Electronic Filing, Received, Clerk's Office, August 15, 2005

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 15, 2005 Water Remediation Technology LLC, by its undersigned attorneys, electronically filed with the Office of the Clerk of the Illinois Pollution Control Board of the attached ***COMMENTS SUBMITTED ON BEHALF OF WATER REMEDIATION TECHNOLOGY LLC AT THE CLOSE OF THE SECOND FIRST NOTICE COMMENT***, a copy of which is served upon you.

Dated: August 15, 2005

Respectfully submitted,

By: ______________________
One of the Attorneys for Water Remediation Technology LLC

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THIS FILING IS BEING SUBMITTED ON RECYCLED PAPER

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COMMENTS SUBMITTED ON BEHALF OF WATER REMEDIATION TECHNOLOGY LLC AT THE CLOSE OF THE SECOND FIRST NOTICE COMMENT

Water Remediation Technology LLC ("WRT"), by its undersigned attorneys, submits its comments on the Second First Notice, issued by the Illinois Pollution Control Board (the "Board") on April 7, 2005. WRT applauds the Board for attempting to come up with a reasonable and reasoned proposal. Clearly, the Illinois Environmental Protection Agency (the "Agency" or the "IEPA") had not given the Board a viable proposal. In these comments, WRT urges the Board to: (1) remove subparagraph (d) from the proposed revision to 35 ILL. ADMIN. CODE § 302.207; and (2) take further action to address the improper disposal of radium residuals by sludge application to cropland. In support hereof, WRT submits the following comments.

I. THE BOARD'S PROPOSAL TO ADOPT A 3.75 pCi/L WATER QUALITY STANDARD IS CONSISTENT WITH THE RECORD, BUT THE BALANCE OF THE PROPOSAL IS CONTRARY TO THE RECORD AS WELL AS TO FEDERAL AND STATE LAW

A. The Board's Proposal to Adopt a 3.75 pCi/L Water Quality Standard is Consistent with the Record. No Further Exception is Needed

In its April 7, 2005 Order (the "Order"), the Board made several findings with which WRT concurs, and which are supported by the record:

- There is a need to maintain a general water quality standard protective of both human health and riparian mammals. (P. 1 at ¶ 2.)

- Compliance also must be reasonable for Northern Illinois Publicly Owned Treatment Works ("POTWs") located in areas where naturally occurring radium is prevalent in source water. (P. 1 at ¶ 2.)

- The studies presented in the record demonstrate that radium can adversely impact aquatic biota in addition to humans. (P. 12 at ¶ 2.)

- Because radium is bioconcentrating and bioaccumulating and persists in the environment for so long (Radium 226 has a half life of 1600 years), conservative assumptions are appropriate to protect human health and the environment at this time. (P. 12 at ¶ 2.)

- It is appropriate to promulgate a water quality standard protective of the environment, including riparian mammals, as well as human health. (P. 16 at ¶ 4.)

- The Department of Energy Biota Dose Assessment Committee technical standard provides sufficient scientific basis and support for establishing a general water quality standard for radium. (P. 16 at ¶ 5.)

- The cost to human health and the environment from discharging concentrations of radium above protective levels in the waters of our State is even greater than any costs of compliance. (P. 22 at ¶ 2.)

- The record indicates that radium negatively impacts aquatic life and riparian mammals in addition to humans. (P. 24 at ¶ 3.)

- The Agency's proposal fails to protect the most sensitive use of the State's water and, accordingly, the general water quality standard for Radium 226 and 228 must be retained to afford protection to the most sensitive use, the protection of riparian mammals. (P. 24 at ¶ 3.)

- The DOE technical standard provides the necessary guidance to establish a water quality standard for Radium 226 and 228 applicable to general use waters and Lake Michigan's basin. (P. 24 at ¶ 4.)

- The Board's general use standard will be protective of human health and the environment including aquatic life and riparian mammals, and assure that high levels of radium cannot be discharged into Illinois waterways. (P. 25 at ¶ 1.)

At the time the Board went to its Second First Notice in April, the impression given the Board by the Agency and by the municipalities was that <u>every</u> municipality treating its well water supply needed regulatory relief from the 1 pCi/L existing water quality standard for Radium 226. But there really was no data on existing water quality conditions. See Comments Submitted on Behalf of WRT at pp. 5-6 and n.1 (hereinafter referred to as "WRT Comment").

The City of Joliet and other municipal agencies apparently heard this complaint, and have endeavored to provide information regarding existing water quality conditions. WRT applauds their efforts and have reviewed their sampling data. Indeed, WRT has incorporated that data into this public comment as Attachment 1.

However, those data do not support the relaxation that has been requested here by Joliet and other POTWs, nor that now is proposed by the Board. The highest level detected from six different points in the Des Plaines River, Hickory Creek, and in the DuPage River was 1.1 pCi/L for Radium 226. That was in an "upstream sampling" point in the Des Plaines River at Jefferson Street. There were several samples below detection limits. But, even if the combined total for Radium 226 and 228 was at the detection limits, the highest combined Radium level found still is less than 2 pCi/L. This is hardly a compelling case for any regulatory relief for dischargers into the waters of the State!

Nevertheless, WRT does support the use, by the Board, of the best information in the record. Recall, however, that the 3.75 pCi/L is not conservative nor does it consider all potential impacts. It specifically does not include any sediment component, nor does it include the effect on endangered species. The record here makes manifest that sediment concentrations can become significant, and that the buildup in particular species may exceed the DOE recommended safety level. Therefore, the 3.75 pCi/L value should not be viewed as conservative.[1]

The Board has expressed concern that many communities would not be able to meet a water quality standard of 3.75 pCi/L. But the record shows just the opposite. It appears that most communities can meet the 3.75 pCi/L proposed standard. And that is even before one applies the averaging factors allowed for grab and composite sampling, or before mixing in the receiving stream. See 35 ILL. ADMIN. CODE § 304.104.

Table 1 - Radium Community Sample Summary for Northern Illinois

Community	Date	Treatment	Influent Combined Radium 226 and 228	Effluent Combined Radium 226 and 228
Joliet Eastside WWTP *Average***	2/04 to 5/05	*None*	*5.9***	***4.2*****
Joliet Westside WWTP *Average***	2/04 to 5/05	*None*	*7.5***	***2.8*****
Channahon	4/15/05	*Yes*	--	***1.9 +/-0.9***
Community A *Average***	7/00 to 2/01	*Unknown*	***6.2***	***2.9***
Average [footnoted data excluded from average]	2/03 to 9/03	*Unknown*	*11.7*	***6.2***
Average	1/04 to 6/04	*Unknown*	***8.7***	***5.2***
Community B	4/28/05	*Unknown*	***5.9 +/-0.8***	***5.9***
DeKalb Sanitary Dist.	5/10/05 - 5/11/05	*Yes*	***5.3 +/-1.8***	***1.7 +/-0.8***
Monmouth Main	5/11/05	*Yes*	--	***1.0 +/-0.5***
Monmouth North	5/11/05	*Yes*	--	***<0.6***
Romeoville	4/15/05	*Yes*	--	***1.2 +/-0.6***

All data, except Averages, reproduced as reported by City of Joliet [Attachment 1].

[1] See Comments Submitted on Behalf of Water Remediation Technology LLC at 13-14, Dec. 8, 2004; Comments Submitted by Theodore Adams, Brian Anderson, and Charles Williams at 2-3, Dec. 8, 2004; Post-Hearing Comments of the Sierra Club and the Environmental Law and Policy Center at 8, Dec. 8, 2004.

** Averages for Joliet and "Community A" plants taken from Attachment 1, without calculating "range" included for reported data. For the Joliet plants, since the upper range reported is less than the average of the data reported, and because Joliet did not report how many samples were taken to produce the 2005 values, it is likely that a true statistical average may be less than the mean of the 3 reported values presented here for Joliet's plants. At this level of analysis, without knowing stream flows, more precise calculations would not change this analysis. WRT has averaged effluent samples over roughly an annual period of time to suggest the effect of a longer term average.

Table 1 is taken from the data provided by the City of Joliet (Attachment 1). Looking at Table 1, one sees that over half of the POTWs appear to have average effluent values within the proposed 3.75 pCi/L, without applying any mixing zone or considering the downstream data. Interestingly, each of these communities with effluent below 3.75 pCi/L already has installed treatment to meet the radium drinking water standard. Further, it appears that the Joliet East Side Treatment Plant and Community A[2] discharge into the Des Plaines River or the Chicago Sanitary and Ship Canal, and that data shows <u>no</u> water quality standard exceedance. Thus, only Community B has a discharge that might not meet the proposed water quality standard after mixing.

Community B presents somewhat of an anomaly since the effluent appears to be the same concentration as the influent (5.9 pCi/L), and there is only one data point. One would expect some removal of radium across a treatment works (the record previously showed removal of 20% to 80% of radium across a POTW plant, and the other treatment plants in Table 1 also reflect some removal from influent to effluent). Even removal of less than 50% across this treatment plant would allow Community B to meet the proposed water quality standard, at the point of discharge -- even if it were discharging into a zero-flow stream. Or, if Community B discharged into a stream with low flow equal to that of the plant, an upstream concentration of

[2] Given the intensity of sampling presented by Community A, the only other participant with a record of such intense sampling is the Metropolitan Water Reclamation District of Greater Chicago for its Lemont facility. We believe that plant discharges into the Sanitary and Ship Canal, which is a secondary contact water and not subject to the existing 1 pCi/L standard.

1 pCi/L (the highest sample result in the Joliet data) would allow for compliance after mixing. Thus, in light of the actual water quality data collected, there is no apparent need for any relaxation beyond the proposed standard of 3.75 pCi/L.

WRT recognizes that there may be unique site-specific conditions in Community B (or even Community A) that might make it difficult to meet a water quality standard of 3.75 pCi/L. However, site-specific issues of that sort are not apparent from the record. Moreover, unique site-specific issues are why the Board provides for adjusted standards and site-specific rule changes. It is certainly no basis for setting statewide policy for a carcinogen.

B. Even if the Data Indicated a Need for Higher Discharge Levels, Federal and State Law Precludes the "One Mile Exemption" Approach Suggested by the Board

Proposed Section 302.207(d) eviscerates the water quality protections intended by the 3.75 pCi/L standard, as well as all of the very specific rules on mixing zones and related issues.[3] In these low-flow streams, terrestrial animals are even more likely to be exposed than in the larger river settings. This proposal is contrary to the Environmental Protection Act, the Clean Water Act, and other requirements.

WRT agrees with the U.S. EPA's concern that the 30 pCi/L "one-mile exemption" provides no level of protection consistent with the designated use:

> There does not appear to be any technical or scientific justification for creating a categorical exemption from a water quality standard intended to protect aquatic life and wild life for a mile downstream of the water discharge. In addition, it is not clear how the proposed 30 pCi/L standard would be implemented to protect possible downstream public water supply intakes.

[3] See 35 ILL. ADMIN. CODE § 302.102 (Allowed Mixing, Mixing Zones and ZIDs) and § 302.105 (Anti-degradation). If discharges of a carcinogen such as radium can be excused from rules for mixing based on cost, what about other chemicals, naturally occurring or not?

See June 10, 2005 letter to Amy Antonioli from Linda Holtz, Chief Water Quality Branch. (Attachment 2.) Based on our review of federal and state law, the U.S. EPA's point should be accepted by the Board.

The Board determined that riparian animals living in or near the water are the group of organisms with the most sensitive use, and further concluded that a combined concentration limit of 3.75 pCi/L provides the appropriate level of protection. Opinion and Order of Ill. Pollution Control Bd., at 25, Dkt. No. R-041 (Apr. 7, 2005). However, while no evidence or testimony [other than as to the savings of the WRT technology introduced in Exhibit 3 to the Testimony of Charles Williams] was presented regarding the relative costs for radium removal, the Board asserted that "POTWs in communities using high radium groundwater as the raw water source must receive regulatory relief." Id. at 19. To provide this relief, the Board proposed a separate limit of 30 pCi/L combined Radium 226 and 228 applicable to stream segments within one mile of an outfall from POTWs accepting high radium wastewater. Id. This one-mile categorical exemption is not a "mixing zone" subject to the requirements of 35 ILL. ADMIN. CODE § 302.102, but rather a separate general use standard.[4] Id. at 25. The Board ultimately concluded that the one-mile exemption to the general use standard of 3.75 pCi/L combined radium is appropriate, as it allows "POTWs to continue operations without incurring significant costs, while at the same time protecting human health and the environment." Id. at 25.

Noticeably absent from the Order, however, is any evidence to support the Board's assertion that the separate limit of 30 pCi/L combined radium will protect human health and the environment. Nor does the Order contain any technological or scientific justification for creating a different one-mile exception from general use water quality standards designed to protect

[4] See 35 ILL. ADMIN. CODE § 302.102, which limits the portion volume and area in which "mixing" is permitted.

riparian animals. Moreover, the Order does not discuss how the 30 pCi/L combined radium standard will be implemented, nor does the Order explain how one mile, as opposed to any other distance, provides the dilution necessary to allow POTWs to meet the 3.75 pCi/L general use standard.[5] In fact, there is no such information in the record. And even if there were, considerations of cost cannot be used to create a separate general use water quality standard unless the Board changes the designated use of all those streams one mile below a POTW!

The Clean Water Act ("CWA") requires criteria designed to protect designated uses be "based on sound scientific rationale." 40 C.F.R. § 131.11(a)(1); see also People of Ill. v. Pollution Control Bd., 103 Ill. 2d 441, 450-52, 469 N.E.2d 1102, 1107-08 (1984). For water with multiple-use designations, the criteria must support the most sensitive use. 40 C.F.R. § 131.11(a); see, e.g., Natural Resources Def. Council, Inc. v. U.S. Envtl. Prot. Agency, 16 F.3d 1395, 1405 (4th Cir. 1993). Economic factors, such as the cost of compliance, are not considered by the U.S. EPA in determining whether a state's proposed criterion is protective of designated uses. See Miss. Comm'n on Natural Resources v. Costle, 625 F.2d 1269, 1277 (5th Cir. 1980). Rather, the U.S. EPA's review is focused on whether the proposed criterion is "scientifically defensible and protective of the designated uses." Natural Resources Def. Council, 16 F.3d at 1401.

In People of Ill. v. Pollution Control Bd., the Illinois Supreme Court considered whether the Board's decision to repeal water quality standards governing maximum levels of fecal-coliform in recreational waters and to amend the bacterial effluent standard to apply only to discharges within 20 miles of public beaches contravened state and federal law. 103 Ill. 2d at

[5] Given the data only now provided by Joliet (that it had sampled its effluent in 2004 and found the levels to be less than 6.2 pCi/L), we wonder why Joliet sought an effluent level of 60 pCi/L, nearly ten times higher in its prior Comments!

443-44, 447-48, 469 N.E.2d at 1104-06. In support of the revised standards, the Board argued the bacterial criterion did not serve as an appropriate measure of water quality and a 20-mile effluent limitation adequately protected recreational uses. 103 Ill. 2d at 446, 469 N.E.2d at 1106-07. In addition, the Board asserted the 20-mile buffer zone was appropriate, based on testimony from the IEPA that "more than 90% of the State's wastewater treatment plants complied with the effluent standard, but the in-stream fecal-coliform measurements exceeded the maximum about 50% of the time due to sources such as agricultural run-off." 103 Ill. 2d at 451, 459 N.E.2d at 1108.

In striking the Board's revisions, the Court found that the Board acted arbitrarily and capriciously, as the revisions were not supported by evidence in the record or based on any scientific rationale. 103 Ill. 2d at 450-52, 469 N.E.2d at 1107-08. Specifically, the record demonstrated the primary motivation behind the revised water quality standards was to relieve a regulatory burden by minimizing the expensive discharge chlorination process used to treat sewage and wastewater. 103 Ill. 2d at 445-46, 469 N.E.2d at 1105. Moreover, considering the appropriateness of the 20-mile buffer zone, the Court concluded that persistent violation of the existing standard was "scarcely a reason to relax a rule which precludes licensed discharges from further contributing to [the] problem." 103 Ill. 2d at 451, 469 N.E.2d at 1108.

Similarly, in Costle, the Court affirmed the U.S. EPA's rejection of Mississippi's proposed general use standard for dissolved oxygen, determining that the U.S. EPA's decision to require the state to adopt nationally recommended criteria was based on sound scientific rationale. 625 F.2d at 1277-78. There, the state commission argued that Mississippi's topography and climate "result[ed] in naturally low DO concentrations" and the U.S. EPA "improperly failed to consider economic factors in evaluating the [State's] DO criteria." Id. at

1274. The Court explained that, while states may consider economic factors in designating uses, "those factors are irrelevant to the scientific and technical factors to be considered in setting criteria to meet those uses." Id. at 1277.

Here, the Board's proposed standard of 30 pCi/L combined Radium 226 and 228 for areas within one mile of an outfall from POTWs receiving wastewater with high radium concentration is not "based on sound scientific rationale," as required by the CWA. 40 C.F.R. § 131.11(a)(1). First, like the revised water quality standards governing maximum levels of bacteria in recreational waters and the proposed 20-mile buffer zone rejected in People of Ill. v. Pollution Control Bd., the 30 pCi/L combined radium standard was created for the sole purpose of relieving a regulatory burden and is not supported by the record or based on any scientific rationale. 103 Ill. 2d at 450-52, 469 N.E.2d at 1107-08. Absent from the Order is any evidence or explanation that the 30 pCi/L combined radium limit within a one-mile mixing zone provides the level of protection necessary to protect designated uses, much less the most sensitive use. In fact, the only justification offered is a one-line unsupported statement: "the Board presently believes that a 1-mile segment of the stream should provide an adequate mixing zone for POTW discharges to comply with the proposed general use standard of 3.75 pCi/L[.]" Opinion and Order of Ill. Pollution Control Bd., Dkt. No. R-041, p. 25 (Apr. 7, 2005). Without any additional justification, the 30 pCi/L one-mile limit cannot be reconciled with the 3.75 pCi/L value.

Second, the existence of a naturally occurring radium belt in Northern Illinois is not a relevant consideration in setting criteria to protect designated uses. See Costle, 625 F.2d at 1274. In Costle, the Court affirmed the U.S. EPA's disapproval of water quality standards designed to accommodate low levels of dissolved oxygen naturally occurring in Mississippi waterways. Id. at 1278. Specifically, the Court held that economic factors, such as compliance issues, are "irrelevant to the scientific and technical factors to be considered in setting criteria" to protect designated uses. Id. at 1277. Thus, while the Board may have properly considered the economics of a community in designating water uses, it cannot consider this factor in setting criteria protective of those uses. Id.

Moreover, while states are not required to develop a single criterion protective of humans and the environment, any criterion established must be protective of the water's most sensitive *designated* use. 40 C.F.R. § 131.11(a); see also Natural Resources Def. Council, 16 F.3d at 1405. The record contains no evidence that the 30 pCi/L limit provides protection for either purpose; indeed, the Board found that the 3.75 pCi/L standard was necessary and appropriate.

Finally, the record shows there is no need for this exemption zone at all. There is no clear evidence demonstrating that any communities cannot comply with the 3.75 pCi/L standard after mixing. Further, there is no evidence that treatment technology to meet the existing, or the proposed, combined radium water quality standard is not affordable. Nor is there any evidence demonstrating that applying a one-mile exemption will make a difference and allow compliance.

The Joliet data entitled "Well Sample Results for Wells Pumped to Storm Sewers with No Dilution in the First Mile Downstream" is unclear as to its relevance. The data shows that even after a one-mile exemption zone, water quality would not meet the 3.75 pCi/L standard. But the water sampled is obviously not treated drinking water or a POTW discharge. All potable water will be treated in the future and any direct pumping will not be at elevated levels. Therefore, this information appears to indicate that the exemption zone concept will not allow for compliance for dischargers into zero-flow or low-flow streams.

Accordingly, the Board should delete the proposed standard because it is not supported by the record, not scientifically defensible, and not protective of the most sensitive designated use, i.e. riparian animals. The one-mile exemption zone is contrary to federal and state law, and unsupported by the record. WRT urges the Board to delete proposed subparagraph (d) from the proposed Section 302.207.

II. THE AGENCY FAILED TO ADDRESS THE RESIDUAL SOLIDS OR SLUDGE; THE ISSUE MUST BE ADDRESSED IN THIS PROCEEDING

In its original comments, WRT urged the Board to proceed carefully and authorize relief only for those communities who needed it. WRT continues to recommend that policy to the Board. But, while WRT supports the Board's choice of the 3.75 pCi/L standard, there remains a critical issue that WRT urges the Board to address by opening an inquiry docket, or present a warning comment on the amended rule.

