BEFORE THE POLLUTION CONTROL BOARD
OF THE STATE OF ILLINOIS

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STATE OF ILLINOIS
Pollution Control Board

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 Theodore G. Adams On Behalf Of Water Remediation Technology, LLC** a copy of which is served upon you.

WRT Environmental [Illinois] LLC

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

TESTIMONY OF THEODORE G. ADAMS
ON BEHALF OF WATER REMEDIATION TECHNOLOGY, LLC

I. INTRODUCTION

My name is Theodore G. Adams. I am President of T. G. Adams and Associates, Inc., an environmental and radiological consulting firm located in Springville, New York. My educational background consists of a B.S. in Environmental Biology from the University of Pittsburgh, Pittsburgh, PA and a M.S. in Health Physics from Purdue University, West Lafayette, IN. I have 25 years' experience in the areas of Radiation Safety and Environmental Protection, Radioactive Waste Management, and Decontamination and Decommissioning/Remediation for both commercial and government clients.

I have extensive experience in providing radiological consulting expertise to Public Owned Treatment Works (POTWs) and currently serve as the Radiological Safety Officer for the Northeast Ohio Regional Sewer District, a POTW located in Cleveland, OH. I am a certified Radiation Expert in the State of Ohio and a certified Project Management Professional (PMP #185793). I am also a licensed remediation service provider in the State of Ohio (License No. 03219990004). My resume is attached as Exhibit A to my testimony.

I have reviewed the transcripts and other information submitted to the Pollution Control Board in this matter. It is my testimony that the proposed rule change, and the prior testimony in this matter, does not take into account the safety and liability issues relating to treatment of a raw water supply containing elevated levels of Radium-226 or Radium-228.

In the transcript of the April 1, 2004 hearing, the hearing officer, Ms. Antoniolli, asked a very important and critical question of Mr. Kinsley. She asked "[a]re the radium levels high enough in the sludge to require special disposal of the sludge?" (See Hearing Transcript dated April 1, 2004 at 50:19-21.) That question was not squarely answered. In my experience, the answer is a resounding "Yes." The sludge requires special handling and special disposal.

Treatment of raw water with elevated radium levels creates safety and liability issues at both the water treatment plant works and the POTW. The handling and disposal of the contaminated sludge poses a significant concern and a major impact, both economic and regulatory, to POTWs. Of equal concern is the potential radiological exposures to the POTW worker, the family who resides on property where contaminated sludge has been applied and the biota (terrestrial and aquatic animals and plants) exposed to the contaminated effluent and sludge released from the POTW.

My testimony will address each of these areas in detail to show that allowing the disposal of water treatment residuals into the public sewer, and subsequent treatment and disposal by POTWs, could result in significant operational, economic, regulatory and worker safety issues/impacts for the POTWs, as well as environmental impacts to the biota, and health impacts to residents residing on sludge-applied land.

II. POTW RESPONSIBILITIES

There have been many situations where radiological contaminants have been discharged to POTWs without the knowledge of the POTW or the ability to take precautionary measures. These discharges, even of small amounts of radiological materials over time and at then-accepted levels, have caused these POTWs to undertake expensive cleanup measures and, for some, to come under the jurisdiction of the Nuclear Regulatory Commission (NRC). The U.S. Environmental Protection Agency's (EPA or U.S. EPA) adoption of the drinking water standard for radium should cause all concerned to carefully review that prior record and take precautions to avoid repeating those situations.

The economic and operational impacts of radiologically contaminated influent/sludge on POTWs are well documented. Table 1 summarizes the POTWs across the United States where the acceptance, processing, or handling of radiological contaminated influent and resulting sludge have caused major impacts. While some impacts required minor corrective action/response, others (i.e., Cleveland, OH and Tonawanda, NY) required significant expenditures of resources (dollars and manpower) to satisfactorily address the problem of dealing with contaminated hardware, facilities and product (i.e., sludge, ash and grit).

Two cases that I am personally familiar with are the contaminated POTWs of NEORSD, Cleveland, OH and KVWPCA, Kiski, PA. Since 1993, the NEORSD has spent more than $2 million to remediate three contaminated ash lagoons and surrounding areas and place the Co-60-contaminated ash (174,000 cubic yards) into two Ohio Environmental Protection Agency (OEPA) permitted onsite disposal facilities at its Southerly Plant and to remediate Co-60-contaminated soil/grit at its Easterly Plant. The cleanup criteria established by the NRC was 8 pCi/g. Ash contaminated above this limit was remediated and placed into two onsite disposal areas – one area had average and maximum concentrations of 30 pCi/g and 458 pCi/g, and the other area had average and maximum concentrations of 19 pCi/g and 112 pCi/g. But that cleanup did not resolve the situation.

Contaminated ash remains throughout the Southerly Plant and at isolated locations at the Easterly Plant. NEORSD has had to retain the services of a licensed remediation contractor to provide the necessary radiological coverage to address the radiological issues during excavation, movement, and drilling (i.e., normal construction projects/activities) at any onsite location where ash is present. At the present time, the Ohio Department of Health, Bureau of Radiation (ODH) (Ohio is an Agreement State) is considering requiring the NEORSD to become a radioactive materials licensee. If this becomes reality, then the NEORSD will be required to develop its own Radiological Control Program, hire qualified radiological expertise, procure necessary radiological equipment, incur additional annual costs to maintain its license, and be subject to the inspections and potential notice of violations/fines from the ODH if the NEORSD Radiological Control Program is not properly carried out.

