rates have not changed since 1986, village officials explained. During the past 18 years, the current rate of $2 per 100 cubic feet of water meant that Elburn residents bought 3.74 gallons of water for one penny.

"WRT's zeolite technology is saving Elburn millions of dollars."

– Village President Jim Willey

"Compare that to a gallon of distilled water at the store versus out of the tap," said Village President Jim Willey. "If our rates had been adjusted five-percent over the last 18 years, our current rate would be $4.81 per 100 cubic feet. If our rates were adjusted 2.5 percent, our rate would be $3.12 per 100 cubic feet versus the $2 we currently pay."

While the current cost is the half-full portion of the glass, the half empty part is the additional funding needed to pay for a village radium removal system. The mandated project to remove radium from the village's water supply will cost $2.2 million. More good news can be found when considering this cost of $2.2 million to use Water Remediation Technology's (WRT) radium removal process is drastically reduced from the $14 million it would cost to use the lime softening method of radium removal, or the $5 million it would cost to use the ion-exchange method, which was the original choice Elburn was prepared to make.

"I give us a lot of credit for being nimble enough to say we've got to look at this new technology (of WRT's) that removes radium and carts it off to an approved trace radium site, instead of redistributing it (as other radium removal methods do)," said Willey.

The $2.2 million cost Elburn must invest for radium removal is further reduced when the $474,000 in federal funds secured by U.S. Speaker Dennis Hastert and the $350,000 in developer contributions are subtracted from the price tag. This leaves a balance of $1.7 million to be paid from the village to WRT. The Arvada, Colo.-based company also offers a prepayment plan of the $575,000 in capital costs it will take to install WRT's system. By paying this amount up front, the village will save several thousands of dollars over the next 20 years, the length of the WRT contract.

There is further good news here, said Willey, when you consider other municipalities are seeking low-interest loans to pay for radium removal, when Elburn has savings to cover the $575,000 prepayment cost.

"Paying a little more money up front means less money overall," said Willey. "This is very significant. We were prudent with our funds because we knew this was coming."

However, the residents will still need to pay more for water. Village officials selected the 34.5-percent increase as one of three options. This option will raise the rates to $2.69 per 100 cubic feet of water, and the village will save money in the long run by paying capital costs up-front, allowing for $28,500 in recapture costs and helping build a reserve to pay for improvements to water mains in town, such as improvements that must be made to increase fire flows in the northwest quadrant of the village.

While increasing the water rate from $2 to $2.69 per 100 cubic feet, the village plans to keep the sewer rate at the current $2/100 cubic feet rate, which translates to an "effective" rate increase in a homeowner's total water bill of 17.25-percent. On an average, a quarterly household bill of $80 would increase to $93.80.

"We needed to raise water rates anyway in my opinion," said trustee Jeff Humm. "We need to replace existing water mains and raise connection rates for capital improvements."

"We didn't ask for this, but we're trying to figure out what to do," said trustee Jeffrey Metcalf. "We've done the best we can and we're farther ahead (because of planning ahead)."

"Tomorrow's headlines will probably say 'Elburn Considers Raising Water Rates by 34.5 percent,'" but that's not the whole story," said Willey. "What the headlines might not say, but should, is that Elburn hasn't raise its water rates for 18 years and the increase is really only a 17.25 percent increase on the total water bill by holding the sewer rate the same. Also, Elburn can solve its radium problem without borrowing, which represents a tremendous savings to future taxpayers. WRT's zeolite technology is saving Elburn millions of dollars over the ion-exchange or lime softening methods, and Elburn's radium will be properly disposed of and not flushed into streams, spread on a farm field or dumped into an unsuspecting landfill. We've always tried to be environmentally conscious here."

"Elburn's radium will be properly disposed of and not flushed into streams, spread on a farm field or dumped into an unsuspecting landfill."

– Village President Jim Willey

At next Monday's Village Board meeting, trustees will vote to approve the 20-year contract with WRT to remove radium from the village's water supply. The state of Illinois requires municipalities with higher than acceptable levels of radium in their water to remove the radium from the water. It is believed that exposure to high enough levels of radium for long enough periods of time may cause cancer. WRT has completed a pilot plant study in Elburn and has determined its patented process can effectively remove radium here.