A. The U.S. EPA's Policy is to Require Disposal of Radioactive Solid Residues into Landfills

Since the August 2004 hearing, the Agency has asserted that "the sludge issue" is not a part of this proceeding. But that issue actually is the major issue in this proceeding. It has been obvious since the October 2004 hearing that how the residual radionuclides are managed is part and parcel of this proceeding because it affects the decision made for communities to install technology to meet the drinking water standard.

If the Board has any doubts, consider the following sequence:

- On September 21, 2004, then Director Cipriano wrote a letter to the U.S. EPA's Acting Assistant Administrator for the Office of Water. The letter stated that about 100 community water suppliers in Illinois "are in the process of complying with the Radionuclides Regulations . . . and are relying on Illinois EPA's advice and guidance on the proper residual disposal practice that can be employed. These systems are in the process of making decisions on alternatives for compliance that involve the commitment of millions of dollars and obligate the communities to a number of years of financial burden . . . ."

See Attachment 3 hereto, p. 2. Several months later, the U.S. EPA replied:

> [U.S.] EPA appreciates the difficult decisions that drinking water systems must make to comply with drinking water standards for radionuclides . . . [U.S.] EPA recognizes that systems will be seeking cost-effective solutions for these management issues, but has consistently expressed concern about the potential creation of new contaminated sites that would someday require remediation and/or the use of institutional or engineering controls.

See Attachment 4 hereto, p. 1 (emphasis added; quotations omitted). The U.S. EPA is advising Illinois that land applying sludge with solid residuals from radionuclide treatment is a risky choice, and one not approved by the U.S. EPA.

The same view is contained in the U.S. EPA's recently released manual, "A Regulators' Guide to the Management of Radionuclide Residuals from Drinking Water Treatment Technologies" (the "Guide"). The Guide is available at epa.gov/safewater/reads/pdfs/regulators_guide_final.pdf. At page 14, in language nearly identical to the March 4 letter, the U.S. EPA states:

> U.S. EPA is aware that some states allow land spreading or soil mixing as an alternative to landfill disposal for water treatment residuals. One central concern with land spreading 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.

(Emphasis supplied.) And if there were any doubt that the U.S. EPA disapproves radionuclide residuals from water treatment being applied to crop land, then consider the Guide's "Decision Tree 1: Solids Residuals Disposal." See Attachment 5 hereto, p. 17 of the Guide. All of the solids disposal options in Decision Tree 1 are to some sort of a landfill: a Low Level Radioactive Waste ("LLRW") landfill, a hazardous waste, RCRA Subtitle C landfill, or an authorized "mixed waste" landfill.

This issue should not be ignored by the Board. It is a critical issue not only for human health and the environment, but also of fiscal prudence for Illinois communities in evaluating all the economic and technological risks in deciding how to comply. While it would have been better if the U.S. EPA had issued these guidelines sooner, the U.S. EPA clearly is proceeding toward regulatory action. Water treatment plants built on the assumption that radioactive residuals may be disposed of in any manner now allowed may be faced in the future with an expensive retrofit -- or expensive landfill disposal costs.

B. Recent Information Underscores the Public Health Threat of Discrete Radioactive Particles

The effect of the action of the IEPA and the Illinois Emergency Management Agency (the "IEMA") to date is to leave unregulated discrete radioactive particles when handled by municipal treatment workers. These treatment workers are not being protected currently by the IEMA, and it appears that the IEPA is not desirous of becoming involved in these materials. As the Board knows, WRT did submit its technology to licensing by the IEMA. (Exhibit 17.) No other technology has done so. And the IEMA is not taking action to regulate municipal sources even if they produce high-level radioactive materials.

Two recent reports underscore the importance of the Board protecting public health and the environment by addressing what happens to the radioactive materials once they are removed from the well supply. Attachment 6 is a statement issued by the Health Physics Society and the Organization of Agreement States. These entities are intimately involved in protecting human health and the environment with respect to radioactive materials. Consider their assertions:

- Discrete sources of technical enhanced natural occurring radioactive material ("TENORM") and accelerated produced radioactive material should be uniformly regulated throughout the United States. TENORM is defined as "naturally occurring radioactive material that has been removed from the natural environment and has concentrated levels greater than found in the natural environment due to human activities (indoor Radon, because it is not technologically enhanced, should be specifically exempt from this provision for discrete sources)."

- . . . the term 'discrete' . . . should include both an activity limit and a concentration limit on any such source, such as the radiological hazards are controlled in a manner consistent with other sources of radioactive material posing the same radiological hazard.

- Disposal . . . should be allowed at facilities licensed by the NRC, . . . in such a manner that (a) does not change the definition of low level radioactive waste and the Low-Level Radioactive Waste Policy Amendments Act of 1985; and (b) does not adversely effect the implementation of congressionally approved Compacts... thus preventing such sources from becoming "orphan" from disposal.

(See Attachment 6 hereto, p. 2.)

The most recent review of the toxicology associated with radioactive particles confirms the need for continued vigilance. The National Academy of Sciences just published its updated review of health risks from exposure to low levels of ionizing radiation. (See Attachment 7.) This report continues to support the stringency of the U.S. EPA's rules for exposure, which require disclosure to affected members of the public (and non-nuclear plant workers) of exposure to elevated levels of radiation. This disclosure requirement -- to workers and members of the public alike -- is an important safety precaution. It is one of the requirements that comes with being licensed by the IEMA. It is a requirement that WRT undertakes by being licensed by the IEMA, but those same risks exist for all those communities that are "treating" well water to meet the federal drinking water standard for radionuclides.

The U.S. EPA also is warning that treatment plants with elevated radionuclide levels should take safety precautions so as to not endanger their workers:

- Systems need to determine whether a radiation problem exists and, if it does take appropriate safety precautions to prevent or limit water system staff members' exposure to radiation. For example, if a system tested its treated water 2 years ago and found levels of 3pCi/L for radium-226 and 228, a radiation survey of the facility would be prudent.

- If radionuclides or radiation have been found in drinking water or at a system, having operators who are trained in treating for radionuclides, and handling, disposing of, and transporting TENORM waste, is highly recommended.

- Shower after exposure to potentially radioactive materials and launder work clothing at the system if possible. If laundering equipment is not available, workers should deep and wash work clothing separately and avoid wearing contaminated clothing into the home. Work boots or shoes should be wiped and cleaned after potential contamination. They should stay at the system or not be worn into the home.

See Guide at pp. 22, 24, 25 (Attachment 8). Since radium cannot be smelled, tasted or felt, workers will not know that they are being exposed to a carcinogen, unless notified.

The U.S. EPA has documented its concerns relating to radionuclide exposure for POTW workers:

> [U.S.] EPA is concerned about TENORM for three reasons. First, TENORM has the potential to cause elevated exposure to radiation. Second, people may not be aware of TENORM materials and need information about them. Third, industries that generate these materials may need additional guidance to help manage and dispose of TENORM in ways that protect people and the environment and are economically sound.

(Attachment 9.) The U.S. EPA has listed some ten categories of activities where TENORM is known to occur.[6] Of all these listed, filters at water treatment plants have the highest radiation loading -- 40,000 pCi/g on average! See Attachment 10; TENORM Source, Summary Table, at www.epa.gov/radiation/tenorm/source_table.htm.[7]

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[6] The other wastes with TENORM of concern to EPA are Geothermal Energy Waste Scales, Petroleum, Aluminum, Coal and Coal Ash, Copper Waste Rock, Phosphate Ores and Phosphogypsum, Rare Earths, Titanium Ores, Uranium and Zircon. (See Attachment 10.)

[7] The high levels of Radium 226 and 228 on water treatment sludge is 11,686 pCi/g. Such a level is several times higher than the level of radiation in the Uranium tailings that, after being used as backfill at Reed-Keplar Park in West Chicago, had to be removed and disposed of. (See Attachments 11 and 12.) These data demonstrate that in light of the persistence and extended half-life of radium residuals, repeated spreading of sludge with elevated radium residuals on land could lead to a CERCLA cleanup.

These statements by the U.S. EPA support and are consistent with the exhibits and testimony provided to the Board by WRT.[8] Clearly, the discrete radioactive particles that can be produced by treating of radium-contaminated well water are capable of producing the same radioactive activity as those materials now regulated by the Nuclear Regulatory Commission ("NRC") and Agreement States. By repealing the 1 pCi/L limit for Radium 226, the Board should not open the door for the disposal into waterways of sludge that was previously illegal and regulated. WRT urges the Board to insert a warning comment into its rules with Section 302.207 by calling attention to the Guide. In the alternative, the Board could initiate inquiry hearings on the adequacy of existing regulation programs for radionuclides.[9] The IEPA promised a year ago to have sludge rules proposed to the Board: the unique issues involving radionuclide treatment would appear well-suited to a separate consideration. We submit that the Illinois communities would benefit from such a procedure.

The present regulatory approach, by the IEMA and the IEPA, ignores the issue. It allows POTW management to decide whether to expose its workers to elevated radium levels -- without disclosure to them.[10] It allows the POTW management to decide that TENORM particles will be

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[8] The EPA recommends against land application of any sludge containing elevated radium levels. (Tr. August 24, 2004 p. 24 lines 7-8; see also Hearing Exhibit 4 Tab I.) The EPA is investigating the issues associated with elevated levels of radium in filtrate and backwash from treatment of groundwater for drinking water consumption. (Tr. August 25, 2004 p. 24 lines 8-10; see also Hearing Exhibit 4 Tab I.) The guidance from the EPA supports a prohibition on the discharge of filtrate and backwash with elevated levels of radium from a drinking water treatment plant. (Tr. August 25, 2004 p. 24 lines 11-12; see also Hearing Exhibit 4 Tab I.)

[9] Further, pursuant to Section 651 of the Energy Policy Act of 2005, discrete sources of Radium 226 and discrete sources of naturally occurring radioactive material will now be regulated by the NRC, and hence of Agreement States such as Illinois. The forthcoming rules may have a direct impact on certain treatment systems for potable water in northeastern Illinois.

[10] 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. (Tr. August 25, 2004 p. 22 lines 18-21; see also Hearing Exhibit 4 Tab E.) Radioactive particles, disposed of in the sanitary sewer, have created significant economic and operations impacts to the POTWs. (See Hearing Exhibit 4 Tab B.; Tr. August 25, 2004 p. 12 lines 6-16; see also Hearing Exhibit 4 Table 1 p. 7.) ISCORS did not model unique isolated instances in which higher levels of radium were released into sanitary sewers. (Tr. August 25, 2004 p. 23 lines 13-20; see also Hearing Exhibit 4 Tabs D & F.) WRT/ARS demonstrated, via their POTW operations data and dose modeling

in its sludge that it distributes on farmland -- without notice to the farmers.[11] This lack of disclosure vitiates any informed consent.

These appear to be the unintended consequences of the Board's effort to be "reasonable" with regard to the POTWs. WRT is concerned that the desire to minimize near term costs will create longer term liabilities. And, in any event, there is no evidence in the record that removal of radioactive particles from sewer discharges (and hence from going onto the land or exposure by the treatment plant workers) will cost any more.[12]

C. The Board's Proposal Violates Applicable Illinois Law Due to Its Failure to Address the Re-Introduction of Radioactive Residuals into the Environment Following Treatment of Well Water

The Board acknowledges the deleterious effects of radium as a bioconcentrating, bioaccumulating, human carcinogen and mutagen. Radium 226 has a half life of 1600 years; the particles do not dilute; therefore, radioactive particles discharged in POTWs will perpetually remain highly radioactive. The cumulative impacts of radiation exposure place humans and biota in severe jeopardy.

The General Assembly has provided unambiguous instruction to prevent the intentional release of radioactive particles into sewers and waters of the State of Illinois. The Illinois Pollution Prevention Act, the Illinois Groundwater Protection Act, the Illinois Low Level

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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). (Tr. August 25, 2004 p. 23 lines 13-20; see also Hearing Exhibit 4 Tab J.)

[11] 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). (Tr. August 25, 2004 pp. 14 -17; see also T. Adams August 11, 2004 Pre-filed testimony Table 5 p. 16.)

[12] ". . . Mr. Williams (WRT) states the cost of treatment systems that do not dispose of radium to the sewer or streams is competitive or lower than systems that do. For example, Mr. Williams states that the communities of Oswego and Elburn . . . will save $2 and $2.6 million, respectively, over the life of their treatment technology contract." (See April 7, 2005 Board Opinion and Order at p. 21, ¶ 5; see also Hearing Exhibit 5.)

Radioactive Waste Management Act, the Illinois Endangered Species Act and the Environmental Protection Act all evidence the legislature's clear intent. The Board should fulfill that intent and prohibit the release of radioactive particles, formed by the treatment of groundwater, into POTWs and the environment of Illinois.

For example, the Illinois Pollution Prevention Act was enacted to reduce the disposal and release of toxic or hazardous materials. (415 ILCS 115/5(c) (2004).) It unambiguously states that treatment in an environmentally sound manner should be utilized. The disposal and treatment of toxic or hazardous materials is allowed *only as a last resort*, when treatment of such materials is not possible. (415 ILCS 115/5(b) (2004).) Indeed, one of the Board's purposes is to stimulate pollution prevention strategies. Allowing radioactive particulates to be flushed down a sewer is contrary to that Act.

Moreover, the Illinois Endangered Species Act also precludes adoption of the proposed rule. This Act prohibits the possession, taking, disposal or transport of specimens or products of animals or species of plants in danger of extinction and statewide extirpation. (520 ILCS 10/1 (2004).) Here, the record demonstrates that several endangered species are downstream of the communities that will be treating their radium water supply. (See Hearing Exhibits 1, 2 and 14 Tabs A & E.) All State and local government agencies are directed to enter into a consultation process with the Department of Natural Resources to evaluate whether actions authorized, funded or carried out by the agencies are likely to jeopardize the continued existence of Illinois-listed endangered and threatened species or are likely to result in the destruction or adverse modification of the designated essential habitat of such species. (520 ILCS 10/11 (2004).) That consultation has yet to occur. (See Hearing Exhibit 13.)

The Environmental Protection Act provides that in rulemaking under Section 27(a), such as this one, the Board shall consider various factors in making a decision, including the technical feasibility and economic reasonableness of measuring or reducing the particular type of pollution. The Board need not conclude that compliance with the proposed regulation is "technically feasible and economically reasonable" before it can adopt such a regulation. Monsanto Co. v. Pollution Control Board, 67 Ill. 2d 276, 292-93, 367 N.E.2d 684, 690-91 (1977). If the Board, in its discretion and based on its technical expertise, determines that a proposed regulation is necessary to carry out the purpose of the Act, it may adopt technology-forcing standards that are beyond the reach of existing technology. 67 Ill. 2d at 292-93, 367 N.E.2d at 684, 690-91. In the instant matter, the undisputed testimony is that there are a number of alternative technologies that can achieve the required standard. It is clear to us that the Board failed to consider all of the available information in the record regarding compliance, as required by Section 27(a) of the Act.[13] (See n.12 regarding the lower or competitive cost of treatment systems that do not dispose of radium to the sewer or streams.)

Thus, the General Assembly provides clear instruction to prevent the release of radioactive materials, and especially radioactive particles, into the sewers and waterways of the State of Illinois. Illinois courts consistently have struck down rules adopted by the Board where the Board has acted contrary to directives established by the General Assembly. The clear policy

[13] The Board did not consider the data submitted by WRT, including but not limited to the comments of Charles Williams on December 7, 2004: "The municipal workers in a full scale plant are exposed to only a small increase above background and will be trained and advised of that exposure . . . The three millirem exposure represents only 3 percent of the maximum exposure allowed to a member of the general public from a licensed facility." The Board did not consider this info in referencing the WRT technology. Opinion and Order of Ill. Pollution Control Bd., Dkt. No. R-041, p. 20 (Apr. 7, 2005). Joliet's own consultant found that "none of the processes significantly changed the radon concentrations in the water."

of the State of Illinois is to prohibit the intentional release of radioactive particles into the public sewers and waterways.

III. CONCLUSION

WRT recommends that the Board follow the As Low As Reasonably Achievable ("ALARA") principle. The ALARA principle is a fundamental objective of all DOE, U.S. 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. (Tr. August 25, 2004 p. 23 line 20; p. 24 line 6; see also Hearing Exhibit 4 Tab I.) Not only do the absorptive media technologies, such as that of WRT, 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. (Tr. August 25, 2004 p. 47 lines 21-24 and p. 48 line 1.)

Dated: August 15, 2005

Respectfully submitted,

By: ______________________
One of the Attorneys for Water Remediation Technology LLC

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11923832v6

THIS FILING IS BEING SUBMITTED ON RECYCLED PAPER

Electronic Filing, Received, Clerk's Office, August 15, 2005

CERTIFICATE OF SERVICE

The undersigned, an attorney, certifies that he/she has served upon the individuals listed on the attached Service List true and correct copies of ***COMMENTS SUBMITTED ON BEHALF OF WATER REMEDIATION TECHNOLOGY LLC AT THE CLOSE OF THE SECOND FIRST NOTICE COMMENT*** by First Class Mail, postage prepaid, on August 15, 2005.

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ATTACHMENT 1

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July 29, 2005

Jeffrey C. Fort
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Re: R 04-21 Radium Sampling Results

Dear Mr. Fort and Ms. Reid:

As set forth in Joliet's Motion for additional time, please find the enclosed Summary of Radium Samples for Various Communities in Northern Illinois.