The situation at KVWPCA has been going on for more than 10 years. The radiological material in an ash lagoon containing 11,700 yards of enriched uranium is on the POTW property and has been sampled with concentrations found ranging from 2.6 to 923 pCi/g. The land remains unusable (even though current plans for expansion of the plant require the additional space that the lagoon could provide), while the NRC and the Pennsylvania Department of Environmental Protection

(PADEP) continue to be in disagreement about the ultimate disposition of the material. If the ash must be disposed of at a licensed radioactive disposal facility, the estimated cost is $6 million – about six times the cost of ordinary off-site disposal.

These are two instances of which I have personal involvement. In each case, the POTW has been saddled with extraordinary costs and required to undertake significant monitoring activities.

Costs associated with dealing with contaminated piping, hardware, facilities, and sludge/ash, which as shown can be substantial, normally have been the responsibility of the POTW. The NRC and/or agreement states have not required any discharger (i.e., licensees) to pay for the remediation/cleanup of the contamination of the POTW due to licensed discharge. As in the case of the NEORSD, economic restitution normally is sought in public court. In short, the POTW is left holding the bag!

Investigations into the safety and regulatory requirements for discharges to POTWs

As a result of the NEORSD POTW contamination (and others), in 1994 the General Accounting Office (GAO) issued a report entitled "Nuclear Regulations and Actions Needed to Control Radioactive Contamination at Sewage Treatment Plants" (GAO/RCED-94-133). The GAO report recommended that "the NRC determine the extent to which radioactive contamination of sewage sludge, ash and related by-products from sewage treatment plants is occurring; directly notify the POTWs that receive discharges from NRC's and the Agreement States' licensees of the potential for radioactive contamination because of the concentration of radioactive material and of the possibility that the plants may need to test or monitor their sludge for radioactivity content; and establish acceptable limits for radioactivity in sludge, ash and related by-products to protect the health and safety of POTW workers and the public."

A joint House/Senate hearing was held in 1994 to officially release and address questions raised in the GAO report. The hearing was prompted by the concern related to the contamination of the NEORSD POTW in Cleveland, Ohio. The GAO stated that, over the past 20 years, NRC had documented elevated levels of radioactivity in sewage sludge or sludge incineration ash from certain POTWs (see Table 1); however, there had been no national surveys of radiation levels present in sewage sludge or sludge incinerator ash to determine the extent of potential radioactive contamination.

On the basis of limited information on radiation levels on sewage sludge and ash across the country, the GAO concluded that re-concentration of radionuclides may have been associated with authorized effluent releases from both NRC and Agreement State licensees; however, these problems occurred prior to the revision to NRC's regulation with regard to release from NRC licensees (soluble and biologically dispersible) which became effective in 1991. (See Exhibit B – **"Overview of Federal Efforts to Protect POTWs from Impacts from Receiving Radioactive Materials from NRC-licensed Facilities"**.)

While the GAO and Congress were dealing with the issue of radiological contamination at POTWs, the POTWs decided to conduct their own evaluation.

In 1996, the Association of Metropolitan Sewerage Agencies (AMSA) conducted a limited, confidential, voluntary survey of the concentration of radioactivity in sewage sludge and ash samples from some of its member POTWs. The results of the AMSA study are presented in "Characterization of Radioactivity Sources of Wastewater Treatment Facilities" (The National Biosolids Partnership, May 1999). (A copy of the relevant portions of this report are attached as Exhibit C.) The objective of the study was to develop a better estimate of the concentration of radioactivity in sewage sludge and sludge-incinerated ash. A total of 55 POTWs located in 17 states supplied voluntary sludge and ash samples, which were analyzed for radioactivity. These plants were distributed across the United States and ranged in size from small (10 MGD) to some of the largest POTWs in the country (100^+ MGD). The study found that the most significant levels of radioactivity were the naturally occurring potassium and radium isotopes.

This independent study served as the first real effort at gaining an understanding of the extent to which radioactivity was entering a POTW and the impacts on the resultant sludge or ash. Background information on the nature of radioactivity in sewage sludge can be found in the NRC Reports entitled "Evaluation of Exposure Pathway to Man From Disposal of Radioactive Materials Into Sanitary Sewer Systems" (*NUREG/CR-5814*) and "R econcentration of Radioactive Material Released to Sanitary Sewers in Accordance with 10 CFR 20" *(NUREG/CR-6289)*, published in 1992 and 1994, respectively. Other useful background documents are:

- Radioactivity of Municipal Sludge (*EPA, 1986*)
- Environmental Radioactivity from Natural, Industrial and Military Sewers (*Eisenbud and Gesell, 1997*)
- Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Material (*National Academy of Sciences, 1999*)

Based on the 1994 GAO report recommendations, the NRC and the EPA, in cooperation with the Interagency Steering Committee on Radiation Standards (ISCORS), decided to jointly fund a voluntary survey of POTW sewage sludge and ash to help assess the potential need for NRC and/or EPA regulatory decisions.

The NRC and the EPA conducted a pilot study involving nine POTWs to field-test the feedback questionnaire, validate sampling methods and analytical procedures, and obtain feedback from participating POTWs. The results of the pilot study were documented in EPA-833-R-99-900, May 1999.

The final voluntary survey had two components: a questionnaire and a program for sampling and analyzing sewage sludge and incinerator ash. Based on the results of the questionnaire, the NRC and the EPA selected 313 POTWs to be evaluated. The selection emphasized POTWs with the greatest potential to receive waste from licensees and in areas with higher levels of naturally occurring radioactive material (NORM). All together, 311 sewage sludge samples and 35 ash samples were obtained. The samples were analyzed by Oak Ridge Institute for Science and Education (ORISE) in Oak Ridge, Tennessee and by the EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama.

The results of the analyses revealed that POTW samples primarily contained NORM such as radium.