The Beacon News
June 18, 2004

Elburn sees savings in new water filtering technology

By Linda Girardi
SPECIAL TO THE BEACON NEWS

ELBURN — The village has found a way to remove trace levels of radium in its drinking water supplies without significantly raising residential water rates.

"It's a tremendous savings," Mayor Jim Willey said of the $2.2 million federally mandated project.

The Village Board is expected Monday to authorize signing a 20-year lease agreement with Water Remediation Technology for a relatively new technology patented to remove trace levels of radium from drinking water supplies.

Per the agreement, the village's water rate would increase from $2 per 100 cubic feet to $2.69 per 100 cubic feet. The average quarterly bill per household would go up from $40 to $54, village officials estimate.

Elburn's water rates have remained constant since 1986.

Radium is a naturally occurring element found in deep wells across northern Illinois. The Environmental Protection Agency is demanding municipalities remove the radium to reduce the risk of cancer over a prolonged time.

In the last couple of years, the Village Board has studied the use of ion exchange and lime softening that would require the construction of centralized plants, costing in the range of $5 million to $9 million. In addition, the systems would have required costly operational and maintenance costs.

"We had to look at this technology — the savings was too great," Willey said of the Water Remediation Technology proposal.

Water Remediation Technology radium removal process involves passing Elburn's drinking water through a resin to absorb the radium out of the water. The filtering system is changed approximately once a year.

Willey said the WRT lease agreement has a $575,000 capital prepayment option which could save the village several thousands of dollars over the life of the agreement.

Elburn is a recipient of a $474,000 federal grant obtained by U.S. House Speaker Dennis Hastert, R-Yorkville. The village must fund the remaining $1.7 million balance for the project.

"Our village has the funds available to pay for this project and to take advantage of the prepayment option without any borrowing," Willey said.

The Beacon News

January 22, 2004

Elburn to go high tech to remove radium

By Linda Girardi
SPECIAL TO THE BEACON NEWS

ELBURN — The village has agreed to move forward with a relatively new technology that will remove trace levels of radium from its drinking water supplies.

The Village Board this week authorized the mayor to sign an agreement with the Illinois Environmental Protection Agency, outlining the village's responsibilities relative to funding, preparation and completion of the process.

"There's an incredible savings here on behalf of the community,"

–Village Administrator David Morrison

The IEPA agreement sets a compliance date of December 2005.

"There's an incredible savings here on behalf of the community," said Village Administrator David Morrison, adding there might be even better news next week when the board discusses the overall impact on residential water rates.

Radium is a naturally occurring element found in deep wells across northern Illinois. The EPA is demanding municipalities and villages remove the radium to reduce the risk of cancer over a prolonged time.

The Village Board has studied the use of ion exchange and lime softening that would require the construction of centralized plants, costing between $5 million and $9 million. In addition, the systems would require on-going operational and maintenance costs.

Mayor Willey said the village received a $475,000 federal grant through the help of U.S. House Speaker Dennis Hastert. The village would lease the equipment to eliminate additional costs.

"For an unfunded mandate, to save the citizens this much money is huge," Trustee Craig Swan said.

Village Engineer Bill Gain, of Rempe Sharpe & Associates in Geneva, said the Water Remediation Technology Z-88 radium removal process involves passing Elburn's drinking water through a resin to absorb the radium. The filtering system is changed once a year.

The process would involve building two structures, resembling farm silos at Well No. 3 and Well No. 4 on First Street and North Street.

Gain said the Well No. 4 structure would stand about 28 feet above ground. It would sit four feet below surface and would be situated away from the Veterans Memorial.

"For Well No. 3, we recognize it is a residential area and we'll sink it into the ground about 12 feet, giving the structure a height of approximately 19 feet," Gain said.

"We have gone through the pilot testing, so we know the process does work and it was accepted by the IEPA. That removed most of the risk out of it."

–Village Engineer Bill Gain

"We have gone through the pilot testing, so we know the process does work and it was accepted by the IEPA. That removed most of the risk out of it."

Construction is scheduled to begin in March 2005. Gain said the system would not drastically alter the condition of the drinking water supply.

"There may be some difference," he said, "but not a great difference."