Very truly yours,

Roy M Harsch

Roy M. Harsch

RMH/dmc
Enclosure
cc: Service List

	Date	Radium 226	Radium 228	Combined Radium	
Influent Samples					
Joliet Eastside Wastewater Treatment Plant					
	Feb-04	3	5.3	8.3	
	8-Mar-04	1.9	4.3	6.2	
	12-May-05	1.1 +/- 0.6	2.2 +/-0.7	3.3 +/-1.3	
Joliet Westside Wastewater Treatment Plant					
	Feb-04	2.9	5.1	8	
	8-Mar-04	3.9	6.1	10	
	12-May-05	1.8 +/- 0.6	2.7 +/-0.9	4.5	
Community A					
	Jul-00	4.3 +/- 0.8	1.4 +/-1.0	5.7 +/-1.0	
	8-Feb-01	2.7 +/- 0.1	3.9 +/- 0.1	6.6 +/- 0.1	
	22-Feb-01	2.6 +/- 0.1	3.6 +/- 0.1	6.2 +/- 0.2	
	Dec-02	5.2-8.8	NA	3.7-6.9	Note 1
	Jan-03	0.2-2.2	NA	2.6-4.2	Note 1
	Feb-03	5.6 +/- 1.9	<6.0	11.6 +/6.0	
	Mar-03	3.1 +/- 1.2	5.6 +/- 1.2	8.7 +/- 2.4	
	Apr-03	5.7 +/- 1.9	8.5 +/- 3.0	14.2 +/- 4.9	
	May-03	3.24 +/- 1.48	8.22 +/- 4.23	11.46 +/- 5.71	
	Jun-03	7.38 +/- 2.03	8.82 +/- 2.54	16.2 +/- 4.57	
	Jul-03	6.85 +/- 1.9	1.76 +/- 1.6	8.61 +/- 3.5	
	Aug-03	2.9 +/- 0.9	6.1 +/- 1.7	9 +/- 1.6	
	Sep-03	7.47 +/- 1.7	6.19 +/- 1.6	13.66 +/- 3.3	
	Jan-04	5.75 +/- 1.6	8.12 +/- 2.1	13.87 +/- 3.8	
	Feb-04	5.25 +/- 1.4	3.13 +/-0.96	8.38 +/- 2.36	
	Apr-04	3.87 +/- 1.1	1.86 +/- 0.71	5.73 +/- 1.81	
	Jun-04	3.12 +/- 0.9	3.55 +/- 0.88	6.67 +/- 1.78	
Community B	28-Apr-05	3 +/- 0.2	2.9 +/- 0.6	5.9 +/- 0.8	
DeKalb Sanitary District	11-May-05	0.8 +/- 0.5	4.5 +/- 1.3	5.3 +/- 1.8	

	Date	Radium 226	Radium 228	Combined Radium	
Effluent Samples					
Joliet Eastside Wastewater Treatment Plant					
	Feb-04	1.2	3.9	5.1	
	8-Mar-04	2.6	3.5	6.1	
	12-May-05	<0.7	1.5 +/-0.7	1.5 +/-1.4	
Joliet Westside Wastewater Treatment Plant					
	Feb-04	2	2.9	4.9	
	8-Mar-04	0.9	1	1.9	
	12-May-05	0.6 +/- 0.6	1.6 +/-0.7	1.5 +/-1.3	
Community A					
	Jul-00	2.2 +/- 0.8	1.5 +/-0.9	3.7 +/-1.0	
	8-Feb-01	2.1 +/- 0.1	<1.0	3.1 +/- 0.2	
	22-Feb-01	<0.9	<1.0	<1.9	
	Dec-02	3.0-5.2	NA	3.3-4.9	Note 1
	Jan-03	2.7-5.1	NA	2.7-4.3	Note 1
	Feb-03	3.6 +/- 1.9	<3.8	7.4 +/1.4	
	Mar-03	2.8 +/- 1.2	2.9 +/- 1.2	5.7 +/- 2.4	
	Apr-03	2.8 +/- 1.9	4.2 +/- 1.8	7.0 +/- 3.0	
	May-03	2.26 +/- 1.48	3.97 +/- 1.66	6.23 +/- 2.63	
	Jun-03	2.33 +/- 0.84	3.72 +/- 1.76	6.05 +/- .6	
	Jul-03	1.96 +/- 0.7	3.12 +/- 1.4	5.08 +/- 2.1	
	Aug-03	3.4 +/- 1.0	3.4 +/- 1.2	6.8 +/- 2.2	
	Sep-03	2.88 +/- 0.75	2.47 +/- 1.1	5.35 +/- 1.85	
	Jan-04	3.01 +/- 1.1	3.22 +/- 1.2	6.23 +/- 2.3	
	Feb-04	2.74 +/- 1.0	1.94 +/- 0.75	4.68 +/- 1.75	
	Apr-04	3.43 +/- 1.1	0.54 +/- 0.53	3.97 +/- 1.63	
	Jun-04	3.21 +/- 0.96	2.69 +/- 0.69	5.9 +/- 1.65	

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Department of Public Works and Utilities

	Date	Radium 226		Radium 228	Combined Radium
Community B	28-Apr-05	3		2.9	5.9
Romeoville	15-Apr-05	0.7 +/- 0.1		0.5 +/- 0.5	1.2 +/- 0.6
Monmouth North	11-May-05	<0.6		<6.6	<7.2
Monmouth Main	11-May-05	1.0 +/- 0.5		<6.0	<7.0
DeKalb Sanitary District	10-May-05	<0.3		1.4 +/- 0.5	1.7 +/- 0.8
Channahon	15-Apr-05	1.1 +/- 0.9		0.79 +/- 0.83	1.9 +/- 0.9
Upstream Samples					
DesPlaines River at Jefferson Street	12-May-05	1.1	+/-0.1	<0.7	1.1
Hickory Creek Upstream Joliet ESWWT	12-May-05	<0.1		<0.7	<0.8
Downstream Samples					
DesPlaines River at Brandon Road	12-May-05	<0.7		<0.7	<1.4
DesPlaines River at I-55	12-May-05	<0.1		<0.7	<0.8
Romeoville, 1 mile downstream	15-Apr-05	0.1 +/- 0.1		0.5 +/- 0.4	0.6 +/- 0.5

Prepared by City of Joliet
Department of Public Works and Utilities

	Date	Radium 226	Radium 228	Combined Radium
Other sites				
DuPage River at Caton Farm Road	12-May-05	<0.1	<0.6	<0.7

Well Sample Results for Wells pumped to storm sewers with no dilution in the first mile downstream

	Date	Radium 226	Radium 228	Combined Radium
Williamson Ave	18-May-05	9.9 +/- 0.3	10.8 +/- 1.1	20.7 +/- 1.4
9-D	18-May-05	5.5 +/- 0.2	7.7 +/- 1.0	13.2 +/- 1.2
10-D	18-May-05	6.4 +/- 0.3	7.7 +/- 1.1	14.1 +/- 1.4
11-D	18-May-05	5.6 +/- 0.3	5.4 +/- 0.9	11.0 +/- 1.2
12-D	18-May-05	7.7 +/- 0.3	9.2 +/- 1.2	16.9 +/- 1.5
15-D	18-May-05	2.9 +/- 0.2	4 +/- 8	6.9 +/- 1.4
17-D	18-May-05	2.9 +/- 0.1	5.1 +/- 0.6	8.0 +/- 0.7
18-D	18-May-05	5.8 +/- 0.3	4.5 +/- 0.7	10.3 +/- 1.4
21	18-May-05	3.2 +/- 0.2	2.9 +/- 0.5	6.1 +/- 0.7

Note 1 Due to insufficient sample volume, results are reported as a range. Results are based on statistical average results for multiple analysis

Prepared by City of Joliet
Department of Public Works and Utilities

Electronic Filing, Received, Clerk's Office, August 15, 2005

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

R04-21
PC41

JUN 10 2005

REPLY TO THE ATTENTION OF: WQ-16J

RECEIVED
CLERK'S OFFICE
JUN 14 2005
STATE OF ILLINOIS
Pollution Control Board

Amy Antoniolli
Illinois Pollution Control Board
100 W. Randolph, Suite 11-500
Chicago, Illinois 60601

Dear Ms. Antoniolli:

Recently, the Illinois Pollution Control Board (Illinois PCB) proposed revised water quality standards for radium for General Use waters in Illinois. Illinois' existing radium standard for General Use waters is 1 pCi/L for radium 226. The proposed revision would change the General Use standard to 3.75 pCi/L for radium 226 and 228 in all General Use waters, except for areas within one mile of an outfall from a wastewater treatment plant, "receiving wastewater discharge from public drinking water supplies using ground water with a high radium concentration" where a standard of 30 pCi/L would apply. The United States Environmental Protection Agency, Region 5 (USEPA) has informally reviewed the Illinois PCB proposal and offers the following comments.

There are no national criteria recommendations for radium to protect aquatic life or wildlife, and there are insufficient data to support derivation of water quality criteria for either of these endpoints using USEPA methods. USEPA is unaware of any scientific evidence that would suggest that a standard set at this level would compromise protection of any of the applicable designated uses, and does not anticipate disapproval of the proposed General Use standard of 3.75 pCi/L.

However, USEPA is concerned that the proposal does not include any demonstration that 30 pCi/L within a one-mile mixing zone provides a level of protection consistent with the 3.75 pCi/L value, nor any other independent level of protection for the designated use. There does not appear to be any technical or scientific justification for creating a categorical exemption from a water quality standard intended to protect aquatic life and wildlife for a mile downstream of a wastewater discharge. In addition, it is not clear how the proposed 30 pCi/L standard would be implemented to protect possible downstream public water supply intakes.

USEPA also has questions about the duration and frequency of exceedance associated with the proposed standard. As proposed, it appears that any exceedance of the standard would be considered to indicate impairment of the use. However, the proposed revised standard appears to be based on exposure to wildlife from consumption of contaminated aquatic organisms that might accumulate radium in their tissues from exposure to radium in the water. This type of exposure is long-term and a more appropriate indicator of the level of risk to wildlife is probably some measure of average concentration over time. Therefore, it would appear to be appropriate to express the standard as an average value over some period of time to reflect the concern over longer-term exposure, rather than a value that can never be exceeded. For example, in the Great Lakes Water Quality Guidance (40 CFR 132), USEPA recommends that waste load allocations based on wildlife standard be calculated using the 90-day, 10-year low flow as the design flow. However, if the Illinois PCB chooses to express the General Use standard as a long-term average value, then the Illinois PCB should also establish a 5 pCi/L Public and Food Processing Water Supply standard as an instantaneous maximum standard for public water supply intakes. This would ensure that public water supplies utilizing surface water would meet the Federal drinking water maximum contaminant level for radium.

Finally, we note that USEPA's regulations define "pollutant" to include radioactive materials, except those regulated under the Atomic Energy Act of 1954, as amended. *See* 40 CFR122.2; *Train v. Colorado Public Interest Research Group, Inc.*, 426 U.S. 1 (1976). Although it is appropriate for Illinois to adopt water quality standards for radium, it will be necessary for the State, or USEPA where appropriate, to establish that a particular radioactive material is a "pollutant" before taking other actions under the Clean Water Act (CWA), such as establishing National Pollutant Discharge Elimination System (NPDES) limitations consistent with water quality standards or listing a waterbody or establishing or approving a total maximum daily load under Section 303(d) of the CWA for a waterbody that is not achieving these standards. A radioactive material may be a "pollutant" within the definition of 40 CFR 122.2 in some fact-specific contexts, while not being a "pollutant" within that definition in other fact-specific contexts.

If you have any questions, please feel free to contact me at (312) 886-6758, or Ed Hammer of my staff, at (312) 886-3019.

Very truly yours,

Allen Melcer

for Linda Holst, Chief
Water Quality Branch

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

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James R. Thompson Center, 100 West Randolph, Suite 11-300, Chicago, IL 60601, 312-814-6026

~~Rod R. Blagojevich, Governor~~ — Renee Cipriano, Director

217/782-3397

SEP 21 2004

Mr. Benjamin H. Grumbles
Acting Assistant Administrator
Office of Water
United States Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Grumbles:

The Illinois EPA and Illinois Emergency Management Agency, Division of Nuclear Safety, have been working with the Office of Radiation and Indoor Air and Office of Ground Water and Drinking Water regarding disposal of drinking water treatment residuals containing radium. In particular, our discussions to date have dealt with certain provisions of the draft document, *A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technology*. In addition, USEPA, in cooperation with other federal and state agencies of the Interagency Steering Committee on Radiation Standards, have produced another draft guidance document that deals with disposal of sewage treatment residuals, *ISCORS Assessment of Radioactivity in Sewage Sludge: Recommendations on Management of Radioactive Materials in Sewage Sludge and Ash at Publicly Owned Treatment Works*. The two documents conflict on the issue of land application of these residuals for agronomically beneficial uses, a practice that Illinois initiated in 1984 after considerable evaluation by both state agencies.

In Illinois, disposal of residuals generated at a drinking water treatment plant or sewage treatment plant require that a permit for disposal be obtained from Illinois EPA. The treatment residuals are to be checked for a number of contaminants, including radium, if there is reason to believe radium may be present. Residuals containing 5 picoCuries per gram of radium or less are not considered to pose a threat of significant radiation exposure. Those residuals containing more than 5 picoCuries per gram and up to 50 picoCuries per gram of radium are reviewed for disposal alternatives by both IEPA and IEMA/Division of Nuclear Safety.

Illinois regulations allow that residuals containing 50 picoCuries per gram of radium or less may be buried in an Illinois EPA approved landfill provided there is at least 10 feet of uncontaminated soil cover. For agronomic applications, these residuals may be applied to cropland provided the incremental increase in radium does not exceed 0.1 picoCuries per gram above naturally occurring background levels. Residuals containing more than 50 picoCuries per gram of radium are reviewed individually by IEMA/Division of Nuclear Safety for conformance with Illinois Regulations for Radiation Protection. For certain types of higher concentration residuals, disposal may require shipment to an out-of-state facility that is licensed to accept such wastes.

Allowing use of material with agricultural value to farmers is no different than the fundamental basis for all federal and state regulation of any radioactive materials that have a beneficial use. Following international guidance, the beneficial use of the material in question is weighed against the risks involved and dose or concentration limits are established for the use of the material to limit the dose and risk to the general public. These limits take into consideration a number of factors including natural background and the potential for human exposures. In all areas where USEPA has authority to become involved in radiation protection, the material in question is already a waste or a contaminant.

As I am sure you are aware, USEPA has raised an issue regarding the impacts of implementation of this approach on the management of Superfund sites. The use of a water treatment by-product containing radioactive constituents for beneficial agricultural purposes is very different than the cleanup of a site with known contamination. In a Superfund case, no beneficial use of material containing radioactivity is purported.

Examination of radium site Superfund cleanups does provide a useful comparison in terms of radium concentrations considered protective of human health and the environment. As it happens, the incremental increase in radium concentration that would be permitted under regulated beneficial use of a water treatment plant residual, as is practiced in Illinois and a number of other states, is a small fraction (0.1 pCi/g) of the soil cleanup level of 5 pCi/g above background levels adopted for use at most radium sites. The use of USEPA's own 40 CFR 192 as a human health based Applicable, Relevant and Reasonable Requirement (ARAR) is a widely accepted practice. The incremental increase is also a small fraction of the total radium concentration of 2.2 pCi/g in Northern Illinois natural background.

Of great concern to Illinois EPA is the continued inconsistent position on land application/ beneficial use articulated in the two draft guidance reports noted above, that address the same topic of disposal of residuals containing radionuclides. The conclusions reached in the sewage sludge report indicate that the residuals may be incorporated into agricultural land without undue exposure concerns even though the levels contained in the sewage residuals are at the same levels being found in drinking water treatment residuals. The issue is further confounded by the introduction of a USEPA argument that water treatment plant residuals should be handled the same as for waste materials involved in a Superfund radiation cleanup project. It is not clear why USEPA is differentiating between sewage treatment plant and water treatment plant residuals that have essentially the same level of radium. Illinois is asking that USEPA be consistent in its approach.

Illinois has about 100 community water supplies that are in the process of complying with the Radionuclide Regulations and are relying on Illinois EPA's advice and guidance on the proper residual disposal practices that can be employed. These systems are in the process of making decisions on alternatives for compliance that involve the commitment of millions of dollars and obligate the community to a number of years of financial burden. Water plants that employ a process that generates a solid waste (e.g. lime softening precipitation of radium) currently use land application at agronomic rates. Water plants that generate a liquid waste must use a controlled discharge to a sewage treatment plant.

The purpose of this letter is to request a clear and consistent position by USEPA on the issue of land application of these residuals for agronomically beneficial uses, and request the written opinion of USEPA supporting the continued use of current Illinois disposal practices. As noted, our Illinois water supplies are considering a number of alternative treatment processes. One common element of concern is the cost of disposal of the treatment wastes. Alteration of the present disposal practice could very well make operation of the treatment facilities untenable for most of the water supplies classified as small systems, but if this alteration is necessary, now is the time for all of us to be advised so that millions of dollars are not wasted on an unacceptable disposal alternative.

Your immediate attention and reply to this matter will be very much appreciated. Please let me know if you would like to discuss this issue further or need additional information.

Sincerely,

Renee Cipriano

Renee Cipriano
Director

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 4 2005

OFFICE OF
WATER

Ms. Renee Cipriano, Director
Illinois Environmental Protection Agency
1021 North Grand Avenue East, P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Cipriano:

Thank you for your letter dated September 21, 2004. Your letter seeks clarification from the U.S. Environmental Protection Agency (EPA) on discussions contained in two draft guidance documents regarding the use of land application as a disposal option for treatment residuals. In this reply, we hope to provide you with an update on the development of these documents and invite you to continue to work with us to better communicate EPA's position on the potential use of land application for this material.

EPA appreciates the difficult decisions that drinking water systems must make to comply with drinking water standards for radionuclides. Affected water systems will need to find alternative sources of water or apply treatment technologies to remove the radionuclides from their source water, balancing source availability, treatment and disposal costs. EPA recognizes that systems will be seeking cost-effective solutions for these management issues, but has consistently expressed concern about the potential creation of new contaminated sites that would someday require remediation and/or the use of institutional or engineering controls.

You expressed concerns that the language within the following two draft documents were inconsistent: (1) *A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies*; and (2) *ISCORS*[1] *Assessment of Radioactivity in Sewage Sludge: Recommendations on Management of Radioactive Materials in Sewage Sludge and Ash at Publicly Owned Treatment Works*. We are in the process of revising both documents, though the ISCORS report is a multi-agency effort, not solely that of EPA. Our goal is to insure that the language contained within these documents is compatible, recognizing that water treatment residuals and sewage sludge are different waste streams and the extent of analysis done by the Agency has differed in depth and complexity.

[1]ISCORS is the Interagency Steering Committee on Radiation Standards comprised of several Federal agencies whose purpose is to facilitate consensus on acceptable levels of radiation risk to the public and workers, and promote consistent risk approaches in setting and implementing standards for protection from ionizing radiation.

EPA has an extensive history of multi-year environmental and scientific research studies assessing land application of sewage sludge, which resulted in regulatory standards describing conditions under which such application is acceptable (40 CFR part 503). The multi-agency ISCORS report focused on sewage sludge's radionuclide content, and on dose assessments to workers and the public from a variety of exposure scenarios. This report which also examined land application of sewage sludge is the latest study in which EPA has participated. However, EPA has not explicitly evaluated the land application of drinking water treatment residuals, regardless of whether the waste contains radionuclides. Although we are aware of some research on this topic, we do not have any basis to judge the benefits of such land application. Further, we do not believe that it would be appropriate to rely on the conclusions of the ISCORS report (which pertains to sludge) when considering the land application of drinking water treatment residuals containing radionuclides.

The drinking water guide was shared over the summer with a diverse set of stakeholders and we are in the process of considering their comments and making revisions as appropriate. The drinking water document does not recommend prohibiting the practice of land application of drinking water residuals, but does caution that the regulator should weigh the potential risks for both short and long term scenarios.

Illinois also expressed interest in EPA providing written support of Illinois disposal practices. As you know, EPA has no specific federal regulations regarding radionuclides in land-applied drinking water residuals and has not performed the requisite analyses. Therefore, we cannot endorse any state's practices in this area. The Agency recognizes that Illinois has put considerable time and effort into researching the benefits and risks of land-applying drinking water sludges with radionuclides, and we would be interested in learning more about such practices in the future.

We will continue to work with Illinois and other stakeholders as we tackle these complicated issues. If you have further questions, please let me know or your staff may contact Steve Heare, Director, Drinking Water Protection Division at (202) 564-7992.

Sincerely,

Benjamin H. Grumbles
Assistant Administrator

Electronic Filing, Received, Clerk's Office, August 15, 2005

CERTIFICATE OF SERVICE

The undersigned, an attorney, certifies that he/she has served upon the individuals named on the attached Notice of Filing true and correct copies of ***COMMENTS SUBMITTED BY BRIAN ANDERSON*** by First Class Mail, postage prepaid, on April 6, 2005.