The NRC and the EPA joint survey and the sampling and analysis program results are presented in "ISCORS Assessment of Radioactivity in Sewage Sludge: Radiological Survey Results and Analysis (*ISCORS Technical Report 2003-02, November 2003*). (A copy of the relevant portions of this report is attached as Exhibit D.)

In addition to the survey and sampling/analyses results report, ISCORS also prepared two supplemental reports. (Copies of the relevant portions of these reports are attached as Exhibits E and F, respectively.) The first report, entitled "ISCORS Assessment of Radioactivity in Sewage Sludge: Modeling to Assess Radiation Doses" (*ISCORS 2003-03, November 2003*), is a dose assessment report that describes the exposure scenarios for sewage sludge processing, use and disposal. (See Section III of my testimony.)

The second report, entitled "ISCORS Assessment of Radioactivity in Sewage Sludge: Recommendations on Management of Radioactive Materials in Sewage Sludge and Ash at Publicly Owned Treatment Works" (*ISCORS Technical Report 2003-04, November 2003*), provides recommendations for POTW operators on determining sources of radioactivity at POTWs, describes sampling and analysis procedures and suggests alternative corrective actions if circumstances (e.g., location of high NORM area) or actual measurements indicate that a problem exists. (See Section III of my testimony.)

Summary

It is clear that POTWs bear the brunt of discharges to their sewers of radiological materials, including Radium-226 and Radium-228. It is also clear that numerous regulatory agencies are looking into these issues. Over the last decade, NRC has tightened its restrictions on allowable discharges to POTWs – now only materials that are soluble are allowed. (See Exhibit B – **"Overview of Federal Efforts to Protect POTWs from Impacts from Receiving Radioactive Materials from NRC-licensed Facilities".**) EPA also has convened a working group and published two recent guidances, in 2000 and 2004, on this issue. The EPA guidance documents recommend against any release to sanitary sewers of filtrate collected from treatment of raw water to meet the Maximum Contaminant Level (MCL) for Radium-226 and Radium-228. These issues will be reviewed in subsequent sections of my testimony.

Table 1. Sewage Treatment Plants Where Elevated Levels of Radioactive Material Were Found			
Location	**Year Found**	**Radionuclides**	**Actions Taken**
Tonawanda, New York	1983	Americium-241	State spent over $2 million cleaning up treatment plant. No final decision has been made regarding radioactive material found in the landfill.
Grand Island, New York	1984	Americium-241 Hydrogen-3 Polonium-210	No plant cleanup was warranted.
Oak Ridge, Tennessee	1984	Cobalt-60 Cesium-134 Cesium-137 Manganese-54	Soil around sewer line cleaned up, and some special sludge disposal occurred.
Royersford, Pennsylvania	1985	Manganese-54 Cobalt-58 Cobalt-60 Strontium-89 Zinc-65 & others	No plant cleanup was warranted.
Erwin, Tennessee	1986	Americium-241 Plutonium-239 Thorium-232 Uranium	Sludge digester cleaned up.
Washington, D.C.	1986	Carbon-14 Hydrogen-3 Phosphorous-32 & 33 Sodium-22 Sulfur-35 & others	No plant cleanup was warranted.
Portland, Oregon	1989	Thorium-232	Sewage lines cleaned up and pretreatment system added.
Ann Arbor, Michigan	1991	Cobalt-60 Manganese-54 Silver-108m, 110m Zinc-65	No plant cleanup was warranted.
Cleveland, Ohio	1991	Cobalt-60	Treatment plant cleanup and related activities have cost over $2 million.
Kiski Valley, Pennsylvania	1994	Enriched Uranium (Uranium 234, 235)	Decontamination and decommissioning plan. Prepared remediation cost range from $1-6 million.
Pottstown, Pennsylvania	2004	Cobalt-60	Delay in treatment and disposal of Royersford sludge. $50,000 charge for treatment service.

In nearly all of these cases, the release of radioactive materials to the sewers was halted or modified to correct the contamination problem.

III. ADVERSE IMPACT IN POTW WORKER FROM EXPOSURE TO RADIUM-BEARING SLUDGE

As presented in Section II of my testimony, there have been a number of cases of radionuclides discovered in sewage sludge and ash. These incidents made clear the need for a comprehensive determination of the prevalence of radionuclides in POTW sewage sludge and ash around the country and the level of potential threats posed to human health and the environment by various levels of such materials.

To provide a reasonable bound on the amounts of radionuclides that actually occur in sewage sludge and ash, the EPA and the NRC, in conjunction with ISCORS, conducted a limited survey of radioactivity in POTW sludge and ash across the United States and, as a subsequent effort, undertook a dose assessment to help assess the potential threat that these materials may pose to human health.

Dose modeling was performed by ISCORS using the sewage sludge 95th percentile results (13 pCi/g for Radium-226 and 5.1 pCi/g for Radium-228) under various exposure scenarios to estimate potential doses to workers and the public. The modeling results were presented in an ISCORS Draft Report – *Assessment of Radioactivity in Sewage Sludge: Modeling to Assess Radiation Doses (ISCORS Report 2003-03 November 2003)*. (See Exhibit E to my testimony.) The exposure scenarios chosen by ISCORS reflect the observation that most of the public exposure to sewage sludge results from its land application, disposal in a landfill, or incineration. Exposures of a worker through proximity to or direct contact with the sludge can occur during processing, sampling, loading, transport, or application. Such exposure scenarios also were evaluated by ISCORS. The exposure scenarios were designed so that exposures to the seven listed groups below were explored. ISCORS did not explore a family farm scenario where sewage sludge had been used as a fertilizer.