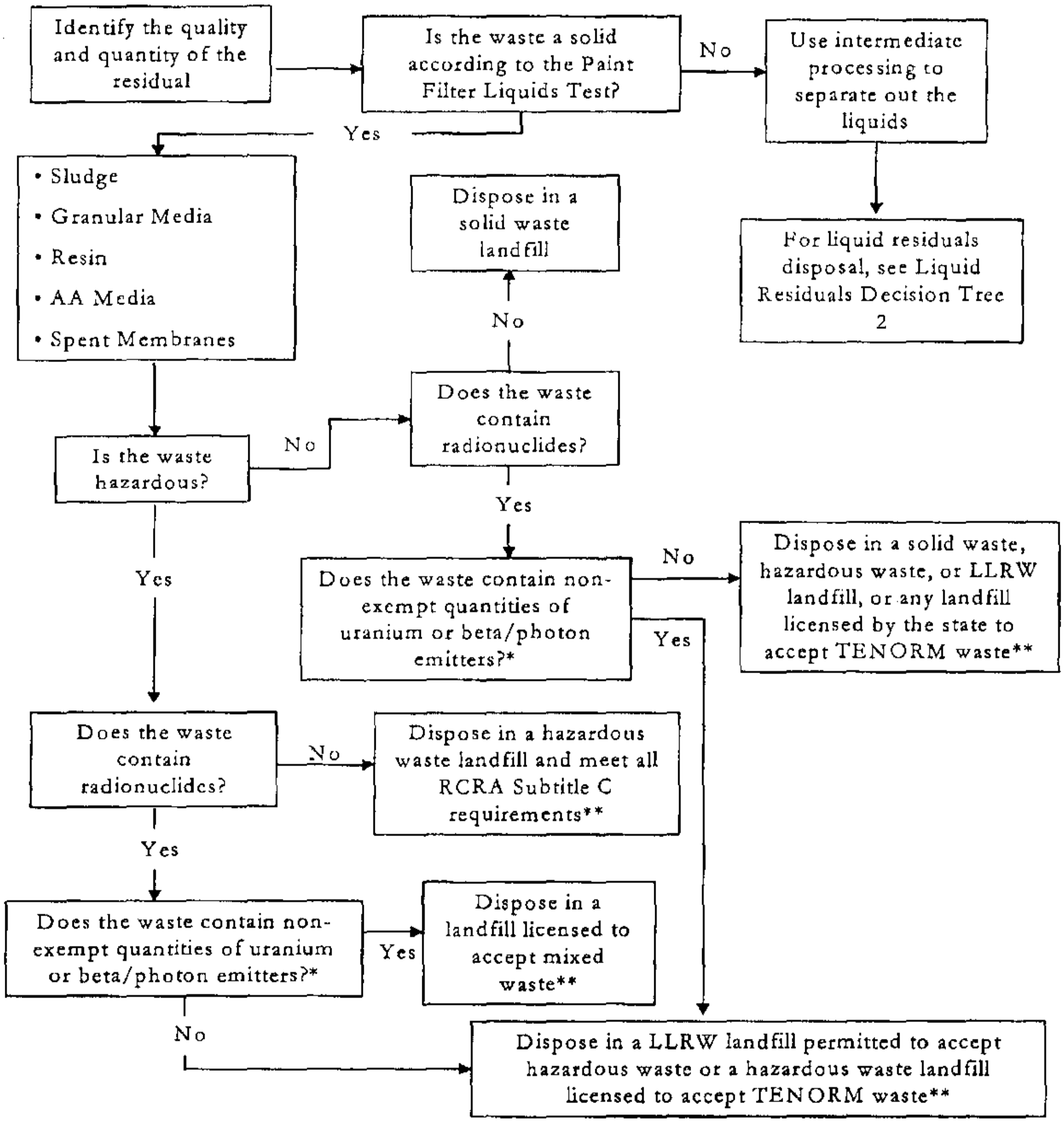
____

SERVICE LIST

R04-21

Dorothy Gunn Clerk of the Board Illinois Pollution Control Board 100 West Randolph Street Suite 11-500 Chicago, IL 60601	Amy Antoniolli Hearing Officer Illinois Pollution Control Board 100 West Randolph Street Suite 11-500 Chicago, IL 60601
Deborah J. Williams Stefanie N. Diers Illinois Environmental Protection Agency 1021 North Grand Avenue East P.O. Box 19276 Springfield, IL 62794-9276	Joel J. Sternstein, Assistant Attorney General Matthew J. Dunn, Division Chief Office of the Illinois Attorney General Environmental Bureau 188 West Randolph 20th Floor Chicago, IL 60601
Stanley Yonkauski Acting General Counsel Illinois Department of Natural Resources One Natural Resources Way Springfield, IL 62701	Richard Lanyon Metropolitan Water Reclamation District 100 East Erie Street Chicago, IL 60611
Roy M. Harsch Sasha M. Engle Gardner Carton & Douglas 191 North Wacker Drive Suite 3700 Chicago, IL 60606-1698	Claire A. Manning Posegate & Denes 111 North Sixth Street Springfield, IL 62701
Lisa Frede CICI 2250 East Devon Avenue Suite 239 Des Plaines, IL 60018	William Seith Total Environmental Solutions 631 East Butterfield Road Suite 315 Lombard, IL 60148
Albert F. Ettinger Environmental Law and Policy Center 35 East Wacker Drive Suite 1300 Chicago, IL 60601	John McMahon Wilkie & McMahon 8 East Main Street Champaign, IL 61820
Dennis L. Duffield City of Joliet Department of Public Works and Utilities 921 East Washington Street Joliet, IL 60431	Abdul Khalique Metropolitan Water Reclamation District of Greater Chicago 6001 West Pershing Road Cicero, IL 60804

Decision Tree 1: Solid Residuals Disposal



* Check with the state Radiation Program to see if beta/photon emitters are considered byproduct material and advise system to contact the NRC Regional office or relevant Agreement State agency to discuss potential licensing requirements.

** LDR treatment standards also apply. Check with the state Radiation Program to determine the proper disposal methods for waste containing radionuclides and hazardous waste.

Electronic Filing, Received, Clerk's Office, August 15, 2005

Organization of Agreement States

CONGRESSIONAL ACTION IS NEEDED TO ENSURE UNIFORM SAFETY AND SECURITY REGULATIONS FOR CERTAIN RADIOACTIVE MATERIALS

POSITION STATEMENT OF THE HEALTH PHYSICS SOCIETY AND ORGANIZATION OF AGREEMENT STATES *

The Health Physics Society (HPS) and the Organization of Agreement States (OAS), which represent radiation safety professionals and regulatory agency stakeholders, believe congressional action is needed to ensure the uniform regulation of all discrete sources of radioactive material to provide appropriate radiation safety standards to protect the public from these sources, including protection from malevolent uses of such sources by terrorists.

Currently, naturally occurring radioactive materials, especially radium, and radioactive materials produced by nuclear particle accelerators (accelerator-produced radioactive material) are not comprehensively regulated in the United States. These sources are not defined in the Atomic Energy Act of 1954, as amended (AEA), which has the effect of excluding these sources from regulation by the independent federal agency charged with regulation of other radioactive materials, i.e., the United States Nuclear Regulatory Commission (NRC). As a result of their omission in the AEA, the regulation of these sources rests with various federal agencies and each individual state. Our organizations believe that this fragmented regulatory framework allows for inconsistent standards for the possession, use, and disposal of these sources, which can potentially have a negative impact on public health and safety and on national common defense and security.

Therefore, we recommend congressional action to ensure not only the security of such sources, but also the uniformity of standards regarding their possession, use, and disposal.

The HPS and OAS jointly recommend enactment of federal legislation to regulate these sources according to the following principles:

1. Discrete sources of technologically enhanced naturally occurring radioactive material (TENORM)[1] and accelerator-produced radioactive material should be uniformly regulated throughout the United States. The most effective way to ensure uniformity in regulation is to include such sources in the definition of byproduct material in the AEA.

2. The NRC should be the sole agency authorized to promulgate federal regulations establishing requirements for controlling the acquisition, possession, transfer, use, and disposal of such sources to protect the public health and safety and the national security of the United States, except for those sources regulated by the United States Department of Energy.

3. The NRC shall, in consultation with the states and other stakeholders, develop a regulatory definition of the term "discrete," as applied to sources of TENORM and accelerator-produced radioactive materials. This definition should include both an activity limit and a concentration limit on any such source, such that the radiological hazards are controlled in a manner consistent with other sources of radioactive material posing the same radiological hazard.

4. Disposal of such sources should be allowed at facilities licensed by the NRC, by states that have entered into agreements with the NRC pursuant to the AEA, or in facilities regulated pursuant to the Resource Conservation and Recovery Act (RCRA) when such disposal is appropriate and authorized by the regulatory agency (or agencies) having jurisdiction.

5. Placing such sources under the NRC's jurisdiction should be done in such a manner that (a) does not change the definition of low-level radioactive waste in the Low-Level Radioactive Waste Policy Amendments Act of 1985 and (b) does not adversely affect the implementation of congressionally approved Compacts pursuant to the Low-Level Radioactive Waste Policy Act of 1980 as amended, thus preventing such sources from becoming "orphaned" from disposal.

6. In fulfilling its new responsibilities, the NRC shall consult with state radiation control agencies that have established regulations for controlling the safe use, security, and disposal of these sources.

7. The NRC is encouraged to consult with other federal agencies as it develops regulations for controlling the safe use, security, and disposal of these sources.

Footnote

[1] TENORM is naturally occurring radioactive material that has been removed from the natural environment and has been concentrated to levels greater than that found in the natural environment due to human activities. (Indoor radon, because it is not technologically enhanced, should be specifically exempt from this provision for discrete sources.)

* The Health Physics Society is a nonprofit scientific professional organization whose mission is to promote the practice of radiation safety. The Organization of Agreement States is a nonprofit society of staff members from those states that have established programs under section 274 of the AEA to assume a portion of NRC regulatory authority.

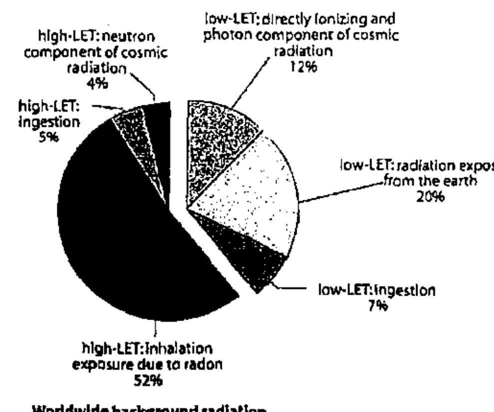
BEIR VII: Health Risks from Exposure to Low Levels of Ionizing Radiation

BEIR VII develops the most up-to-date and comprehensive risk estimates for cancer and other health effects from exposure to low-level ionizing radiation. It is among the first reports of its kind to include detailed estimates for cancer incidence in addition to cancer mortality. In general, BEIR VII supports previously reported risk estimates for cancer and leukemia, but the availability of new and more extensive data have strengthened confidence in these estimates. A comprehensive review of available biological and biophysical data supports a "linear-no-threshold" (LNT) risk model—that the risk of cancer proceeds in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans.

This report is the seventh in a series of publications from the National Academies concerning radiation health effects called the Biologic Effects of Ionizing Radiation (BEIR) reports. BEIR VII focuses on the health effects of low levels of low linear energy transfer (low-LET) ionizing radiation such as x-rays and gamma rays. The most recent BEIR report to address low level low-LET radiation was the BEIR V report published in 1990. Humans are exposed to ionizing radiation from both natural and man-made sources (see Figure 1). Very high doses can produce damaging effects in tissues that can be evident within days after exposure. Late effects such as cancer, which can occur after more modest doses including the low-dose exposures that are the subject of this report, may take many years to develop.

Most radiation sources have a mixture of high- and low-LET radiation. Compared to high-LET radiation, low-LET radiation deposits less energy in the cell along the radiation path and is considered less destructive per radiation track. The BEIR VII report defines low doses as those in the range of near zero up to about 100 mSv (0.1 Sv) of low-LET radiation. People in the United States are exposed to average annual background radiation levels of about 3 mSv; exposure from a chest X-ray is about 0.1 mSv and exposure from a whole body computerized tomography (CT) scan is about 10 mSv.

There are many challenges associated with understanding the health effects of low doses of low-LET radiation, but current knowledge allows several conclusions. The BEIR VII report concludes that the current scientific evidence is consistent with the hypothesis that, at the low doses of interest in this report, there is a linear dose-response relationship between exposure to ionizing radiation and the development of



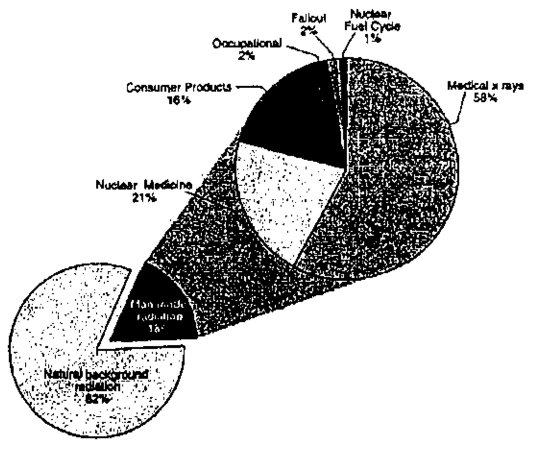


Figure 1. The chart on the left shows the sources of global background radiation of both high- and low-LET radiation. The figure at right shows the relative contributions of the various types of man-made radiation to the U.S. population.[1] Medical x-rays and nuclear medicine account for about 79% of the man-made radiation exposure in the United States. Substances in consumer products such as tobacco, the domestic water supply, building materials, and to a lesser extent, smoke detectors, televisions, and computer screens, account for another 16%. Occupational exposures, fallout, and the nuclear fuel cycle comprise about 5% of the man-made component.

[1]Figures based on data from Ionizing Radiation Exposure of the Population of the United States, National Council on Radiation Protection and Measurements, No.93, 1987.

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solid cancers in humans. It is unlikely that there is a threshold below which cancers are not induced, but at low doses the number of radiation-induced cancers will be small. Other health effects (such as heart disease and stroke) occur at higher radiation doses, but additional data must be gathered before an assessment of any possible dose response can be made between low doses of radiation and non-cancer health effects. The report also concludes that with low dose or chronic exposures to low-LET irradiation, the risk of adverse heritable health effects to children conceived after their parents have been exposed is very small compared to baseline frequencies of genetic diseases in the population.

Radiation Exposure and Health Effects

The mechanisms that lead to adverse health effects after ionizing radiation exposure are not fully understood. Ionizing radiation has sufficient energy to change the structure of molecules, including DNA, within the cells of the body. Some of these molecular changes are so complex that it may be difficult for the body's repair mechanisms to mend them correctly. However, the evidence is that only a small fraction of such changes would be expected to result in cancer or other health effects.

The most thoroughly studied individuals for the evaluation of health effects of ionizing radiation are the survivors of the Hiroshima and Nagasaki atomic bombings, a large population that includes all ages and both sexes. The Radiation Effects Research Foundation (RERF) in Japan has conducted follow-up studies on these survivors for more than 50 years. An important finding from these studies is that the occurrence of solid cancers increases in proportion to radiation dose. More than 60% of exposed survivors received a dose of radiation of less than 100 mSv (the definition of low dose used by the BEIR VII report).

Risk Models for Cancer

An important task of the BEIR VII committee was to develop "risk models" for estimating the risk that an exposed individual will develop cancer. This task requires expressing the dependence of risk on radiation dose and also on sex and age at exposure. Data from epidemiologic studies were used to accomplish this task. The Japanese atomic bomb survivors were the primary source of data for estimating risks of most solid cancers and leukemia. For 2 of the 11 specific cancers evaluated, breast and thyroid cancer, atomic bomb survivor data were combined with data on medically exposed persons to estimate risks. Data from additional medical studies and from studies of nuclear workers were evaluated and found to be compatible with BEIR VII models.

Since the publication of BEIR V in 1990, more comprehensive data on cancer incidence (including non-fatal diseases) in atomic bomb survivors have become available, mortality follow-up has been extended for 15 years nearly doubling the number of deaths from solid cancer, and an improved dosimetry system (DS02) has been implemented. In addition, new data have become available from studies of persons exposed to radiation for medical reasons and from studies of nuclear workers exposed at low doses and dose rates. These developments have strengthened the epidemiologic data that are used to develop risk estimates. Box 1 lists some of the new epidemiologic information and approaches that have become available since BEIR V.

On average, assuming a sex and age distribution similar to that of the entire U.S. population, the BEIR VII lifetime risk model predicts that approximately one

Box 1: New epidemiologic information and approaches used in BEIR VII risk models

1) The information available from epidemiologic studies has been greatly increased.
   a. For the A-bomb survivors, cancer incidence data from the Hiroshima and Nagasaki tumor registries have become available (13,000 cases of solid cancer) and the number of solid cancer deaths available for analysis has nearly doubled (10,000 deaths).
   b. There are new data from many studies of persons exposed for medical reasons. These data have been incorporated in estimating risks of female breast cancer and thyroid cancer.
   c. There are new data from studies of nuclear workers exposed at low doses and dose rates, including results of analyses that combine data from many studies. These data were evaluated and found to be compatible with BEIR VII risk estimates.
2) BEIR VII provides estimates of both cancer incidence (including non-fatal cancer) and cancer mortality, whereas previous reports focused on mortality data.
3) The availability of cancer incidence data on A-bomb survivors has made it possible to develop estimates for eleven specific cancer sites.
4) The newly implemented DS02 dosimetry system for A-bomb survivors provides a more accurate basis for evaluating the dependence of risk on dose.

individual in 100 persons would be expected to develop cancer (solid cancer or leukemia) from a dose of 100 mSv while approximately 42 of the 100 individuals would be expected to develop solid cancer or leukemia from other causes (see Figure 2). Lower doses would produce proportionally lower risks. For example, it is predicted that approximately one individual in 1000 would develop cancer from an exposure to 10 mSv. Table 1 shows BEIR VII's best estimates of the lifetime attributable risk (LAR) of incidence and mortality for all solid cancers and for leukemia per 100,000 persons exposed to 100 mSv. The report also provides estimates for cancers of several specific sites.

Risk Estimates at Very Low Doses

At doses of 100 mSv or less, statistical limitations make it difficult to evaluate cancer risk in humans. A comprehensive review of available biological and biophysical data led the committee to conclude that the risk would continue in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans.[3] This assumption is termed the "linear-no-threshold" (LNT) model.

There are two competing hypotheses to the linear no-threshold model. One is that low doses of radiation are more harmful than a linear, no-threshold model of effects would suggest. BEIR VII finds that the radiation health effects research, taken as a whole, does not support this hypothesis. The other hypothesis suggests that risks are smaller than predicted by the linear no-threshold model are nonexistent, or that low doses of radiation may even be beneficial. The report concludes that the preponderance of information indicates that there will be some risk, even at low doses, although the risk is small.

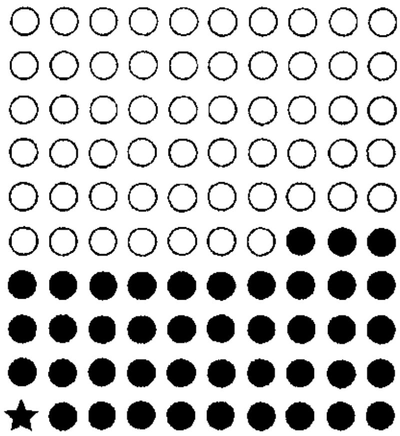

Figure 2. In a lifetime, approximately 42 (solid circles) of 100 people will be diagnosed with cancer[2] from causes unrelated to radiation. The calculations in this report suggest approximately one cancer (star) in 100 people could result from a single exposure 100 mSv of low-LET radiation.

Health Effects Other than Cancer

Radiation exposure has been demonstrated to increase the risk of diseases other than cancer, particularly cardiovascular disease, in persons exposed to high therapeutic doses and also in A-bomb survivors exposed to more modest doses. However, there is no direct evidence of increased risk of non-cancer diseases at low doses, and data are inadequate to quantify this risk if it exists. Radiation exposure has also been shown to increase risks of some benign tumors, but data are inadequate to quantify this risk.

	All solid cancer		Leukemia	
	Males	Females	Males	Females
Excess cases (including non-fatal cases) from exposure to 100 mSv	800 (400–1600)	1300 (690–2500)	100 (30–300)	70 (20–250)
Number of cases in the absence of exposure	45,500	36,900	830	590
Excess deaths from exposure to 100 mSv	410 (200–830)	610 (300–1200)	70 (20–220)	50 (10–190)
Number of deaths in the absence of exposure	22,100	17,500	710	530

Table 1. The table shows the estimated number of cancer cases and deaths expected to result in 100,000 persons (with an age distribution similar to that of the entire U.S. population) exposed to 100 mSv. The estimates are accompanied by 95% subjective confidence intervals shown in parentheses that reflect the most important uncertainty sources including statistical variation, uncertainty in adjusting risk for exposure at low doses and dose rates, and uncertainty in the method of transporting data from a Japanese to a U.S. population. For comparison, the number of expected cases and deaths in the absence of exposure is listed.

[2]Approximately 42 cancers per 100 individuals calculated from Table 12-4 in Chapter 12 of the BEIR VII report.

[3] In special cases, such as *in utero* exposure, some evidence suggests excess cancers can be detected as low as 10 mSv.

Estimating Risks to Children of Parents Exposed to Ionizing Radiation

Naturally-occurring genetic (i.e., hereditary) diseases arise as a result of alterations (mutations) occurring in the genetic material (DNA) contained in the germ cells (sperm and eggs) and are heritable (i.e., they can be transmitted to the offspring and subsequent generations). The concern over whether exposure to ionizing radiation would cause an increase in the frequencies of genetic diseases launched extensive research programs to examine the adverse genetic effects of radiation in the children of A-bomb survivors and other studies focusing on mammals that could be bred in the laboratory, primarily the mouse.

Studies of 30,000 children of exposed A-bomb survivors show a lack of significant adverse genetic effects. During the past 10 years, major advances have occurred in our understanding of the molecular nature and mechanisms underlying naturally occurring genetic diseases and radiation-induced mutations in experimental organisms including the mouse. The risk estimates presented in this report have incorporated all these advances. They show that, at low or chronic doses of low-LET irradiation, the genetic risks are very small compared to the baseline frequencies of genetic diseases in the population.

Given BEIR VII estimates, one would not expect to see an excess in adverse hereditary effects in a sample of about 30,000 children (the number of children evaluated in Hiroshima and Nagasaki). One reason that genetic risks are low is that only those genetic changes compatible with embryonic development and viability will be recovered in live births.

Research Needs

Continued research is needed to further increase our understanding of the health risks of low levels of ionizing radiation. BEIR VII identifies the following top research needs:

- Determination of the level of various molecular markers of DNA damage as a function of low dose ionizing radiation.
- Determination of DNA repair fidelity, especially double and multiple strand breaks at low doses, and whether repair capacity is independent of dose.
- Evaluation of the relevance of adaptation, low-dose hypersensitivity, bystander effect, hormesis, and genomic instability for radiation carcinogenesis.
- Identification of molecular mechanisms for postulated hormetic effects at low doses.
- Reduction of current uncertainties on the specific role of radiation in how tumors form.
- Studies on the genetic factors that influence radiation response and cancer risk.
- Studies on the heritable genetic effects of radiation.
- Continued medical radiation and occupational radiation studies.
- Continued follow-up health studies of the Japanese atomic-bomb survivors, 45% of whom were still alive in 2000.
- Epidemiologic studies to supplement studies of atomic-bomb survivors, for example studies of nuclear industry workers and persons exposed in countries of the former Soviet Union.

Committee to Assess the Health Risks from Exposure to Low Levels of Ionizing Radiation: Richard R. Monson *(Chairman)*, Harvard School of Public Health; **James E. Cleaver** *(Vice Chairman)*, University of California, San Francisco; **Herbert L. Abrams**, Stanford University; **Eula Bingham**, University of Cincinnati; **Patricia A. Buffler**, University of California, Berkeley; **Elisabeth Cardis**, International Agency for Research on Cancer, Lyon, France; **Roger Cox**, National Radiological Protection Board, UK; **Scott Davis**, University of Washington and Fred Hutchinson Cancer Research Center, Seattle, WA; **William C. Dewey**, University of California, San Francisco; **Ethel S. Gilbert**, National Cancer Institute; **Albrecht M. Kellerer**, Ludwig-Maximilians-Universität, München, Germany; **Daniel Krewski**, University of Ottawa, Ontario, Canada; **Tomas R. Lindahl**, Cancer Research UK London Research Institute; **Katherine E. Rowan**, George Mason University; **K. Sankaranarayanan**, Leiden University Medical Centre, Leiden, The Netherlands; **Daniel W. Schafer**, Oregon State University (from May 2002); **Leonard A. Stefanski**, North Carolina State University, (through May 2002); **Robert L. Ullrich**, Colorado State University, **Rick Jostes** (Study Director), National Research Council.

This brief was prepared by the National Research Council based on the committee's report. For more information, contact the Nuclear and Radiation Studies Board at 202-334-3066. *BEIR VII: Health Risks from Exposure to Low Levels of Ionizing Radiation* is available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 800-624-6242; www.nap.edu. This report is sponsored by the U.S. Department of Defense, U.S. Department of Energy, U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, and U.S. Department of Homeland Security.

I-E Worker Exposure and Safety

Because radiation is invisible, tasteless, and odorless, it is commonly overlooked as a potential hazard at water systems. Exposure to elevated levels of radiation at water treatment facilities may cause serious health effects. Systems need to determine whether a radiation problem exists and, if it does, take appropriate safety precautions to prevent or limit water system staff members' exposure to radiation. For example, if a system tested its treated water 2 years ago and found levels of 3pCi/L for radium-226 and 228, a radiation survey of the facility would be prudent.

Water system staff can be exposed to radiation during normal treatment processes for radionuclides, through handling the residual streams generated by treatment, and during media replacement or transportation. Relatively undetectable levels of radionuclides in source waters can 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, uranium, or radium-bearing materials (including water) are present. Naturally occurring radon gas can enter through openings in the building's concrete or foundation walls. Underground connections to manholes, piping conduits, and utility tunnels provide additional pathways for radon entry. For example, elevated gamma ray levels have been found around IX columns and associated piping at some facilities. This could result in an exceedance of public dose limits.

I-E.1 Radiation Surveys

A system should contact a professional radiation protection specialist or a health physicist for assistance in conducting a radiation survey if: (1) the system has had an analytical result within the past 5 years that has approached or has exceeded an MCL for a regulated radionuclide; or, (2) if calculations derived from use of the U.S. EPA SPARRC model indicates potential concentrations of radioactivity in residuals and filters at the system.[17]

A radiation survey can be conducted by:

1. Using a radiation survey meter to identify any points at which contamination exists.

2. Using an integrating radiation measuring device to determine whether exposure could occur over time.

3. Sampling filter media, wastes, and water through further laboratory analyses. These analyses should focus on finding the principal NORM/TENORM isotopes found in surface and groundwater supplies: radium, uranium, thorium, and potassium as well as their radioactive daughter decay products.[18]

Some states require radiation protection specialists or health physicists who conduct radiation surveys (including radon surveys) to be certified or licensed. State Radiation Control contact information appears in Appendix D.

As a result of the survey, the system may need to establish a monitoring program, change existing management practices, alter methods for managing radioactively contaminated equipment and wastes, or establish worker radiation safety and education programs. The survey may also recommend methods for decontaminating buildings or facilities, if needed.

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[17]A working draft of SPARRC is available for estimating the volume and concentration of radionuclides in waste produced by water systems. The program allows the operator to select the type of treatment process, as well as input and output parameters such as water flows, doses of coagulant and polymer, and filter capacities. To view the spreadsheet, see http://www.npdespermits.com/sparrc.

[18]Decay products such as isotopes of radon, lead, polonium, and bismuth may need to be analyzed in order to calculate the concentrations of the original parent radionuclide such as radium or uranium. Characterizing the types and amounts of radionuclides present will be beneficial in identifying sources in the drinking water, understanding how, where, and why they are collecting in the treatment plant, correcting a contamination problem in the plant through selection of treatment technologies and management techniques, and aiding management in deciding where hazardous waste products should be disposed or where they might be accepted.

Although designed for post-cleanup surveys of radioactively contaminated sites, U.S. EPA's *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (EPA 402-R-97-016 Rev. 1) provides useful information on planning and conducting a survey of potentially contaminated surface soils and building surfaces. The manual and other information on radiation surveys can be obtained from U.S. EPA's Radiation Protection Division Web site at http://www.epa.gov/radiation/marssim.

Seven federal and two state agencies contributed to the development of MARLAP. MARLAP provides guidance for the planning, implementation, and assessment phases of projects that require laboratory analysis of radionuclides. This guidance is intended for project planners, managers, and laboratory personnel and provides extensive detail on the radiological sampling and analytical process, including laboratory procedures. A copy of the manual can be found at: http://www.epa.gov/radiation/marlap/manual.htm.

U.S. EPA also recommends that the system check for the presence of radon in buildings encasing system equipment. States should consult with radiation program staff to determine whether radon measurements have been taken in the county, whether a map or survey of indoor radon measurements has been developed for the county, where the system is located, and to determine the appropriate means and methods for conducting radon surveys. The state or private radon proficiency programs may be able to provide a list of licensed or certified radon contractors who could conduct the survey. Additional information on how to find qualified professionals can be found at http://www.epa.gov/iaq/radon/proficiency.html.

For U.S. EPA guidance documents on approaches to risk assessments of soil and water, see the Superfund Radiation Web sites at http://www.epa.gov/superfund/resources/radiation and http://www.epa.gov/superfund/resources/radiation/whatsnew.htm.

I-E.2 Radiation Exposure Due to Water Treatment Operations

The following discussion applies only to systems where there is the potential for accumulation of radioactivity.

Water system workers are most likely to be exposed to elevated levels of radioactive materials when coming into contact with residuals, filter backwash, and sludge; during maintenance of contaminated pumps or piping; or while moving or transporting wastes and filters for disposal. Possible sources of radiation include pumps and piping where mineral scales accumulate; lagoons, and flocculation and sedimentation tanks where residual sludges accumulate; filters, pumping stations, and storage tanks where scales and sludges accumulate; and facilities where filter backwash, brines, or other contaminated water accumulates. Facilities that are enclosed present the potential for enhanced radiation inhalation exposure, particularly from radon. Exposure to radiation can also occur at residuals processing or handling areas at the system and off-site locations such as landfills where residuals are shoveled, transported, or disposed of.

The table below shows the three primary paths of radiation exposure at a system: inhalation, ingestion, and direct exposure.

Pathway	Concern
Inhalation	Inhalation of alpha- or beta-emitting radioactive materials is a concern because radioactive material taken into the body results in radiation doses to internal organs and tissues (e.g., lining of the lungs). Workers could inhale radioactively contaminated dust or water droplets while dealing with residuals or during normal filter operations. Cleaning methods such as air scour, high pressure water sprays, and backwash operations can increase suspension of radioactively contaminated water, dusts, and particulates in respirable air, thus increasing the potential hazard of inhalation or ingestion. Workers can inhale radon and its progeny in both wet and dry conditions. Simple dust masks may not provide adequate protection from exposures via this pathway, and systems may need to implement Occupational Safety and Health Administration (OSHA) requirements for respirators.

Pathway	Concern
Ingestion	Ingestion, or the swallowing of alpha, beta, or gamma-emitting radioactive materials, is a concern for the same reasons as inhalation exposure. Workers can ingest radioactive materials if they fail to observe good sanitary practices including washing their hands before eating; failing to cover their noses and mouths by wearing approved respiratory protection and swallowing contaminated dusts and water droplets; or eating and drinking in areas (including land disposal sites), where dusts or water droplets could settle on food or drink. Simple dust masks may not provide adequate protection from exposures via this pathway.
Direct Exposure	Radioactive materials that emit gamma radiation are of concern because the gamma rays pose an external radiation exposure hazard. Because gamma rays can pass through common construction materials and most protective clothing, the distance between the radioactive material and the person, as well as the time spent in proximity to the material are factors in the amount of exposure the person receives. As gamma radiation travels through air, exposure can occur near a source of radiation as well as through direct contact. Workers most likely to be directly exposed are those who handle or work in the vicinity of resin tanks, residuals, filter backwash, and contaminated brines or waters, or participate in the maintenance of the treatment system or the replacement and transportation of filter media.

The International Commission on Radiological Protection (ICRP) and National Council on Radiation Protection and Measurements (NCRP) have recommended that facilities strive to make the levels of radiation to which the public and the environment are exposed as low as reasonably achievable (ALARA) (i.e., below regulatory limits) taking into account social and economic considerations. Steps that facilities can take include limiting the time that workers spend handling radioactive material, increasing the distance between workers and the material, and providing shielding from the radioactive material.

In addition, OSHA has developed occupational radiation standards (see 29 CFR 1910.1096) that might apply whenever an operator becomes aware of the presence of radiation at the facility. Although these standards may not apply to municipal water treatment plant workers, these workers may be covered by their state OSHA program, requiring that all controls, monitoring, record keeping, and training outlined in the OSHA standards be met.

Additional OSHA standards that may be applicable to water systems include:

- Requirements that personal protection equipment (or PPE, for the eyes, face, head, and extremities) such as protective clothing, respiratory devices, and protective shields and barriers be provided, used, and maintained whenever processes or radiological hazards capable of causing injury through absorption, inhalation, or physical contact necessitate such equipment. There are numerous other requirements related to the possession and use of PPE, including training for employees who would use the equipment. For more information, see 29 CFR 1910.132-136.

- Requirements for practices and procedures to protect employees in general industry from the hazards of entry into permit-required confined spaces. For more information, see 29 CFR 1910.146.

- Lockout/tagout requirements that require employers to establish a program and follow procedures for affixing appropriate lockout or tagout devices to energy isolating devices and disable machines or equipment. This avoids injury to employees by preventing unexpected energization, start-up, or release of stored energy. For more information, see 29 CFR 1910.147.

- Hazardous communication requirements that ensure the potential hazards of chemicals produced during or imported for treatment are evaluated and the information from this evaluation is communicated to employees through measures such as container labeling, material data safety sheets, and employee training, among others. These requirements do not apply to RCRA-defined hazardous waste or ionizing or non-ionizing radiation. For more information, see 29 CFR 1910.1200.

In circumstances where a facility may in the future be licensed by the NRC or Agreement State, worker safety precautions and radiation protection controls would take precedence (e.g., 10 CFR 20.1900, which lists radiation exposure posting requirements).

In addition to the OSHA requirements, systems should be encouraged to follow the safety practices listed below. These measures can reduce workers' risk of exposure to radioactivity and radioactive particulates:

Safety Measures

- ✓ Use an OSHA-approved respirator to avoid inhalation of biological pathogens and chemically toxic materials in residuals. Simple dust masks may not provide adequate protection.
- ✓ Limit time spent at land disposal sites to reduce inhalation of contaminated dust.
- ✓ Ventilate all buildings, especially where waste with high concentrations of radium is stored.
- ✓ Take standard OSHA measures to limit the potential ingestion of heavy metals and biological pathogens present in filters, residual sludges, and at land disposal sites to help reduce possible ingestion exposure to radioactive materials.
- ✓ Use protective gloves and frequently wash hands (particularly before eating and drinking) to reduce the potential for ingestion. Similarly, avoid eating and drinking in the vicinity of facilities or land disposal sites where air suspension of contaminated particulates or water droplets could occur.
- ✓ Avoid direct contact with any solid TENORM waste and use shovels or other remote-handling tools during extraction, transfer, and packaging.
- ✓ Locate treatment units and waste storage areas as far away from common areas (e.g., offices) as possible.
- ✓ Shower after exposure to potentially radioactive materials and launder work clothing at the system if possible. If laundering equipment is not available, workers should keep and wash work clothing separately and avoid wearing contaminated clothing into the home. Work boots or shoes should be wiped and cleaned after potential contamination. They should stay at the system or not be worn into the home.
- ✓ Use gamma survey instruments or equivalent monitors at least once annually to monitor the system's ambient radiation levels in areas where radionuclides are removed.
- ✓ 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.

Treatment plants that are licensed by the NRC or Agreement State should be referred to CFR Parts 19 and 20 for licensee reporting, notification, inspection, and safety requirements. Licensed facilities are required to post the regulations listed under Parts 19 and 20, along with numerous other documents related to the license and the activities conducted under the license. Employees likely to receive occupational doses greater than 100 mrem/year must be kept informed and instructed on various issues related to health protection, relevant regulations, and the facility's storage and transport of radioactive materials, among other things. Licensees must also keep individual employees informed of the annual radiation dose that they receive. Current and former employees can also request reports on their exposure to radiation or radioactive material.

10 CFR Part 20 outlines requirements for licensees to develop radiation protection programs (10 CFR 20.1101), sets dose limits and occupational limits for exposure to radiation (10 CFR 20.1201 to 1302), instructs licensees on how to

control access to areas where radiation levels are high or very high (10 CFR 20.1601 and 1602), and sets restrictions on the use of individual respiratory equipment (10 CFR 20.1703 and 1704), among other things.

Part 20 also sets requirements related to storage and control of licensed material, including posting, signage, and labeling requirements (10 CFR 20 Subparts I and J). These regulations stipulate that licensees' radiation protection programs be designed around the ALARA principle and require licensees to limit air emission of radioactive material (excluding radon-222 and its daughters) so that the highest total effective dose equivalent received by any member of the public is no greater than 10 mrem/year. Part 20 also sets notification requirements in the case of an incident at the licensed facility or for cases in which the facility is required to report exposures, radiation levels, or concentrations of radioactive materials exceeding constraints or limits (10 CFR 20.2201 to 2203). Consult with your NRC regional office or relevant state agency to ensure that any licensed facilities in your state are aware of these additional worker safety requirements.

I-E.3 Additional Safety Considerations

Radon is a natural decay product of radium and other radionuclides. It can vary in concentration by time of day or seasonally. It is appropriate for systems to consider radon protection measures when handling wastes containing radium. U.S. EPA recommends that action be taken to reduce radon levels in homes and schools where testing shows average concentrations of 4 pCi/L or greater. Although exposure to radon in homes or schools is evaluated differently than occupational exposure, many nations and the ICRP recommend that intervention levels for exposure to radon in homes also be used in workplaces.[19] U.S. EPA recommends that the action level used for homes and schools be used for water systems.

If radionuclides or radiation have been found in drinking water or at a system, having operators who are trained in treating for radionuclides, and handling, disposing of, and transporting TENORM waste, is highly recommended. In addition, determine whether your state requires someone specifically licensed by the state or NRC to handle these types of residuals. Operators should also be trained in how to measure radioactivity levels. Encourage systems to check with the relevant state office regarding licensing requirements and training opportunities.

Assistance and advice are available from the appropriate State Radiation Control Program (see Appendix D), the Conference of Radiation Control Program Directors at http://www.crcpd.org, and the U.S. EPA Regional Radiation Programs. For additional references on this and other topics discussed in this guide, see Appendix G.

[19]ICRP, 1993.

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ATTACHMENT 9

U.S. Environmental Protection Agency

TENORM

About Tenorm

Why is EPA concerned about TENORM?

Much of what can be labeled "TENORM" has only trace amounts of radiation and is part of our everyday landscape. However, some TENORM has very high concentrations of radionuclides that can result in elevated exposures to radiation.

EPA is concerned about TENORM for three reasons. First, TENORM has the potential to cause elevated exposure to radiation. Second, people may not be aware of TENORM materials and need information about them. Third, industries that generate these materials may need additional guidance to help manage and dispose of TENORM in ways that protect people and the environment and are economically sound.

EPA is working to coordinate all of its TENORM efforts with other federal agencies, state and tribal governments, Industry and public interest organizations. Coordinating our projects in this way will help us see the problem as a whole and will allow us to work together to develop solutions more effectively both within the Agency and with stakeholders outside the Agency.

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What EPA is Doing about TENORM?

EPA is working to understand the TENORM problem and to develop effective ways to protect humans and the environment from harmful exposure to the radiation in these materials. TENORM is a particularly challenging problem in the U.S. because it is produced by many industries in varying amounts and

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occurs in a wide variety of products. Although EPA and others working on the problem already have learned a good deal about TENORM, we still do not understand fully all of the potential radiation exposure risks it presents to humans and the environment.

RPD's strategy is a four-pronged approach to the problem:

- Study the TENORM-producing industries to determine what's in the wastes from the industries and how much risk they pose.
- Identify and study existing TENORM sites to assemble a nation-wide view of the problem--where the wastes are, what's in them, and the risks they present.
- Develop and provide education and guidance for safely and economically controlling exposures to TENORM wastes.
- Work with other organizations that are confronting the problem of TENORM, including states, tribes, other federal agencies, industry and environmental groups, and international organizations. return to: [top] [previous location]

TENORM-Producing Industries

EPA has studied TENORM-producing industries in the United States to learn which aspects of the problem, including health and environmental risks, are unique to a given industry and which are common across all industries. The results of these studies will appear as a series of reports on individual industries. Each report will contain the following information:

- generation of TENORM by the industry
- content of the TENORM
- ways that people could be exposed to the industry's TENORM
- potential effects of exposure to TENORM from the industry
- how the industry handles or disposes of TENORM wastes.

In addition, EPA and other federal agencies who have radiation responsibilities have conducted a joint pilot study of radionuclides including TENORM at sewage treatment plants.

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Existing TENORM Sites

EPA is working cooperatively with several organizations to identify TENORM sites and characterize the contamination:

Navajo Nation


Water-filled open pit uranium mine, northern Arizona

EPA, the Navajo EPA, and the Navajo Abandoned Mine Lands Reclamation Department are working together to assess hazards of radioactivity and abandoned uranium mines on the Navajo Reservation. This work includes individual site assessments, hazards mapping, planning for surveys to locate houses built with uranium mine wastes and community education on radiation hazards.

Colorado Plateau Data Coordination Group

EPA is working with the multi-agency Colorado Plateau Data Coordination Group Steering Committee to develop geographic information database on uranium mines and mills. The database will identify and show the location of active and inactive uranium mines and mills in eleven western states. It also will contain other information about the sites. This is the first step in developing an ecological atlas about the Colorado Plateau for use by the public and federal, state, tribal, academic, and industrial organizations.

EPA is providing assistance to the Spokane Indian Tribe and the EPA Superfund Program to clean up the radiological hazards in water and soils from an abandoned uranium mine that is on tribal lands. EPA is assisting by evaluating the radiological contamination at the site and site clean-up methods that provide radiation protection to tribal members and the environment and are also economical. return to: [top] [previous location]


Midnite Uranium Mine, NPL Site, Washington state

Information and Guidance

EPA has several activities underway that will help us provide guidance to those who deal with TENORM problems.