1. Residents of houses built on agricultural fields formerly applied with sludge;
2. Recreational users of a park where sludge has been used for land reclamation;
3. Residents of a town near fields upon which sludge has been applied;
4. Neighbors of a landfill that contains sludge and/or ash;
5. Neighbors of a sludge incinerator;
6. Agricultural workers who operate equipment to apply sludge to agricultural lands; and
7. Workers at a municipal treatment plant involved in sampling, transport, and biosolids loading operations.

Based on the ISCORS modeling results, the largest potential dose (420 mRem/yr) is to the POTW Biosolids Loading Worker for exposure to Radium-226, Th-228 and indoor radon. This relatively high dose estimate is consistent with estimates developed in previous studies (*Kennedy, et al.*

1992). This dose significantly exceeds the annual exposure limit (100 mRem/yr) set for members of the general public. Although a relatively significant potential dose to a POTW Biosolids Loading Worker (specific case) was determined, ISCORS concluded that there was no widespread or nationwide public health concern identified by the sewage assessment survey. However, ISCORS stated clearly that "The survey was not designed to identify unique or isolated instances in which high levels of radionuclides may be present in sewage sludge or ash and inferences to high levels of radionuclides cannot be made from the survey results alone." It would appear that the treatment of groundwater in northeastern Illinois to meet the federal drinking water standard for radium presents just such a local or unique situation. A discharge of concentrated radium sludge from a water treatment plant is a unique high level of concentrated radioactivity.

To evaluate this situation, I assessed the potential doses to POTW workers and the public from water treatment facility effluent containing radium at various concentrations in raw waste (5 - 25 pCi/L), various dilution volumes (0% and 50%) and various radium removal efficiencies (20%, 80% and 90%). The anticipated radium concentrations in POTW discharge (sludge and effluent) and related assumptions are presented in Table 2, attached as Exhibit G. These analyses bracket the actual radium levels found in groundwater by WRT and presented in Mr. Williams's testimony.

Using a typical radium concentration of raw waste of 15 pCi/L for the 6 POTWs and using ISCORS methodology, a correlation to a potential dose to a POTW Biosolids Loading Worker was made (Table 3). This table differentiates the effect of radium going to the POTW sludge or the water discharge.

I next compared the exposure to a POTW worker in a wastewater treatment plant with these amounts of radium in the sludge. The following table demonstrates the impact on those workers. In every case involving substantial radium removal from the sanitary wastewater, the workers will be exposed to levels in excess of the 100 mRem/yr allowable exposure. Also, the resulting levels of exposure are higher than or very comparable to the levels in Ohio and Pennsylvania, discussed above, where expensive cleanup is being required. And, as documented below, virtually every scenario results in workers being exposed to radiation levels high enough to trigger regulatory oversight and standards.

Table 3

Plant[1]	Potential Concentration of Radium in Sludge (pCi/g)	TEDE mRem/yr	
		with radon	w/o radon
A	103	3,626	130.8
B	155	5,456	196.9
C	92	3,238	116.8
D	138	4,858	175.3
E	23	810	29.2
F	34.5	1,214	43.8
Worst Case Plant B @ 25 pCi/L	259	9,117	328.9

[1] Radium concentration of raw water = 15 pCi/L

These results indicated the substantial issues raised by putting Radium-226 and Radium-228 into a sanitary sewer. Only two of the plants (E and F without radon) have potential dose estimates below the 100 mRem/yr limit established by the NRC for exposure to ionizing radiation to the public. Even a concentration of approximately 77 pCi/g of radium in the sludge would result in a potential dose of 100 mRem/yr.

One scenario (Plant B) was run using concentrations in raw water of 25 pCi/L (found in Illinois groundwater) with 259 pCi/g in the sludge, associated with high solids removals. The results of the dose assessment indicated exposures to the Biosolids Sludge Loader of 9,117 mRem/yr. By comparison, occupational radiation workers are allowed only 5,000 mRem/yr.

Summary

Thus, it is foreseeable in Illinois that flushing filtrate from a water treatment plant down a sanitary sewer would result in exposure twice those levels, and without any of the personal protections and monitoring that are required by the NRC for individuals with an exposure exceeding 100 mRem/yr. When the contribution to indoor radon is included, all plants/POTW Biosolids Workers exhibit potential doses significantly exceeding the 100 mRem/yr limit. In fact, many approach the limit established by the Federal Government (NRC, Department of Energy (DOE)) for occupational exposure of 5,000 mRem/yr. To be able to place these potential doses to the POTW Biosolids Loading Worker, in perspective, a summary of current federal dose limits for the exposure to ionizing radiation is provided in the table included in Exhibit H (Table 4).

IV. RECOMMENDATIONS FOR PROTECTION OF PERSONNEL EXPOSED TO RADIUM FROM TREATMENT OF DRINKING WATER SUPPLIES

A. EPA'S RECOMMENDATIONS IN ITS 2000 GUIDANCE

The EPA, in its November 2000 draft guidelines for handling and disposal of drinking water treatment containing technologically enhanced naturally occurring radium material (TENORM) recommends the following exposure guidelines for water treatment facility personnel which may be applied to POTW personnel as well. A copy of the relevant portions of the EPA guidance is attached as Exhibit I.

Routine Operations

1. Ambient radiation levels in areas of water treatment plants removing radionuclides from drinking water should be monitored at least yearly, using gamma survey instruments or equivalent monitors.

2. Radiation levels in the vicinity of components that concentrate radioactive materials should be monitored at least quarterly.

3. Additional measurements should be performed when a component that accumulates radioactivity is replaced, if the treatment process is changed, if the length of service is increased, or if significant increases in radionuclide levels are observed in the source water.