- Our studies of existing TENORM sites will give us information we need to select appropriate methods for estimating risks from these sites, the best ways to clean up the sites, and the most economical ways to dispose of the TENORM.
- EPA sponsored a National Academy of Sciences evaluation of existing methods for estimating the risk from TENORM sites and existing guidelines for cleaning them up. EPA sponsored the study at the request of Congress. NAS completed its report, Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials, in January of 1999. Exit EPA

- EPA issued a Report to Congress, Evaluation of EPA's Guidelines for TENORM, describing what it would do to implement the NAS's recommendations.
- EPA develops and distributes information about environmental issues in the mining industry through the National Hardrock Mining Committee. Organizations across EPA that work on these issues form the Committee, which also coordinates mining-related environmental activities across the Agency.
- EPA has issued guidance to its regional personnel which are involved in site visits and inspections. The guidance, Potential for Radiation Contamination Associated With Mineral and Resource Extraction Industries provides a listing of the various types of mineral and other sites which might have associated TENORM radioactivity. Agency staff conducting work at such sites are advised to contact EPA's regional radiation protection personnel for health and safety protection, as well as advice on how to conduct radiation site surveys, field sampling, cleanup and monitoring.

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U.S. Environmental Protection Agency

TENORM

TENORM Sources: Summary Table

The summary table below provides a range of reported concentrations, and average concentration measurements of TENORM in various wastes and materials. This is not a comprehensive list, as TENORM radiation is known to occur in many other materials, but should provide a general sense of the hazards posed by this class of radioactive substances.

Note:

Unless otherwise noted, the radiation level of each waste is shown in the units pCi/gram. For comparison purposes, the average level of radium in soil ranges from less than 1 to slightly more than 4 pCi/gram. "NA" indicates data is not available.

Product or Byproduct:		Radiation Level [pCi/g] low	average	high
Soils of the United States		0.2	NA	4.2
Geothermal Energy Waste Scales		10	132	254
Petroleum (oil and gas)				
	Produced Water [pCi/l	0.1	NA	9,000
	Pipe/Tank Scale	<0.25	<200	>100,000
Water Treatment				
	Treatment Sludge [pCi/l]	1.3	11	11,686
	Treatment Plant Filters	NA	40,000	NA
Aluminum				
	Ore (Bauxite)	4.4	NA	7.4
	Product		0.23	

Production Wastes	NA	3.9-5.6	NA
Coal and Coal Ash			
Bottom Ash	1.6	3.5-4.6	7.7
Fly Ash	2	5.8	9.7
Copper Waste Rock	0.7	12	82.6
more info TENORM in SW Copper Belt of Arizona [EPA 402-R-99-002][about pdf format]			
Fertilizers (Phosphate & Potassium) Phosphate			
Ore (Florida)	7	17.3-39.5	6.2-53.5
Phosphogypsum	7.3	11.7-24.5	36.7
Phosphate Fertilizer	0.5	5.7	21
Gold and Silver			
Rare Earths (Monazite, Xenotime, Bastnasite)	5.7	NA	3224
Titanium Ores		8.0	24.5
Rutile		19.7	NA
Ilmenite	NA	5.7	
Wastes	3.9	12	45
Uranium			
Uranium Mining Overburden			low hundreds
Uranium In-Situ Leachate Evaporation Pond	3	30	3000
Solids	300		
Zircon		68	
Wastes	87		1300

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Links to Related Information

● Radiation in TENORM Sources ● About TENORM ● Frequent Questions ●

...protecting people and the environment

Radiation Home · News · Topics · Information · Programs · Visitors' Center · Site Map

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Last updated on Monday, December 20th, 2004
URL: http://www.epa.gov/radiation/tenorm/sources_table.htm

Waste Control&Cleanup

Superfund

Kerr-McGee to Pay $74 Million for Cleanup Of Radioactive Material in West Chicago Area

CHICAGO—Kerr-McGee Chemical LLC will pay $74 million to remove radioactive material from waterways west of Chicago under the terms of a superfund settlement reached April 20 with three federal agencies and Illinois (*United States v. Kerr-McGee*, N.D. Ill., No. 05C-2318, 4/20/05).

The settlement terms were spelled out in a consent decree entered in the U.S. District Court for the Northern District of Illinois.

Under the settlement, Oklahoma City-based Kerr-McGee will be responsible for excavating 77,000 cubic yards of radioactive material from the West Branch of the DuPage River and Kress Creek and disposing of the waste in a facility licensed to handle such material.

Restoring Natural Habitat. The company also will be required to restore the natural habitat of the region by repairing damage to vegetation, banks, and waterways resulting from the contamination and the cleanup activities.

The federal agencies involved in the settlement included the Environmental Protection Agency, the Department of Justice, and the Department of the Interior.

Illinois Attorney General Lisa Madigan also participated in the settlement on behalf of the state Environmental Protection Agency and the state Department of Natural Resources.

The consent decree and the resulting cleanup effort mark the final phase of an environmental remediation effort involving radioactive waste generated beginning more than 70 years ago at the Rare Earths Facility in West Chicago. Kerr-McGee already has spent more than $550 million over the last decade to address the problem.

"Today marks a major victory for the citizens and environment of the Chicago area," said Kelly A. Johnson, acting assistant attorney general in the Justice Department's Environment and Natural Resources Division. "The last radioactive contamination from the operations that ceased long ago will be cleaned up, and the natural resources in the area will be restored."

Cleanup to Take Four More Years. John Christiansen, a corporate spokesman for Kerr-McGee, said, "Kress Creek is really the last piece of this project. After the entering of the consent decree, we expect the cleanup to be completed in four years."

Rebecca Frey, EPA's remedial project manager for the Kress Creek/DuPage River site, told BNA the environmental problem began in 1932 when the Rare Earths Facility was operated by Lindsay Light and Chemical Co. and then various successor organizations.

For 50 years, the Rare Earths Facility produced non-radioactive elements known as "rare earths" and radioactive elements such as thorium, radium, and uranium along with gas lantern mantles. The facility's processes resulted in the generation of radioactive mill tailings that contained residual levels of thorium, radium, and uranium as well as certain other insoluble metals.

Kerr-McGee purchased the Rare Earths Facility in 1967 and maintained operations there until it was closed in 1973.

During the Rare Earths Facility 's years of operation, it and the surrounding area became contaminated when radioactive mill tailings were discharged and carried by storm sewers into nearby Kress Creek and from there downstream to the West Branch of the DuPage River.

Frey said EPA became involved in the area in 1993 when an initial remedial investigation and feasibility study were undertaken. Four separate areas were designed as superfund sites. Cleanup began the following year under unilateral administrative orders from EPA compelling Kerr-McGee to commence remediation activities.

During the ensuing years, Kerr-McGee funded the cleanup of 675 residential properties, where 110,782 cubic yards of radioactive soil was removed.

The company also completed the remediation of Reed-Keppler Park, where mill tailings were dumped prior to the area's development as a park. That portion of the project removed 114,652 cubic yards of radioactive material.

In addition, Kerr-McGee oversaw the cleanup of the West Chicago sewage treatment plant, which involved the removal of 6,281 cubic yards of contaminated soil.

More Than $550 Million Spent. Kerr-McGee's Christiansen told BNA the company already has spent $120 million on these three remediation projects. In addition, the company has spent $440 million to decommission the Rare Earths Facility pursuant to its license from the Illinois Emergency Management Agency's Division of Nuclear Security.

With the April 20 consent decree, Frey said the final chapter has been written with respect to one of the largest superfund sites in Illinois history.

The decree requires the cleanup of eight miles of waterways in the vicinity of West Chicago.

She said that while the effort would take approximately four years, a substantial portion of the work would be completed before the end of 2005.

While the cleanup costs under the decree are estimated at $74 million, Kerr-McGee's liability will be much higher. According to the Justice Department, the company will pay an additional $6 million into superfund for past costs incurred by EPA. It will also reimburse the agency up to $1.675 million in future oversight costs.

The company will pay $100,000 and $75,000 respectively to the state of Illinois and to the Department of the Interior for costs relating to natural resource resto-

KERR-McGEE CHEMICAL CORPORATION
KERR-MCGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

April 21, 1998
LKE-057

BY AIRBORNE

TO: Mr. David P. Seely
The Superfund Division
U.S. EPA, Region 5
77 W. Jackson Blvd. (SR-6J)
Chicago, Illinois 60604-3590

SUBJECT: Request for Historical Data – REF Tailings and Sediments

REFERENCE: Kerr-McGee Reed-Keppler Park Site ("RKP Site")

Dear Mr. Seely:

During our meeting on April 8, 1998, you requested information regarding the types of 11(e)(2) materials that could have been originally used as backfill at Reed-Keppler Park (RKP). We discussed the information contained in U.S. EPA documentation, the U.S. NRC document, Radiological Survey of the Reed-Keppler Park Site West Chicago, Illinois, NUREG/CR-3035, prepared by Radiation Management Corporation (November 1982), the Engineering Report (1986) and information contained in the records of Kerr-McGee Chemical LLC. This information all indicates that the only Rare Earths Facility (REF) material used as backfill was tailings.

I am enclosing copies of the pertinent pages from Volume VIII, Appendix E (binder 8 of 20) of the Engineering Report (1986). These three tables provide radiochemical data and statistical results for the two primary solid waste materials produced at the West Chicago Rare Earths Facility (REF).

Tailings

Tailings were produced as a consequence of unreacted or unextracted materials in the ore. That is, tailings remain as the solid waste following extraction (commonly called "winning") of the desired materials from the primary ore. Tailings from monazite ore processing, produced from 1932 through 1964, consisted primarily of ~10% unreacted ore constituents (largely branerite phases), ~10% mixed barium/radium sulfate and ~80% unextracted rare earth oxides. The bulk of the tailings typically ranged from 1,500 to 3,000 pCi/g, though some batch lots were up to as high as 30,000 pCi/g.

The average concentrations for the "parent" radionuclides are:

- U-238 14 pCi/g
- Th-232 & Ra-228 1,357 pCi/g (in secular equilibrium)
- Ra-226 812 pCi/g

The ratio of Ra-228 to Ra-226 averages 1.7 to 1. The uranium concentration is negligible relative to the radium-226 and radium-228.

The low ratio of Ra-228 to Ra-226 is the direct result of ~10% barium sulfate being added to the ore, prior to processing, as a "hold-back carrier" for radium. The barium sulfate caused the radium-226 to remain with the tailings.

Sediments (Sludge)

Pond 1 "sludge only" and Sludge Pile "sludge only" are often called sediments. A one-time dredging of Pond 1 conducted around the mid-to-late 1950s created the Sludge Pile. The sludge (sediments) consist primarily of unrecovered rare earth fluorides along with some thorium fluoride, rare earth phosphates, radium fluoride and uranium fluorides. The rare earth, thorium and radium fluorides and phosphates are extremely insoluble in aqueous solutions. While uranium tetrafluoride is also very insoluble in aqueous solutions, some uranyl fluorides were present; uranyl fluorides are highly soluble in water.

The average concentrations of the "parent" radionuclides, corrected for the relative volumes of Pond 1 sludge to Sludge Pile sludge, are:

- U-238 222 pCi/g
- Th-232 & Ra-228 4,183 pCi/g (in secular equilibrium)
- Ra-226 255 pCi/g

The ratio of Ra-228 to Ra-226 averages 16.4 to 1. The uranium concentration is negligible relative to the radium-228; the apparent similarity between the uranium and radium-226 concentrations is coincidental. The high ratio of Ra-228 to Ra-226 is the direct result of ~10% barium sulfate being added to the ore, prior to processing, as a "hold back carrier" for radium. That is, the radium-226 remained with the tailings.

Frc·· an engineering perspective it is unlikely that sediments (or sludges) would have been used for backfill. These materials run nominally 70+% water, and an area backfilled with sediments would have experienced significant and continuing subsidence over years of time.

If you have any questions please contact me at 405-270-3792 or Garet Van De Steeg at 405-270-3574.

Very truly yours,
KERR-McGEE CHEMICAL LLC

JDWhite

J. D. White
Offsites Project Manager

Enclosures

cc: D. M. Jedlicka
M. S. Krippel
R. A. Meserve
G. F. Pilcher
G. E. Van De Steeg
File RKP 1.4-1

C-27972 - WEST CHICAGO

LOCATION: TAILINGS PILE - TAILINGS ONLY

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
265	1	2.0	0.0	0.0	2145.0	34.0	911.0	42.0	0.0	0.0	3056.0	54.0
265	2	3.0	76.0	105.0	1597.0	32.0	614.0	117.0	0.0	0.0	2287.0	160.0
265	2	4.0	6.0	131.0	2297.0	41.0	924.0	146.0	0.0	0.0	3227.0	200.0
265	2	5.0	0.0	0.0	2128.0	34.0	879.0	43.0	0.0	0.0	3067.0	55.0
265	3	6.0	48.0	128.0	2182.0	40.0	967.0	143.0	0.0	0.0	3197.0	196.0
265	3	7.0	0.0	0.0	1937.0	29.0	779.0	35.0	0.0	0.0	2716.0	45.0
265	4	8.0	41.0	142.0	2173.0	44.0	1037.0	160.0	0.0	0.0	3251.0	218.0
265	4	9.0	0.0	0.0	1769.0	32.0	829.0	41.0	0.0	0.0	2598.0	52.0
265	4	10.0	0.0	0.0	1723.0	29.0	750.0	37.0	0.0	0.0	2473.0	47.0
265	5	11.0	0.0	0.0	1910.0	29.0	764.0	36.0	0.0	0.0	2674.0	46.0
265	5	12.0	0.0	0.0	1892.0	34.0	723.0	43.0	0.0	0.0	2615.0	55.0
265	6	13.0	0.0	0.0	1714.0	31.0	829.0	40.0	0.0	0.0	2543.0	51.0
265	6	14.0	0.0	0.0	1655.0	28.0	792.0	37.0	0.0	0.0	2447.0	46.0
265	7	15.0	0.0	0.0	1839.0	30.0	804.0	37.0	0.0	0.0	2643.0	[illegible]
265	7	16.0	0.0	0.0	2337.0	41.0	2274.0	53.0	71.0	25.0	4682.0	72.0
265	7	17.0	0.0	0.0	88.0	70.0	482.0	106.0	418.0	67.0	988.0	[illegible]
265	8	18.0	284.0	236.0	1721.0	58.0	9398.0	284.0	0.0	0.0	11403.0	[illegible]
265	8	19.0	0.0	0.0	52.0	17.0	62.0	25.0	51.0	12.0	165.0	32.0
265	9	20.0	0.0	0.0	1474.0	54.0	2916.0	78.0	65.0	34.0	4455.0	101.0
265	9	21.0	0.0	0.0	2137.0	35.0	1492.0	46.0	0.0	0.0	3629.0	58.0
265	9	22.0	0.0	0.0	2083.0	30.0	1374.0	38.0	0.0	0.0	3457.0	48.0
265	10	23.0	0.0	0.0	1898.0	27.0	1340.0	35.0	0.0	0.0	3238.0	44.0
265	10	24.0	0.0	0.0	2338.0	28.0	1420.0	34.0	0.0	0.0	3758.0	44.0
265	11	25.0	13.0	85.0	2103.0	29.0	1495.0	97.0	0.0	0.0	3611.0	132.0
265	12	28.0	0.0	0.0	2019.0	30.0	1234.0	38.0	0.0	0.0	3253.0	48.0
266	1	2.0	27.0	10.0	122.0	3.0	21.0	11.0	0.0	1.9	170.0	15.0
266	2	3.0	20.0	71.0	1261.0	23.0	788.0	81.0	0.0	0.0	2069.0	110.0
266	3	5.0	0.0	0.0	764.0	42.0	590.0	56.0	93.0	28.0	1446.0	75.0
266	3	6.0	0.0	0.0	760.0	42.0	576.0	55.0	91.0	28.0	1427.0	75.0
266	3	7.0	0.0	0.0	660.0	40.0	460.0	53.0	100.0	27.0	1220.0	72.0
266	4	8.0	0.0	0.0	742.0	48.0	507.0	63.0	134.0	33.0	1383.0	[illegible]
266	4	9.0	0.0	0.0	865.0	66.0	532.0	88.0	212.0	48.0	1609.0	[illegible]
266	5	10.0	0.0	0.0	791.0	60.0	515.0	80.0	185.0	43.0	1491.0	109.0
266	5	11.0	0.0	0.0	647.0	42.0	523.0	56.0	106.0	28.0	1276.0	[illegible]
266	6	12.0	0.0	0.0	708.0	44.0	603.0	59.0	110.0	30.0	1424.0	79.0
266	6	13.0	0.0	0.0	742.0	48.0	611.0	64.0	126.0	33.0	1479.0	86.0
266	7	14.0	0.0	0.0	802.0	51.0	533.0	67.0	139.0	35.0	1474.0	91.0
266	7	15.0	0.0	0.0	777.0	53.0	594.0	71.0	149.0	37.0	1520.0	96.0
266	8	16.0	0.0	0.0	802.0	50.0	503.0	67.0	144.0	35.0	1449.0	91.0
266	9	17.0	0.0	0.0	833.0	55.0	588.0	73.0	155.0	38.0	1576.0	99.0
266	9	18.0	0.0	0.0	765.0	50.0	489.0	66.0	147.0	35.0	1401.0	90.0
266	10	19.0	0.0	0.0	818.0	46.0	814.0	62.0	112.0	31.0	1744.0	83.0
266	10	20.0	0.0	0.0	828.0	56.0	635.0	74.0	159.0	38.0	1622.0	100.0
266	10	21.0	0.0	0.0	693.0	50.0	507.0	68.0	150.0	35.0	1350.0	91.0
266	11	22.0	0.0	0.0	752.0	57.0	524.0	77.0	178.0	41.0	1454.0	104.0
266	12	23.0	0.0	0.0	1507.0	19.0	644.0	23.0	0.0	0.0	2171.0	30.0
270	2	4.0	93.0	61.0	1397.0	20.0	1125.0	70.0	0.0	0.0	2615.0	95.0
270	3	5.0	0.0	0.0	1430.0	19.0	931.0	24.0	0.0	0.0	2361.0	31.0
270	3	6.0	0.0	0.0	829.0	50.0	767.0	67.0	110.0	33.0	1796.0	90.0
270	3	7.0	0.0	0.0	953.0	52.0	659.0	66.0	67.0	34.0	1679.0	91.0

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
270	4	8.0	0.0	0.0	1023.0	64.0	676.0	83.0	121.0	43.0	1820.0	113.0
270	4	9.0	9.0	79.0	1535.0	26.0	1123.0	91.0	0.0	0.0	2667.0	123.0
270	5	10.0	0.0	0.0	910.0	54.0	614.0	70.0	81.0	36.0	1605.0	95.0
270	5	11.0	0.0	0.0	949.0	56.0	671.0	72.0	78.0	37.0	1698.0	98.0
270	5	12.0	0.0	0.0	911.0	57.0	610.0	74.0	87.0	38.0	1608.0	102.0
270	6	13.0	0.0	0.0	943.0	53.0	486.0	68.0	86.0	36.0	1517.0	92.0
270	6	14.0	0.0	0.0	941.0	56.0	599.0	72.0	82.0	37.0	1622.0	98.0
270	7	15.0	0.0	0.0	875.0	54.0	533.0	69.0	90.0	36.0	1498.0	95.0
270	7	16.0	0.0	0.0	700.0	44.0	493.0	57.0	67.0	29.0	1260.0	76.0
270	8	17.0	0.0	0.0	828.0	55.0	546.0	72.0	106.0	38.0	1480.0	98.0
270	9	19.0	0.0	0.0	774.0	52.0	528.0	68.0	89.0	35.0	1391.0	92.0
270	10	20.0	0.0	0.0	788.0	51.0	505.0	66.0	92.0	34.0	1385.0	90.0
270	11	22.0	0.0	0.0	857.0	44.0	535.0	57.0	111.0	30.0	1503.0	78.0
270	11	23.0	0.0	0.0	958.0	49.0	554.0	63.0	123.0	33.0	1635.0	86.0
271	2	5.0	0.0	0.0	793.0	35.0	561.0	46.0	76.0	23.0	1430.0	62.0
271	3	6.0	0.0	0.0	527.0	15.0	367.0	19.0	22.5	9.4	916.0	26.0
271	3	7.0	0.0	0.0	780.0	38.0	510.0	49.0	94.0	25.0	1384.0	67.0
271	4	8.0	0.0	0.0	820.0	45.0	588.0	59.0	112.0	30.0	1520.0	80.0
271	4	9.0	0.0	0.0	843.0	52.0	594.0	68.0	138.0	35.0	1575.0	92.0
271	5	10.0	0.0	0.0	836.0	49.0	507.0	64.0	136.0	34.0	1479.0	87.0
271	5	11.0	0.0	0.0	827.0	56.0	572.0	74.0	168.0	39.0	1567.0	100.0
271	5	12.0	0.0	0.0	798.0	48.0	441.0	62.0	136.0	33.0	1375.0	85.0
271	6	13.0	443.0	364.0	821.0	112.0	548.0	411.0	84.0	72.0	1896.0	565.0
271	6	14.0	0.0	0.0	780.0	48.0	594.0	63.0	132.0	33.0	1506.0	86.0
271	7	15.0	0.0	0.0	832.0	53.0	615.0	70.0	156.0	37.0	1603.0	95.0
271	7	16.0	0.0	0.0	931.0	70.0	631.0	93.0	225.0	51.0	1787.0	127.0
271	7	17.0	0.0	0.0	747.0	60.0	696.0	80.0	172.0	42.0	1615.0	106.0
271	8	18.0	0.0	0.0	800.0	49.0	562.0	64.0	134.0	33.0	1496.0	87.0
271	8	19.0	0.0	0.0	784.0	56.0	508.0	74.0	171.0	40.0	1463.0	101.0
271	9	20.0	0.0	0.0	686.0	49.0	529.0	64.0	136.0	34.0	1351.0	87.0
271	9	21.0	0.0	0.0	807.0	60.0	569.0	80.0	197.0	43.0	1573.0	109.0
271	9	22.0	0.0	0.0	1003.0	66.0	598.0	86.0	203.0	47.0	1804.0	460.0
271	10	23.0	0.0	0.0	982.0	74.0	638.0	98.0	243.0	54.0	1863.0	134.0
271	10	24.0	0.0	0.0	958.0	68.0	752.0	90.0	212.0	48.0	1922.0	122.0
272	1	2.0	0.0	0.0	1132.0	42.0	445.0	52.0	73.0	27.0	1650.0	72.0
272	2	3.0	893.0	475.0	1329.0	132.0	605.0	528.0	0.0	0.0	2827.0	722.0
272	2	4.0	0.0	0.0	1443.0	28.0	658.0	37.0	0.0	0.0	2101.0	46.0
272	3	5.0	0.0	0.0	1245.0	21.0	527.0	27.0	0.0	0.0	1773.0	34.0
272	3	6.0	361.0	372.0	1030.0	107.0	475.0	406.0	0.0	0.0	1866.0	561.0
272	3	7.0	0.0	0.0	1610.0	29.0	814.0	38.0	0.0	0.0	2424.0	48.0
272	4	8.0	0.0	0.0	1523.0	22.0	664.0	27.0	0.0	0.0	2187.0	35.0
272	4	9.0	0.0	0.0	1662.0	31.0	836.0	40.0	0.0	0.0	2498.0	51.0
272	5	10.0	0.0	0.0	1593.0	30.0	730.0	39.0	0.0	0.0	2323.0	47.0
272	5	11.0	2.0	115.0	1619.0	35.0	832.0	129.0	0.0	0.0	2453.0	176.0
272	5	12.0	0.0	0.0	1657.0	36.0	947.0	48.0	0.0	0.0	2604.0	60.0
272	6	13.0	0.0	0.0	1573.0	32.0	900.0	43.0	0.0	0.0	2473.0	54.0
272	6	14.0	0.0	0.0	1705.0	29.0	844.0	37.0	0.0	0.0	2549.0	47.0
272	7	15.0	0.0	0.0	1589.0	29.0	824.0	37.0	0.0	0.0	2413.0	47.0
272	7	16.0	0.0	0.0	1451.0	25.0	616.0	32.0	0.0	0.0	2067.0	41.0
272	7	17.0	0.0	0.0	1493.0	21.0	847.0	27.0	0.0	0.0	2340.0	34.0

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
272	8	18.0	0.0	0.0	1446.0	20.0	667.0	24.0	0.0	0.0	2113.0	31.0
272	8	19.0	0.0	0.0	1048.0	35.0	468.0	44.0	74.0	23.0	1590.0	61.0
272	9	20.0	71.0	68.0	1312.0	22.0	668.0	77.0	0.0	0.0	2051.0	105.0
272	9	21.0	0.0	0.0	2018.0	25.0	684.0	29.0	0.0	0.0	2702.0	38.0
272	9	22.0	0.0	0.0	1023.0	39.0	485.0	49.0	77.0	25.0	1585.0	67.0
272	10	23.0	0.0	0.0	1519.0	23.0	764.0	29.0	0.0	0.0	2283.0	37.0
272	10	24.0	0.0	0.0	1373.0	19.0	885.0	23.0	0.0	0.0	2258.0	30.0
299	1	0.2	0.0	0.0	8075.0	240.0	6110.0	325.0	0.0	0.0	14185.0	404.0
299	2	1.0	0.0	0.0	3734.0	53.0	3078.0	67.0	0.0	0.0	6812.0	85.0
299	2	2.0	0.0	0.0	6020.0	92.0	5430.0	119.0	0.0	0.0	11450.0	150.0
299	3	3.0	0.0	0.0	3094.0	45.0	2539.0	57.0	0.0	0.0	5633.0	73.0
299	4	4.0	0.0	0.0	4175.0	88.0	3730.0	113.0	116.0	54.0	8021.0	153.0
299	5	5.0	0.0	0.0	3726.0	65.0	3361.0	86.0	0.0	0.0	7097.0	[illegible]
300	3	5.0	151.0	102.0	2970.0	36.0	626.0	112.0	0.0	0.0	3747.0	156.0
300	3	6.0	0.0	0.0	759.0	95.0	51.5	135.0	559.0	90.0	1151.0	[illegible]
300	4	8.0	0.0	0.0	8445.0	103.0	1630.0	108.0	274.0	59.0	10349.0	[illegible]
300	4	9.0	83.0	228.0	6533.0	82.0	1825.0	255.0	151.0	44.0	8592.0	354.0
300	5	10.0	0.0	0.0	5552.0	62.0	1197.0	62.0	127.0	33.0	6876.0	94.0
300	5	11.0	0.0	0.0	3280.0	65.0	3808.0	91.0	0.0	0.0	7088.0	112.0
300	6	13.0	0.0	0.0	2141.0	43.0	1011.0	56.0	0.0	0.0	3152.0	71.0
300	6	14.0	0.0	0.0	1951.0	36.0	869.0	47.0	0.0	0.0	2820.0	59.0
300	7	15.0	87.0	148.0	2375.0	46.0	952.0	165.0	0.0	0.0	3414.0	226.0
300	7	16.0	0.0	0.0	2041.0	40.0	845.0	51.0	0.0	0.0	2886.0	65.0
300	8	17.0	0.0	0.0	1626.0	22.0	571.0	27.0	0.0	0.0	2197.0	35.0
301	1	2.0	124.0	54.0	149.0	15.0	42.0	59.0	0.0	0.0	315.0	81.0
301	2	3.0	0.0	0.0	2148.0	36.0	853.0	45.0	0.0	0.0	3001.0	58.0
301	2	4.0	0.0	0.0	2102.0	35.0	838.0	44.0	0.0	0.0	2940.0	56.0
301	3	5.0	0.0	0.0	2101.0	33.0	809.0	41.0	0.0	0.0	2910.0	53.0
301	3	6.0	17.0	96.0	1911.0	31.0	723.0	107.0	0.0	0.0	2651.0	147.0
301	3	7.0	0.0	0.0	1883.0	33.0	752.0	41.0	0.0	0.0	2635.0	[illegible]
301	4	8.0	0.0	0.0	1379.0	30.0	676.0	39.0	0.0	0.0	2055.0	
301	4	9.0	48.0	104.0	1548.0	32.0	749.0	117.0	0.0	0.0	2345.0	160.0
301	5	10.0	0.0	0.0	1383.0	27.0	590.0	35.0	0.0	0.0	1973.0	
301	5	11.0	0.0	0.0	1399.0	25.0	631.0	32.0	0.0	0.0	2030.0	41.0
301	5	12.0	0.0	0.0	1368.0	24.0	687.0	31.0	0.0	0.0	2055.0	39.0
301	6	13.0	0.0	0.0	1518.0	28.0	755.0	37.0	0.0	0.0	2273.0	46.0
301	6	14.0	0.0	0.0	1700.0	28.0	711.0	35.0	0.0	0.0	2411.0	45.0
301	7	15.0	0.0	0.0	1522.0	31.0	743.0	40.0	0.0	0.0	2265.0	51.0
301	7	16.0	0.0	0.0	1627.0	24.0	765.0	31.0	0.0	0.0	2392.0	39.0
301	7	17.0	0.0	0.0	1461.0	25.0	676.0	33.0	0.0	0.0	2137.0	41.0
301	8	18.0	0.0	0.0	1591.0	26.0	729.0	33.0	0.0	0.0	2320.0	42.0
301	8	19.0	0.0	0.0	1597.0	22.0	965.0	28.0	0.0	0.0	2562.0	36.0
301	8	20.0	0.0	0.0	1737.0	23.0	839.0	28.0	0.0	0.0	2576.0	36.0
301	9	21.0	0.0	0.0	1565.0	23.0	829.0	28.0	0.0	0.0	2394.0	36.0
301	9	22.0	0.0	0.0	1607.0	21.0	765.0	25.0	0.0	0.0	2372.0	33.0
301	10	23.0	0.0	0.0	1477.0	25.0	750.0	32.0	0.0	0.0	2227.0	41.0
301	10	24.0	0.0	0.0	989.0	45.0	417.0	36.0	61.0	30.0	1467.0	78.0
302	3	5.0	19.6	4.1	40.2	1.2	6.0	4.6	0.0	0.0	65.8	6.3
302	3	6.0	23.0	28.0	227.0	8.0	134.0	32.0	0.0	0.0	386.0	43.0
302	3	7.0	0.0	0.0	816.0	38.0	588.0	48.0	31.0	24.0	1435.0	66.0

C-27972 - WEST CHICAGO LOCATION: TAILINGS PILE - TAILINGS ONLY

BH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
302	4	8.0	0.0	0.0	785.0	42.0	584.0	54.0	64.0	28.0	1433.0	74.0
302	4	9.0	0.0	0.0	778.0	42.0	565.0	55.0	69.0	28.0	1412.0	75.0
302	5	10.0	0.0	0.0	776.0	44.0	568.0	57.0	82.0	29.0	1426.0	78.0
302	5	11.5	0.0	0.0	795.0	45.0	592.0	59.0	80.0	30.0	1467.0	80.0
302	6	13.0	0.0	0.0	863.0	48.0	580.0	62.0	91.0	32.0	1534.0	85.0
302	6	14.0	0.0	0.0	824.0	49.0	525.0	64.0	104.0	33.0	1453.0	87.0
302	7	15.0	0.0	0.0	840.0	48.0	530.0	62.0	101.0	33.0	1471.0	85.0
302	7	16.0	0.0	0.0	845.0	49.0	510.0	63.0	102.0	33.0	1457.0	86.0
302	7	17.0	0.0	0.0	933.0	58.0	618.0	75.0	129.0	39.0	1680.0	102.0
302	8	18.0	0.0	0.0	924.0	56.0	555.0	73.0	135.0	39.0	1614.0	100.0
302	8	19.0	0.0	0.0	874.0	55.0	529.0	72.0	134.0	36.0	1537.0	98.0
302	9	20.0	0.0	0.0	964.0	57.0	540.0	74.0	145.0	40.0	1649.0	102.0
302	9	21.0	0.0	0.0	1000.0	68.0	545.0	89.0	191.0	48.0	1736.0	[illegible]
302	10	22.0	0.0	0.0	902.0	65.0	537.0	85.0	178.0	46.0	1617.0	116.0
302	10	23.0	0.0	0.0	845.0	51.0	461.0	66.0	129.0	35.0	1435.0	90.0
302	10	24.0	0.0	0.0	904.0	52.0	387.0	67.0	138.0	36.0	1429.0	92.0
303	1	2.0	0.0	0.0	1005.0	46.0	540.0	59.0	90.0	30.0	1635.0	81.0
303	2	3.0	0.0	0.0	1134.0	64.0	894.0	83.0	133.0	43.0	2161.0	113.0
303	2	4.0	0.0	0.0	1233.0	75.0	864.0	97.0	177.0	51.0	2274.0	133.0
303	3	5.0	0.0	0.0	903.0	28.0	580.0	35.0	32.0	17.0	1515.0	48.0
303	3	6.0	0.0	0.0	910.0	36.0	515.0	46.0	66.0	24.0	1491.0	53.0
303	3	7.0	0.0	0.0	949.0	44.0	552.0	56.0	91.0	29.0	1592.0	77.0
303	4	8.0	0.0	0.0	881.0	39.0	547.0	50.0	78.0	26.0	1506.0	68.0
303	4	9.0	0.0	0.0	936.0	39.0	584.0	50.0	63.0	25.0	1583.0	68.0
303	5	10.0	0.0	0.0	938.0	46.0	767.0	60.0	93.0	30.0	1798.0	81.0
303	5	11.0	0.0	0.0	992.0	43.0	594.0	55.0	83.0	28.0	1669.0	75.0
303	5	12.0	0.0	0.0	928.0	52.0	717.0	67.0	108.0	34.0	1753.0	91.0
303	6	13.0	0.0	0.0	1075.0	54.0	756.0	69.0	80.0	36.0	1911.0	95.0
303	6	14.0	0.0	0.0	1257.0	30.0	1004.0	41.0	0.0	0.0	2261.0	51.0
303	7	15.0	0.0	0.0	1291.0	27.0	997.0	37.0	0.0	0.0	2288.0	46.0
303	7	16.0	0.0	0.0	953.0	44.0	606.0	56.0	55.0	29.0	1614.0	77.0
303	7	17.0	0.0	0.0	962.0	44.0	581.0	56.0	74.0	29.0	1617.0	77.0
303	8	18.0	0.0	0.0	947.0	46.0	630.0	59.0	62.0	30.0	1639.0	81.0
303	8	19.0	0.0	0.0	1454.0	27.0	862.0	36.0	0.0	0.0	2316.0	45.0
303	9	20.0	0.0	0.0	1371.0	25.0	753.0	33.0	0.0	0.0	2124.0	41.0
303	9	21.0	57.0	89.0	1755.0	28.0	814.0	99.0	0.0	0.0	2626.0	136.0
303	9	22.0	0.0	0.0	1128.0	54.0	599.0	68.0	92.0	36.0	1819.0	94.0
303	10	23.0	0.0	0.0	1006.0	53.0	605.0	68.0	103.0	35.0	1714.0	93.0
303	10	24.0	0.0	0.0	1601.0	23.0	775.0	28.0	0.0	0.0	2376.0	36.0
306	1	1.0	0.0	0.0	1281.0	19.0	602.0	24.0	0.0	0.0	1883.0	31.0
306	2	2.0	0.0	0.0	1380.0	25.0	679.0	32.0	0.0	0.0	2059.0	41.0
306	3	4.0	0.0	0.0	1401.0	21.0	610.0	27.0	0.0	0.0	2011.0	34.0
306	3	5.0	0.0	0.0	482.0	11.0	120.0	14.0	14.4	7.3	616.0	19.0
307	1	1.0	65.0	71.0	1352.0	22.0	737.0	80.0	0.0	0.0	2154.0	109.0
307	1	2.0	0.0	0.0	1364.0	23.0	758.0	30.0	0.0	0.0	2122.0	38.0
307	2	3.0	0.0	0.0	1370.0	20.0	685.0	25.0	0.0	0.0	2055.0	32.0
307	2	4.0	0.0	0.0	1008.0	60.0	560.0	77.0	116.0	40.0	1684.0	105.0
307	3	5.0	0.0	0.0	968.0	51.0	505.0	65.0	90.0	34.0	1563.0	89.0
307	3	6.0	0.0	0.0	1008.0	52.0	491.0	66.0	94.0	35.0	1593.0	91.0
307	3	7.0	0.0	0.0	900.0	47.0	460.0	60.0	66.0	31.0	1446.0	82.0

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
307	4	8.0	0.0	0.0	1289.0	22.0	778.0	29.0	0.0	0.0	2067.0	36.0
307	4	9.0	0.0	0.0	911.0	48.0	560.0	62.0	79.0	32.0	1550.0	85.0
307	5	10.0	0.0	0.0	944.0	51.0	505.0	65.0	95.0	34.0	1544.0	89.0
307	5	11.0	0.0	0.0	901.0	41.0	547.0	52.0	52.0	27.0	1500.0	72.0
307	5	12.0	0.0	0.0	890.0	42.0	510.0	53.0	63.0	28.0	1463.0	73.0
307	6	13.0	0.0	0.0	881.0	38.0	484.0	48.0	53.0	24.0	1418.0	66.0
307	6	14.0	0.0	0.0	944.0	50.0	515.0	64.0	95.0	33.0	1554.0	88.0
307	7	15.0	0.0	0.0	971.0	52.0	517.0	67.0	94.0	35.0	1582.0	92.0
307	7	16.0	0.0	0.0	925.0	44.0	498.0	56.0	74.0	29.0	1497.0	77.0
307	7	17.0	0.0	0.0	901.0	41.0	472.0	52.0	71.0	27.0	1444.0	72.0
307	8	18.0	0.0	0.0	881.0	46.0	508.0	59.0	96.0	31.0	1485.0	81.0
307	8	19.0	0.0	0.0	824.0	39.0	381.0	49.0	79.0	26.0	1284.0	68.0
307	9	20.0	0.0	0.0	957.0	42.0	425.0	53.0	73.0	28.0	1455.0	73.0
307	10	22.5	0.0	0.0	980.0	45.0	502.0	57.0	79.0	30.0	1561.0	[illegible]
307	10	23.5	0.0	0.0	1026.0	51.0	487.0	65.0	96.0	34.0	1609.0	[illegible]
308	1	1.0	15.8	3.2	51.8	1.0	9.8	3.6	0.0	0.0	77.4	9
308	1	2.0	0.0	0.0	435.0	98.0	894.0	146.0	478.0	90.0	1807.0	[illegible]
308	2	3.0	0.0	0.0	230.0	27.0	96.0	36.0	103.0	20.0	429.0	49.0
308	2	4.0	0.0	0.0	402.0	45.0	166.0	62.0	195.0	36.0	763.0	85.0
308	2	5.0	0.0	0.0	122.0	15.0	46.0	20.0	55.0	11.0	223.0	27.0
308	3	6.0	0.0	0.0	901.0	177.0	651.0	260.0	1035.0	178.0	2578.0	361.0
308	3	7.0	0.0	0.0	882.0	181.0	685.0	267.0	1084.0	184.0	2651.0	371.0
308	4	8.0	0.0	0.0	1609.0	24.0	42.0	27.0	76.0	14.0	1808.0	39.0
308	4	9.0	22.0	55.0	1398.0	18.0	516.0	61.0	0.0	0.0	1936.0	84.0
308	4	10.0	0.0	0.0	919.0	144.0	442.0	208.0	771.0	138.0	2132.0	298.0
308	5	11.0	0.0	0.0	942.0	46.0	427.0	59.0	105.0	31.0	1474.0	81.0

	U238 VALUE pCI/g	U238 ACCU pCI/g	TH232 VALUE pCI/g	TH232 ACCU pCI/g	RA236 VALUE pCI/g	RA236 ACCU pCI/g	OTHER GAM VALUE pCI/g	OTHER GAM ACCU pCI/g	TOT GAM VALUE pCI/g	TOT GAM ACCU pCI/g
NO. SAMPLES, n:	226	226	226	226	226	226	226	226	226	226
MEAN, Xbar:	13.7	15.2	1356.8	44.7	811.8	69.4	78.4	21.4	2260.1	95.0
VARIANCE, s^2:	5561.7	3241.2	1113465.6	736.1	809167.3	3856.2	17309.3	661.3	3037324.4	7820.6
STD. DEV., s:	74.6	56.9	1055.2	27.1	899.5	62.1	131.6	25.7	1742.8	88.4
STANDARD ERROR:	5.0	3.8	70.2	1.8	59.8	4.1	8.8	1.7	115.9	5.9
RANGE:										
MIN. VALUE:	0	0	40.2	1	6	3.6	0	0	65.8	4.9
MAX. VALUE:	893	475	8445	240	9398	528	1084	184	14185	722