4. Radiation doses to personnel working in a drinking water treatment facility should not exceed an administrative control level no greater than 100 mRem/yr, and be kept as far below that level as reasonably achievable (ALARA).

5. If areas in a treatment plant are identified where an individual working in an area could receive a short-term exposure that would be a significant fraction of the above limit, such as 1 mRem/working day, those locations should be clearly marked "Caution Radiation" and restricted to specified personnel.

6. Persons working in areas marked "Caution Radiation" should have appropriate radiation protection training and their radiation exposure should be monitored through area monitoring or personnel monitoring, as appropriate.

7. Radon levels in the air should be monitored, and action taken where appropriate, to reduce indoor radon levels as much as possible. Because of short-term conditions that may result in elevated exposures, such as during maintenance of treatment units, the time period over which radon concentrations are averaged should be chosen to correspond to normal working hours and conditions. Improved ventilation should be considered for the reduction of airborne radon.

8. Sludge storage sites, evaporation beds, and drying lagoons should be fenced to prevent unauthorized intrusion.

Handling and Shipping Radioactive Wastes for Disposal

1. When removing and preparing wastes containing radionuclides for transportation and disposal, the process should be evaluated to keep radiation exposures As Low As Reasonably Achievable (ALARA). This may entail special training, tools, or shielding. In addition, personal protective equipment, such as respirators and protective clothing, may be necessary to reduce exposures in some situations.

2. Only properly trained personnel should handle radioactive wastes.

3. Personnel handling radioactive wastes, including those involved in shipping the wastes, should have their radiation exposure monitored at all times.

4. When handling and shipping radioactive wastes, the appropriate local, state, and OSHA health and exposure regulations should be followed.

5. When shipping radioactive materials whose concentrations exceed 2,000 pCi/g, the appropriate Department of Transportation standards must be followed as prescribed in 49 CFR Parts 100 to 179.

B. EPA's 2004 GUIDANCE

Most of the substantive recommendations of the 2000 Guidance are also in the revised guidance, "A Regulator's Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies" (August 4, 2004), excerpts are included in Exhibit I.

With respect to disposal of solid residuals, the report states:

> EPA does not encourage the land spreading or soil mixing of such TENORM unless there is a demonstrated benefit to the public from the material involved. Where benefits from land application are construed to exist, EPA believes that such benefits should be weighed against the potential hazards and risks of the practice. The main concern is the potential for build-up or movement of radionuclides to create contaminated sites that would require remediation and/or use of institutional and engineering controls.

Id. at p. 12. Clearly, the EPA has some of the same concerns as documented by my testimony here. The EPA also expressed concern with release of liquid residuals into sanitary sewers. The EPA recommended that in all disposal options, the water treatment facility contact the State and the POTW to insure that the release of the water treatment residuals into the sanitary sewer will not interfere with POTW operations or cause a violation of the POTW's National Pollutant Discharge Elimination System (NPDES) permit, and will be accepted by the POTW. Again, EPA recognized, as had ISCORS, the potential for elevated radium levels in unique circumstances to adversely affect the operations of the POTW. Id. at p. 16.

The 2004 Guidance further recognized that relatively undetectable levels of radionuclides in source waters could accumulate in measurable or hazardous quantities in piping, pumps, holding tank scale or sludge, IX and granular filters, backwash and other residual sludge. Radon gas can accumulate in closed or poorly ventilated buildings when thorium, radium and certain other radionuclides-containing materials are present.

The EPA recommended additional precautionary measures be undertaken where the accumulation of radon occurs:

1. The facility should contact a professional radiation protection specialist or health physicist for assistance conducting radiation surveys.

2. The facility should check for the presence of radon in buildings encasing water treatment equipment.

3. Use of an OSHA-approved respirator to avoid inhalation of biological pathogens and chemically toxic materials in residuals. Simple dust masks may not provide adequate protection.

4. Limit time spent at land disposal sites to reduce inhalation of contaminated dust.

5. Shower after exposure to potentially radioactive materials and launder work clothing at the system, if possible. Workers should avoid wearing contaminated clothes home. Work boots or shoes should be wiped and cleaned after potential contamination.

6. Use gamma survey instruments or equivalent monitors at least once annually to monitor system's ambient radiation levels in areas where radionuclides are removed.

7. Monitor levels of radiation to which staff are exposed. Systems should contact, or be referred to, state or other radiation experts for more information on how to monitor radiation levels.

8. Apply the radon action level (<u>i.e.</u> 4 pCi/L) used for homes and schools for water treatment buildings.

And if radionuclides or radiation have been found in a drinking water supply or at a system, the EPA strongly recommended that operators should be trained in treating for radionuclides, and handling, disposing of, and transporting TENORM waste. <u>Id</u>. at pp. 19-22.

C. ISCORS RECOMMENDATIONS

The EPA is not the only entity recommending precautions be taken.

ISCORS (Technical Report 2003-04) recommends that there is no need for further action when estimated doses, using screening calculations, are below 10 mRem/yr. However, if the doses are estimated to be 10 mRem/yr or greater, ISCORS advises the POTW operator to contact its State Radiation Protection Regulatory Agency for further guidance and action.

ISCORS provides guidance on conducting surveys and sampling of POTW operations and interprets the results to determine if there is a problem with radioactive sludge/ash at the POTW. ISCORS also provides additional guidance for monitoring radiation levels to potentially exposed POTW workers, for training, and supports keeping doses to workers ALARA.

Summary

Thus, if sanitary sewers are used for the disposal of radium-contaminated filtrate, it is clear that the POTWs should take numerous additional precautions to protect their workers. Indeed, the measures to be taken may be as extensive as required for workers at nuclear power plants. And undertaking these measures requires financial and human resources.

V. LAND APPLICATION

Obviously, discharging radium-contaminated materials down the sewer transfers responsibility to the POTW where the radium is likely going to end up in the sludge. This section of my testimony demonstrates that those radium-contaminated sludges pose unique problems and added impacts to the environment, unless they are placed into a secure landfill.

As part of the ISCORS modeling effort, several scenarios were examined to evaluate exposure to the public from land application of sludge contaminated with radionuclides (including radium). Specifically, the exposure scenarios that were evaluated by ISCORS related to land application were:

- Residents of houses built on agricultural fields formerly applied with sludge (single and 5-year application)
- Recreational users of a park where sludge has been used for land reclamation
- Residents of a town near fields on which sludge has been applied
- Agricultural workers who operated equipment to apply sludge to agricultural lands (single and 5-year application)

ISCORS did not explore a family farm scenario where sewage sludge had been used as a fertilizer.

Water Remediation Technologies, LLC (WRT) contracted American Radiation Services, Inc. to estimate the potential increased exposure in the "critical groups" scenarios of the ISCORS Report that would result from high radium concentration in sewage sludge, higher than those modeled in the ISCORS Report (ARS Report, "Total Effective Dose Equivalent (TEDE) Calculations for Radium-Bearing Sewage Sludge Under Various Exposure Scenarios," January 26, 2004), copy attached as Exhibit J[1]. Radium removal systems used by municipal and water entities to bring drinking water into compliance with the EPA 5 pCi/L radium limit are examples of unique situations that were not specifically evaluated by ISCORS. The EPA's radionuclide rule of December 7, 2000 requires municipalities generating drinking water with radium activity levels greater than 5 pCi/L to install radium removal systems. Disposal of water treatment residuals from radium removal systems into the sanitary sewer can result in the production of sewage sludge at the POTW with elevated radium activity levels greater than those identified by the ISCORS survey. The radium-bearing sewage sludge is either disposed of at a local landfill, incinerated or used as fertilizer for farming application.

ARS calculated potential radium activity levels in sludge generated by two typical POTWs in use today: a Standard Treatment System and an Activated Sludge System. Generally, a Standard Treatment System and an Activated Sludge System will generate approximately 0.8 and 0.23 grams of sludge per gallon of influent, respectively. (<u>See</u> Exhibit J at p. 4.)

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1 While ARS prepared this report, I have reviewed it and its assumptions and calculations and find them to be reasonable.

ARS selected an average initial radium calculation in groundwater of 10 pCi/L, which corresponded to 148 pCi/g in sludge from an Activated Sludge System and 43 pCi/g in sludge from a Standard Treatment System. ARS also explored a family farm scenario where sewage sludge was used as a fertilizer. ARS utilized the same dose modeling methodologies employed by ISCORS in its dose assessments.

The results of the ISCORS and ARS dose assessments are summarized in Table 5.

Table 5

Comparison of ISCORS Report Exposures with Exposures Resulting from Higher Radium Concentrations in Sewage Sludge

Scenario	NRC/EPA ISCORS Report TEDE Value (mRem/yr)[1]	TEDE based on ISCORS Radium and Progeny Analytical Results (95%) Scaled to 43 pCi/g combined Ra-226/Ra-228 Activity (mRem/yr)[2]	TEDE based on ISCORS Radium and Progeny Analytical Results (95%) Scaled to 148 pCi/g combined Ra-226/Ra-228 Activity (mRem/yr)[2]
On-site Resident, Single Application	3	6.92	34.1
On-site Resident, Five-Year Application	14	23.5	116
Sludge Application Worker, Single Application	0.15	0.39	1.98
Sludge Application Worker, Five-Year Application	0.77	1.30	6.41
Incinerator Neighbor Scenario	7.7	5.27	12.0
POTW Biosolids Loading Worker Scenario, Without Indoor Radon Contribution	26	60	170
POTW Biosolids Loading Worker Scenario, With Indoor Radon Contribution	420	1520	5210
Family Farm Scenario, Single Application	Not Evaluated by ISCORS	5.04	17.36
Family Farm Scenario, Five-Year Application	Not Evaluated by ISCORS	24.3	83.90

Note 1: ISCORS Assessment of Radioactivity in Sewage Sludge: Modeling to Assess Radiation Doses, Table 7.1, ISCORS 2003-03, NUREG-1783, November 2003.

Note 2: Only Ra-226, Pb-210, Ra-228 and Th-228 activity values are scaled to relate to a combined Ra-226 and Ra-228 activity of 43 pCi/g or 148 pCi/g. Pb-210 is assumed to be 31% of the Ra-226 activity. Th-228 activity is assumed to be 80% of the Ra-228 activity.

Dose modeling performed by ARS estimated that a POTW Biosolids (sludge) Loading Worker could receive a dose of 5,210 mRem/yr from sludge containing radium at an activity level of 148 pCi/g and a dose of 1,520 mRem/yr from sludge containing radium at an activity of 43 pCi/g. The 5,210 mRem/yr and the 1,520 mRem/yr TEDE include doses from indoor radon. Without the indoor radon dose component, a Biosolids Loading Worker could receive a dose of 170 mRem/yr and 60 mRem/yr from sludge containing radium at an activity of 148 pCi/g and 43 pCi/g, respectively.