C-27972 - WEST CHICAGO

LOCATION: POND I - SLUDGE ONLY

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
359	4	6.0	0.0	0.0	1269.0	56.0	21.0	69.0	209.0	39.0	1499.0	97.0
359	5	8.0	0.0	0.0	3287.0	65.0	110.0	77.0	104.0	41.0	3501.0	109.0
359	6	0.0	0.0	0.0	1709.0	38.0	63.0	47.0	96.0	24.0	1868.0	65.0
359	6	0.0	0.0	0.0	3772.0	69.0	62.5	79.0	165.0	43.0	3904.0	112.0
359	6	0.0	0.0	0.0	3270.0	63.0	51.0	74.0	122.0	40.0	3346.0	105.0
385	2	3.0	11.7	1.0	28.0	0.5	3.4	1.8	0.0	0.0	43.6	2.4
385	2	4.0	210.0	102.0	2955.0	37.0	272.0	114.0	83.0	20.0	3520.0	159.0
385	3	12.0	0.0	0.0	2346.0	25.0	22.0	25.0	38.0	13.0	2378.0	38.0
385	4	13.0	0.0	0.0	2255.0	32.0	34.5	36.0	105.0	19.0	2357.0	52.0
385	5	15.0	0.0	0.0	6402.0	81.0	0.0	83.0	280.0	46.0	6478.0	125.0
385	6	16.0	0.0	0.0	6467.0	71.0	1.5	68.0	201.0	37.0	6535.0	105.0
385	7	18.0	0.0	0.0	5118.0	66.0	40.0	70.0	180.0	38.0	5338.0	103.0
387	4	5.0	175.0	82.0	1000.0	28.0	39.0	93.0	57.0	17.0	1271.0	126.0
387	5	7.0	0.0	0.0	698.0	18.0	20.0	21.0	54.0	12.0	750.0	30.0
387	6	9.0	0.0	0.0	1371.0	29.0	54.0	35.0	51.0	16.0	1476.0	49.0
387	6	10.0	101.0	175.0	3511.0	58.0	157.5	193.0	104.0	34.0	3645.0	269.0
387	7	12.0	201.0	205.0	3624.0	67.0	53.0	226.0	115.0	40.0	3993.0	315.0
393	4	5.0	0.0	0.0	2220.0	50.0	14.0	60.0	138.0	32.0	2372.0	84.0
393	4	6.0	0.0	0.0	3618.0	62.0	29.0	71.0	217.0	39.0	3864.0	102.0
393	4	7.0	0.0	0.0	1554.0	27.0	52.0	32.0	71.0	16.0	1677.0	45.0
393	5	8.0	0.0	0.0	1070.0	23.0	64.0	28.0	46.0	14.0	1180.0	39.0
393	6	9.0	1140.0	563.0	2004.0	165.0	18.0	621.0	56.0	104.0	3218.0	861.0
393	6	10.0	2091.0	1023.0	4030.0	302.0	1105.0	1122.0	111.0	191.0	6198.0	1560.0
393	7	11.0	0.0	0.0	3958.0	63.0	39.0	71.0	219.0	39.0	4113.0	103.0
393	8	12.0	0.0	0.0	2528.0	52.0	33.5	63.0	198.0	34.0	2667.0	85.0
393	8	13.0	0.0	0.0	6441.0	83.0	55.0	87.0	271.0	48.0	6648.0	129.0
419	2	2.0	13.5	2.4	42.6	0.8	5.9	2.8	0.0	0.0	62.0	3.8
419	3	3.0	0.0	0.0	4801.0	73.0	598.0	83.0	262.0	45.0	5661.0	119.0
419	3	4.0	0.0	0.0	1572.0	25.0	0.0	29.0	70.0	15.0	1562.0	41.0
419	3	5.0	52.0	155.0	4422.0	56.0	210.0	171.0	138.0	30.0	4822.0	239.0
419	4	6.0	0.0	0.0	946.0	18.0	87.0	21.0	25.0	10.0	1058.0	29.0
419	5	7.0	0.0	0.0	2702.0	32.0	6.0	33.0	110.0	18.0	2758.0	49.0
419	5	8.0	0.0	0.0	5339.0	55.0	0.0	51.0	212.0	28.0	5424.0	80.0
419	6	9.0	0.0	0.0	6238.0	66.0	28.5	63.0	218.0	35.0	6837.0	98.0
419	7	10.0	0.0	0.0	5661.0	57.0	12.5	53.0	216.0	29.0	5796.0	83.0
419	7	11.0	0.0	0.0	354.0	10.0	8.5	14.0	11.0	6.0	354.0	16.0
419	8	12.0	0.0	0.0	4187.0	34.0	26.0	57.0	164.0	31.0	4269.0	84.0
419	9	13.0	0.0	0.0	1546.0	23.0	20.0	26.0	57.0	13.0	1591.0	37.0
419	9	14.0	0.0	0.0	7515.0	86.0	0.0	84.0	308.0	47.0	7574.0	129.0
419	10	15.0	0.0	0.0	6497.0	77.0	27.0	78.0	281.0	43.0	6676.0	118.0
419	11	16.0	149.0	53.0	973.0	17.0	24.0	60.0	7.0	10.0	1153.0	82.0
419	12	18.0	0.0	0.0	4857.0	48.0	11.5	41.0	136.0	23.0	4934.0	67.0
420	4	5.0	0.0	0.0	3756.0	56.0	129.0	63.0	203.0	34.0	4088.0	91.0
420	4	7.0	0.0	0.0	1495.0	30.0	35.5	36.0	82.0	19.0	1576.0	50.0
420	5	8.0	0.0	0.0	643.0	16.0	6.0	20.0	28.0	10.0	677.0	27.0
420	5	9.0	0.0	0.0	952.0	22.0	12.0	28.0	64.0	14.0	1028.0	38.0
420	6	10.0	0.0	0.0	3207.0	52.0	28.5	58.0	149.0	31.0	3297.0	84.0
420	7	11.0	0.0	0.0	3734.0	67.0	17.5	77.0	236.0	42.0	3851.0	110.0
420	8	12.0	0.0	0.0	1659.0	44.0	33.0	54.0	116.0	28.0	1733.0	75.0
420	8	13.0	0.0	0.0	3487.0	68.0	57.5	79.0	195.0	43.0	3639.0	113.0

C-27972 - WEST CHICAGO LOCATION: POND I - SLUDGE ONLY

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA236 VALUE	RA236 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
420	9	14.0	0.0	0.0	3679.0	75.0	35.5	87.0	145.0	47.0	3721.0	124.0
420	9	15.0	0.0	0.0	7752.0	119.0	45.5	130.0	328.0	72.0	7911.0	190.0
421	3	5.0	0.0	0.0	2872.0	60.0	45.0	72.0	127.0	38.0	3044.0	[illegible]
421	3	6.0	0.0	0.0	2886.0	54.0	78.0	64.0	133.0	34.0	3097.0	90.0
421	4	7.0	0.0	0.0	3631.0	85.0	95.0	101.0	276.0	55.0	3895.0	143.0
421	4	8.0	0.0	0.0	2586.0	53.0	100.0	64.0	165.0	34.0	2851.0	90.0
421	5	9.0	7.0	71.0	984.0	23.0	48.0	81.0	37.0	14.0	1076.0	111.0
421	6	10.0	46.0	123.0	1606.0	39.0	127.0	137.0	52.0	24.0	1664.0	190.0
421	7	11.0	139.0	129.0	2581.0	43.0	119.5	143.0	43.0	25.0	2719.0	199.0
10385	11	5.0	0.0	0.0	1910.0	36.0	26.0	42.0	64.0	22.0	1942.0	60.0
10385	11	6.0	135.0	153.0	2313.0	49.0	76.0	170.0	84.0	30.0	2473.0	236.0
10385	12	7.0	0.0	0.0	1559.0	38.0	12.0	47.0	65.0	24.0	1636.0	65.0
10385	13	8.0	0.0	0.0	1679.0	38.0	27.0	46.0	80.0	24.0	1786.0	64.0
10385	13	9.0	0.0	0.0	1257.0	34.0	62.0	42.0	46.0	21.0	1365.0	[illegible]
10385	14	10.0	0.0	0.0	3474.0	57.0	23.5	65.0	141.0	35.0	3532.0	[illegible]
10385	15	11.0	0.0	0.0	2453.0	44.0	34.5	50.0	94.0	27.0	2516.0	[illegible]
10385	15	12.0	0.0	0.0	3878.0	70.0	56.5	81.0	171.0	44.0	4000.0	[illegible]
10385	16	13.0	0.0	0.0	6999.0	120.0	86.5	135.0	300.0	74.0	7202.0	195.0
10385	16	14.0	0.0	0.0	5600.0	104.0	36.5	119.0	262.0	66.0	5697.0	171.0
10385	17	15.0	194.0	143.0	2833.0	48.0	72.0	159.0	70.0	28.0	3169.0	221.0
10385	18	16.0	126.0	176.0	4257.0	61.0	72.0	194.0	84.0	34.0	4539.0	189.0
10385	18	17.0	0.0	0.0	6282.0	100.0	41.5	112.0	270.0	62.0	6411.0	162.0

	U238 VALUE pCI/g	U238 ACCU pCI/g	TH232 VALUE pCI/g	TH232 ACCU pCI/g	RA236 VALUE pCI/g	RA236 ACCU pCI/g	OTHER GAM VALUE pCI/g	OTHER GAM ACCU pCI/g	TOT GAM VALUE pCI/g	TOT GAM ACCU pCI/g
NO. SAMPLES, n:	72	72	72	72	72	72	72	72	72	72
MEAN, Xbar:	66.5	43.8	3140.9	56.0	71.1	95.7	133.6	33.8	3340.6	134.4
VARIANCE, s^2:	78829.3	20470.3	3666772.3	1666.6	21698.2	21322.9	7332.9	661.4	3927868.1	40838.8
STD. DEV., s:	280.8	143.1	1914.9	40.8	147.3	146.0	85.6	25.7	1981.9	202.1
STANDARD ERROR:	33.1	16.9	225.7	4.8	17.4	17.2	10.1	3.0	233.6	23.8
RANGE:										
MIN. VALUE:	0	0	28	8.5	0	1.8	0	0	42.6	2.4
MAX. VALUE:	2091	1023	7752	302	1105	1122	328	191	7911	1560

C-27972 - WEST CHICAGO LOCATION: SLUDGE PILE - SLUDGE ONLY

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA226 VALUE	RA226 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
259	1	1.0	71.6	3.3	74.6	1.1	5.5	3.7	0.3	0.6	152.0	5.0
259	2	2.5	49.1	4.3	147.0	2.0	8.3	4.7	0.0	0.0	204.0	7.0
259	3	5.0	0.0	0.0	3501.0	46.0	49.0	50.0	146.0	27.0	3645.0	73.0
259	3	6.0	144.0	146.0	3749.0	53.0	147.0	163.0	157.0	30.0	4018.0	227.0
259	3	7.5	0.0	0.0	2796.0	38.0	162.0	41.0	65.0	22.0	3023.0	60.0
278	3	5.0	2349.0	777.0	2942.0	210.0	196.0	842.0	0.0	0.0	5487.0	1165.0
278	3	6.0	26.0	17.0	279.0	6.0	10.0	19.0	2.2	3.3	317.0	26.0
278	3	7.0	1.9	1.2	4.1	0.3	2.8	1.4	0.6	0.2	9.4	1.9
279	1	1.0	297.0	145.0	5066.0	57.0	178.0	161.0	141.0	30.0	5682.0	226.0
279	1	2.0	505.0	133.0	5194.0	55.0	210.0	148.0	85.0	27.0	5994.0	209.0
279	2	3.0	3426.0	1285.0	4521.0	384.0	149.0	1421.0	141.0	243.0	8237.0	1969.0
279	2	4.0	588.0	153.0	5182.0	60.0	78.0	171.0	99.0	31.0	5947.0	239.0
279	3	5.0	363.0	132.0	5042.0	54.0	322.0	147.0	88.0	27.0	5815.0	206.0
279	3	6.0	471.0	156.0	5024.0	61.0	84.0	174.0	67.0	32.0	5646.0	244.0
279	3	7.0	2869.0	922.0	3250.0	271.0	70.0	1018.0	58.0	171.0	6247.0	1410.0
279	4	8.0	331.0	103.0	4215.0	43.0	203.0	115.0	102.0	21.0	4851.0	162.0
279	4	9.0	192.0	111.0	4299.0	46.0	177.0	123.0	67.0	23.0	4735.0	174.0
279	5	10.0	372.0	86.0	2410.0	32.0	168.0	96.0	46.0	17.0	2996.0	134.0
279	5	12.0	232.0	214.0	5901.0	80.0	217.0	238.0	166.0	44.0	6516.0	333.0
279	6	13.0	135.0	193.0	6648.0	76.0	289.0	215.0	200.0	40.0	7272.0	301.0
279	6	14.0	296.0	179.0	5854.0	69.0	442.0	200.0	175.0	37.0	6767.0	280.0
279	7	15.0	257.0	135.0	4772.0	54.0	333.0	151.0	108.0	28.0	5470.0	211.0
279	7	16.0	40.0	288.0	6131.0	73.0	385.0	210.0	203.0	39.0	6759.0	294.0
279	8	17.0	206.0	222.0	4727.0	78.0	309.0	249.0	183.0	46.0	5425.0	346.0
280	1	1.0	0.0	0.0	4619.0	56.0	23.0	57.0	120.0	32.0	4671.0	66.0
280	1	2.0	0.0	0.0	3948.0	39.0	25.0	36.0	78.0	19.0	4051.0	56.0
280	2	2.5	0.0	0.0	4427.0	60.0	88.0	64.0	166.0	35.0	4681.0	94.0
280	3	5.0	0.0	0.0	5803.0	71.0	429.0	74.0	211.0	40.0	6443.0	110.0
280	3	6.0	117.0	177.0	4181.0	61.0	187.0	196.0	146.0	35.0	4631.0	273.0
280	4	8.0	0.0	0.0	6560.0	84.0	412.0	89.0	223.0	49.0	7195.0	132.0
280	4	9.0	74.0	247.0	6037.0	86.0	383.0	273.0	166.0	48.0	6660.0	391.0
280	5	10.0	0.0	0.0	5852.0	90.0	467.0	99.0	252.0	54.0	6571.0	144.0
280	5	11.0	0.0	0.0	6283.0	99.0	492.0	111.0	233.0	60.0	7008.0	160.0
280	6	13.0	94.0	145.0	5353.0	58.0	243.0	160.0	90.0	28.0	5780.0	225.0
280	7	14.0	0.0	0.0	5246.0	70.0	333.0	75.0	131.0	41.0	5730.0	110.0
280	7	15.0	0.0	0.0	5498.0	66.0	247.0	67.0	215.0	37.0	5960.0	101.0
280	8	16.0	0.0	0.0	5602.0	53.0	348.0	47.0	141.0	26.0	6091.0	75.0
280	9	17.0	137.0	160.0	5030.0	60.0	298.0	177.0	80.0	31.0	5545.0	248.0
280	9	18.0	159.0	137.0	3991.0	50.0	247.0	152.0	82.0	27.0	4479.0	212.0
281	2	3.0	80.0	115.0	3433.0	44.0	83.0	128.0	62.0	24.0	3658.0	179.0
281	2	4.0	84.0	90.0	2903.0	35.0	37.0	101.0	66.0	19.0	3090.0	141.0
281	3	5.0	134.0	80.0	2015.0	29.0	59.0	90.0	57.0	16.0	2265.0	125.0
293	3	6.0	127.0	168.0	4010.0	61.0	34.0	188.0	116.0	35.0	4287.0	262.0
293	3	7.0	0.0	0.0	3215.0	55.0	12.0	62.0	131.0	33.0	3358.0	89.0
293	3	8.0	0.0	0.0	3349.0	57.0	59.0	66.0	161.0	35.0	3496.0	94.0
293	4	9.0	0.0	0.0	3378.0	42.0	27.0	44.0	144.0	24.0	3488.0	65.0
293	4	10.0	0.0	0.0	626.0	8.0	47.3	8.5	21.0	4.6	694.0	12.0
293	5	11.0	49.9	8.3	381.0	4.0	36.3	9.2	2.9	1.7	470.0	13.0
293	5	12.0	868.0	145.0	4695.0	55.0	407.0	161.0	3.0	29.0	5973.0	225.0
294	2	3.0	0.0	0.0	8654.0	89.0	40.0	83.0	240.0	46.0	8808.0	130.0

C-27972 - WEST CHICAGO LOCATION: SLUDGE PILE - SLUDGE ONLY

DH NO	SAMPLE	SMPL DEPTH	U238 VALUE	U238 ACCU	TH232 VALUE	TH232 ACCU	RA226 VALUE	RA226 ACCU	OTH GAM VALUE	OTH GAM ACCU	TOT GAM VALUE	TOT GAM ACCU
294	2	4.0	0.0	0.0	9245.0	119.0	0.5	123.0	386.0	69.0	9386.0	184.0
294	3	5.0	147.0	105.0	3557.0	41.0	115.5	116.0	58.0	21.0	3761.0	163.0
294	3	6.0	0.0	0.0	6141.0	66.0	401.0	63.0	155.0	34.0	6697.0	97.0
294	3	7.0	0.0	0.0	5653.0	77.0	175.0	82.0	212.0	45.0	6040.0	121.0
294	4	8.0	0.0	0.0	6457.0	102.0	289.0	114.0	269.0	63.0	7015.0	165.0
294	4	9.0	0.0	0.0	5414.0	81.0	261.0	90.0	277.0	49.0	5952.0	131.0
294	5	11.0	0.0	0.0	6354.0	95.0	268.0	105.0	253.0	57.0	6875.0	153.0
294	5	12.0	110.0	63.0	1091.0	20.0	106.0	71.0	4.0	12.0	1311.0	98.0
315	1	1.0	0.0	0.0	5715.0	104.0	259.0	119.0	353.0	66.0	6327.0	171.0
315	1	2.0	0.0	0.0	5979.0	67.0	273.0	66.0	190.0	37.0	6442.0	101.0
315	2	3.0	0.0	0.0	5913.0	94.0	285.0	106.0	334.0	59.0	6532.0	153.0
315	2	4.0	0.0	0.0	4848.0	57.0	240.0	59.0	189.0	33.0	5277.0	89.0
315	3	5.0	0.0	0.0	5126.0	81.0	146.0	90.0	257.0	50.0	5529.0	131.0
315	3	6.0	0.0	0.0	4804.0	129.0	97.0	155.0	436.0	86.0	5337.0	[illegible]
326	1	0.3	887.0	231.0	6556.0	84.0	4557.0	264.0	55.0	46.0	12055.0	[illegible]
326	2	1.0	478.0	117.0	2841.0	39.0	2491.0	134.0	0.0	0.0	5738.0	[illegible]
326	4	3.0	17.5	3.9	102.0	1.0	26.1	4.5	0.8	0.8	146.0	[illegible]

	U238 VALUE pCI/g	U238 ACCU pCI/g	TH232 VALUE pCI/g	TH232 ACCU pCI/g	RA226 VALUE pCI/g	RA226 ACCU pCI/g	OTHER GAM VALUE pCI/g	OTHER GAM ACCU pCI/g	TOT GAM VALUE pCI/g	TOT GAM ACCU pCI/g
NO. SAMPLES, n:	67	67	67	67	67	67	67	67	67	67
MEAN, Xbar:	250.5	110.4	4367.4	68.5	287.6	154.3	135.3	37.3	5025.2	216.9
VARIANCE, s^2:	376246.9	45854.3	3976923.3	3323.0	378475.5	48938.9	9984.7	1271.8	5418447.5	93429.9
STD. DEV., s:	613.4	214.1	1994.2	57.6	615.2	221.2	99.9	35.7	2327.8	305.7
STANDARD ERROR:	74.9	26.2	243.6	7.0	75.2	27.0	12.2	4.4	284.4	37.3
RANGE:										
MIN. VALUE:	0	0	4.1	0.3	0.5	1.4	0	0	9.4	- 1.9
MAX. VALUE:	3426	1285	9245	384	4557	1421	436	243	12055	1969