These potential doses are significant to both the POTW worker and members of the public as they exceed regulatory limits and guidelines designed to protect individuals. Additional observations are made with respect to these doses:

- Potential doses would/could be a liability issue to municipalities/POTWs

- Typically, POTW workers are not considered or trained as occupational radiation workers (they are members of the public)

- The above exposures to the Biosolids Loading Worker (with radon component) exceed those of the typical nuclear power plant worker

- Even without the radon component, the exposure to the Biosolids Loading Worker could be almost twice the limit allowed to the general public (170 vs. 100 mRem/yr)

- Average annual dose to nuclear power plant worker, occupational radiation workers and workers in medical industry who received measured ~~non-zero dose are~~ 700 and 240 mRem/yr, respectively. Average to all radiation workers in the United States in 1980 was 210 mRem/yr

ARS also estimated the TEDE to a member of a family farm where radium-bearing sludge had been applied as fertilizer. It was estimated that an on-site resident living in a house located on land where five annual applications of 148 pCi/g radium-bearing sludge had been applied would receive a TEDE of 116 mRem/yr. This exceeds the 100 mRem/yr limit allowed to the general public.

VI. PROPER DISPOSAL OF RESIDUE FROM TREATED RADIUM-CONTAMINATED GROUNDWATER

The ALARA philosophy is a fundamental objective of all effective radiation protection programs. It forms the basis of the national regulatory structure for radioactive materials and is specifically included as the principle of Illinois regulations. 32 Ill. Admin. Code 340 (NRC 10 CFR 20.1101(b)). Reducing or minimizing individual (worker) or collective (public) exposure is desirable. Control of radiation exposure is based on the assumption that any exposure to ionizing radiation involves some risk. This radiation exposure control philosophy has been presumed repeatedly in the guidance provided by organizations such as the National Council of Radiological Protection and Measurement (NCRP), the International Commission of Radiological Protection (ICRP) and the National Academy of Sciences Committee on the Biological Effects of Ionizing Radiation (NAS-BEIR). The NRC issued specific guidance to licensees on designing an acceptable program for establishing and maintaining ALARA levels for gaseous and liquid effluents at materials facilities (*NRC Regulation Guide 8.37: ALARA Levels for Effluent From Materials Facilities (July 1993)).*

Thus, maintaining individual and collective radiation exposure ALARA is a critical element of any radiological control program/philosophy, regardless if the radiological material is man-made, NORM, or TENORM.

The fact that discharges of radioactive material (including radium) to the sanitary sewer system can result in appreciable doses to the POTW worker and to the public was demonstrated in Section III of my testimony.

In concert with the Illinois IDNS/IEMA regulations and the widely held ALARA principle, reduction of exposure to the worker or the public should be implemented commensurate with economic and social consideration. If at all possible, engineering processes and controls should be implemented to reduce/minimize the radiation exposure.

Mr. Williams's testimony demonstrates that using any of several engineered and economical cost-effective water treatment removal techniques, coupled with **NOT ALLOWING** the resultant water treatment residue to be disposed of into the sanitary sewer, represents the best application of the ALARA principle and minimizes the potential exposure to the POTW worker, the public and the environment.

The EPA office of Groundwater and Drinking Water issued draft guidance entitled "Draft Suggested Guidelines for Handling and Disposal of Drinking Water Treatment Waste Containing Technologically Enhanced Naturally Occurring Radioactive Materials" (*EPA, November 2000*). (See Exhibit I.)

This draft guidance supersedes the June 1994 Office of Drinking Water Report entitled "Suggested Guidelines for the Disposal of Drinking Water Treatment Water Containing Radioactive Waste." The guidelines presented in this document were designed to assist water treatment facilities in selecting responsible and cost-effective options for handling and disposition of waste containing TENORM. The report recognizes that "Unquestionably, waste by-products produced by drinking water treatment facilities can be of sufficiently high radioactivity to warrant the implementation of special precautions for their handling and disposal and to use caution when considering the use of technologies that have a high capacity for radionuclide removal. Since these technologies also have a great capability to concentrate these radionuclides in processed wastes."

The guidance evaluates various treatment technologies and highlights those (i.e., AX, CX, HMO) that have high removable efficiencies for radionuclides such as radium. It also notes that "great care must be exercised in selecting and using this technology since radionuclide (i.e., radium) may become so concentrated on the resin and in waste drains that they may not be disposed of safely."

With respect to potential exposure of water treatment personnel and the public, the EPA guidance embraces the ALARA principle and states that the guidance was issued "to assist water system owners and operators to minimize their exposures, that of their staff, and future generations."

The EPA guidance regarding water treatment sludge is summarized below:

- The EPA does not recommend application, mixing or spreading of water treatment waste containing radionuclides at any concentration onto open land (e.g., farm land, pasture land, woodland, construction sites, road beds, etc.) for several reasons including:

  - Health risks due to radium inhalation are significantly greater in buildings constructed on land that has been treated with fertilizers or sludge containing radium.

  - Data relating to plant, animal and human uptake of radionuclides that may result from land application of TENORM from drinking water treatment facilities have not been analyzed extensively.

  - Some radionuclides are extremely long lived. It is difficult to ensure the long-term control, monitoring and safety of sites not specifically designed for waste disposal.

  - The EPA has not collected or reviewed information on surface runoff from land application sites for water treatment wastes containing radionuclides. Preliminary risk assessments indicate that runoff from these sites and subsequent surface water contamination may pose a significant risk to the general population.

  - Although some sludge has been found to have beneficial properties as amendment to agricultural soils, the EPA has not determined that the benefit of application outweighs the potential negative (e.g., food chain contamination, impacts on surface and groundwater) for wastes containing radionuclides.

The EPA recommendations for disposal of radium-contaminated water treatment sludge include:

up to 3 pCi/g	Placement in a standard municipal landfill.
3 - 50 pCi/g	Burial to minimize gamma exposure. Isolation to reduce risk of disturbance or misuse. Placement in RCRA-permitted hazardous waste landfill.
50 - 2,000 pCi/g	Disposal in accordance with 40 CFR 192 (uranium mill tailings) either in RCRA-permitted hazardous waste site or NORM disposal site.
>2,000 pCi/g	Disposal at a licensed Low Level Radioactive Waste (LLRW) disposal site.

The EPA also recognized that, under 40 CFR Part 403, discharges that would interfere with wastewater treatment operations or sludge disposals are prohibited. In addition, if the accumulation of radioactivity is observed in a sanitary sewage distribution system or in a POTW, the discharge of drinking water treatment waste into the sanitary sewer should be discontinued.

Summary

Based on the information presented above (the NRC and IDNS/IEMA regulations, the ALARA principle and the EPA guidelines), it is my opinion that disposal of water treatment sludge/residual containing radium into the sanitary sewer or via land application is inappropriate due to the potential unnecessary exposure and risk to POTW workers, the public and the environment. These exposures and risks can be eliminated by disallowing disposal of water treatment sludge into the sanitary sewer or land application and instead requiring disposal of the material directly into a permitted solid waste, RCRA, NORM or licensed LLRW disposal facility, commensurate with the radium concentration in the sludge, where it will be isolated from the public and maintained in a controlled manner.

VII. ADVERSE EFFECTS ON BIOTA ASSOCIATED WITH EXPOSURE TO RADIONUCLIDES

No one disputes that radium is a human carcinogen. It is common knowledge in the environmental community that human carcinogens are carcinogens or create harmful effects on other living organisms. Of course, often biota and animals are used to screen chemicals to determine if those chemicals also cause adverse health effects, such as cancers, in humans.

In reviewing the transcripts of the hearing, I was struck by the testimony to the effect that the IEPA had done a literature search and found no literature indicating that radium was harmful to aquatic and terrestrial biota. (See Hearing Transcript dated April 1, 2004 at 24:9-11 and 26:12-24.) The scope of the literature search was not given.

There has, in fact, been a great deal of scientific study of the effect of ionizing radiation on terrestrial and aquatic biota. Just one example is the National Council on Radiation Protection and Measurements, Report No. 109 entitled "Effects of Ionizing Radiation on Aquatic Organisms," which references in excess of 50 publications on this topic. A second example is the Biota Dose Assessment Committee established by the DOE that has broad representation from DOE offices, national laboratories, universities and the private sector (BDAC).

A description of the BDAC can be obtained from the BDAC web page at http://homer.ornl.gov/oepa/public/bdac, and the information contained is too voluminous for this testimony. The BDAC has reviewed and commented on the numerous studies relating to the adverse effects of radioactivity on biota and also references in excess of 50 sources.

Clearly, there are reports and studies that are available and that could be used by the IEPA to conduct studies to assess impacts of radium on biota. It is not accurate to claim either (a) that there is no literature on the subject or (b) that there is no evidence that radionuclides in a particular radium cause harm to aquatic and terrestrial biota.

VIII. CONCLUSIONS

- Radium and its by-products are known carcinogens to animals and humans.

- There is scientific literature available with respect to the adverse impacts of radium on aquatic and terrestrial biota.

- Radionuclides including radium, disposed of in the sanitary sewer, have created significant economic and operations impacts to the POTWs.

- The removal of radium by HMO and certain other processes from the groundwater creates an "insoluble waste" (i.e., particulates). NRC and Illinois Department of Nuclear Safety regulations prohibit the disposal of "insoluble waste" into the sanitary sewer. The Illinois Environmental Protection Agency is allowing the disposal of insoluble radium waste to be disposed of in the sanitary sewer. This appears to be inconsistent with their sister agency's prohibition on insoluble waste being released into the sanitary sewer system.

- Radium concentration (ISCORS data) in POTW influent and concentrated sludge has been shown to result in elevated potential POTW worker and public exposures. A POTW sludge loader is estimated to receive 420 mRem/yr dose (from radium/radon) at sludge concentrations of Radium-226 and Radium-228 of 13 and 5.1 pCi/g, respectively. (ISCORS dose modeling.) This is greater than 4 times the allowable limit to the general population (100 mRem/yr).

- ISCORS did not model unique isolated instances in which higher levels of radium were released into sanitary sewers. WRT/ARS demonstrated, via their POTW operations data and dose modeling approach similar to ISCORS, that POTW operators' exposure could be greater than the 100 mRem/yr limit without the radon contribution. With the radon contribution included, the POTW worker dose would approach and could exceed that of a nuclear power plant radiation worker (5,000 mRem/yr).

- The As Low As Reasonably Achievable (ALARA) principle is a fundamental objective of all DOE, EPA, NRC and State radiation projects. Program procedures and engineering controls are used to maintain exposures to workers and public ALARA. Allowing the disposal of radium residue into the sanitary sewer resulting in unnecessary exposures to POTW workers, the public and the biota rather than requiring treatment (engineering control) and disposal (via permitted RCRA or licensed NORM or LLRW disposal facility procedure) is inconsistent with the ALARA philosophy.

- The EPA recommends against land application of any sludge containing elevated radium levels.

- The EPA is investigating the issues associated with elevated levels of radium in filtrate from treatment of groundwater for drinking water consumption. However, the guidance from the EPA supports a prohibition on the discharge of filtrate with elevated levels of radium from a drinking water treatment plant.

Based on the above, it is my opinion that radium-contaminated water treatment sludge/residuals should not be allowed to be disposed of in the sanitary sewer via dispersion, but should instead be disposed of in an environmentally safe, secure and isolated permitted landfill or licensed disposal facility. I would recommend to the Pollution Control Board that it retain a radium general water quality standard and adopt a specific prohibition on disposal of water treatment sludge/residuals in the sanitary sewers.

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 Theodore G. Adams 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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