Radiological Investigation Results for Pennsylvania Landfill Leachate Fall 2005 Tritium Update

Pennsylvania Department of Environmental Protection
Bureau of Radiation Protection
and
Bureau of Waste Management
Harrisburg, Pennsylvania

Project No. 040-195

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Executive Summary

During the fall of 2004, the Pennsylvania Department of Environmental Protection (PADEP) implemented a sampling and analysis plan (SAP) to investigate radioactive material potentially present in untreated landfill leachate. The investigation included all active and permitted landfills in the Commonwealth of Pennsylvania having a leachate collection system (half of the 108 solid waste landfills in the Commonwealth met this selection criterion), a report[1] of the investigation was published in October 2005. Samples of raw, untreated leachate were collected at each of the 54 landfills plus 5 quality control samples for a total of 59 samples. These samples were sent to a commercial radioanalytical laboratory for analysis. During the initial analysis phase of the 59 samples, the following radioactivity concentration parameters were measured: gross alpha, gross beta, gamma emitters by spectroscopy, and tritium (^{3}H as HTO). Additional analysis was performed for landfills where gross alpha concentration exceeded approximately 5 picocuries per liter (pCi/L; 1 pCi = 0.000000000001 Ci). The additional analyses measured the concentration of radium-226 (^{226}Ra, a member of the natural uranium decay series) and radium-228 (^{228}Ra, a member of the natural thorium decay series), as well as the mass concentration (micrograms per liter; µg/L) of total uranium.

The fall 2004 SAP results showed that tritium was the most prevalent radionuclide present in leachate (identified in 57 or 97% of the 59 samples analyzed). Results ranged from 6.86 to 94,400 pCi/L, with a mean concentration of 25,200 pCi/L. Prompted by those tritium results, the Commonwealth planned to conduct a subsequent round of sampling and analysis for tritium in leachate (fall 2005 SAP) at the landfills included in the fall 2004 SAP. This report contains the results of the fall 2005 SAP for tritium.

The fall 2005 SAP results show that tritium was again present in nearly all of the samples (identified in 55 or 93% of the 59 samples analyzed). The tritium concentrations ranged from -62 to 181,700 pCi/L, with a mean concentration of 20,900 pCi/L. By comparison, the range of results for the fall 2004 SAP was significantly narrower (7 to 93,500 pCi/L), but with an almost identical mean concentration of 24,400 pCi/L. There were 16 (27%) samples with results above 20,000 pCi/L in the fall 2005 SAP, about half that seen in 2004 (31 samples or 53%).

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[1] *Radiological Investigation Results for Pennsylvania Landfill Leachate.* Pennsylvania Department of Environmental Protection, Bureau of Radiation Protection and Bureau of Waste Management, Harrisburg, Pennsylvania. October 3, 2005. This report is accessible via the world wide web at http://www.depweb.state.pa.us/dep/site/default.asp - keyword "Radiation Protection," or by request from BRP Radiation Control Division at 717-787-3720.

The U.S. Environmental Protection Agency (USEPA) sets a maximum contaminant level (MCL) of 20,000 pCi/L for tritium under its drinking water standards. In order to ensure that the MCL for tritium in drinking water is not exceeded, the Commonwealth considers 20,000 pCi/L as an applicable or relevant and appropriate requirement (ARAR) standard for leachates and any other waters at the point of intake to a drinking water supply. However, considering the treatment and discharge processes leachate is subject to and the dilution factors associated with possible human exposure scenarios, none of the fall 2004 or 2005 SAP tritium results would exceed ARAR levels at the point of intake to current drinking water supplies.

Nonetheless, the fall 2005 SAP results confirm the existence of measurable concentrations of tritium in landfill leachate effluents and prompted BRP to recommend further monitoring of landfill leachates for possible impact on drinking water supplies. While it is not feasible or practical to confirm the exact sources of the observed tritium in leachate, the Commonwealth believes that gaseous tritium light source (GTLS) 'EXIT' signs have been, and continue to be, disposed in landfills. These GTLS devices contain significant quantities of tritium gas that, once ruptured in a landfill, are readily oxidized into tritiated water that is eventually captured as leachate.

The Commonwealth plans to continue monitoring for tritium in leachate at landfills. The Commonwealth has prepared recommendations that enhance the routine leachate analysis regime required by landfill operating permits by including tritium in the list of analytes requiring periodic monitoring. These recommendations are being implemented in 2006. In addition, based on the 2004 and 2005 leachate sample analysis results, DEP will continue to investigate potential impacts to surface water users downstream of these facilities.

1.0 Introduction

1.1 Scope

A revised radiological sampling and analysis plan (SAP) was implemented at active (permitted) solid waste landfills (LFs) in the state of Pennsylvania for the fall 2005 (i.e., fall 2004 update) investigation. The sampling and analysis activities were conducted during the fourth quarter of 2005 at the direction of the Pennsylvania Department of Environmental Protection (PADEP) Bureau of Radiation Protection to obtain additional tritium concentration data for untreated LF leachate. This report documents this additional data and how it was obtained.

1.2 Background

There are a total of 108 solid waste LFs in Pennsylvania designated for receipt of municipal waste (MW), residual waste (RW), sanitary waste, and construction/demolition (C/D) debris. Of this total, 54 LFs are permitted and active with the remaining 54 inactive or designated by the PADEP not to be included in this sampling event. Most of the active LFs (Table 1) feature a leachate collection system to capture liquids percolating through the LF for wastewater treatment facility processing. Active LF operators are required by PADEP regulations to periodically sample and characterize their leachate for a suite of non-radioactive constituents of concern (COCs; radioactive COCs are not required).

1.3 Data Needs

The primary data need fulfilled by the SAP was tritium radioactivity concentration. There were no secondary data needs anticipated based on a review of the primary data.

1.4 Project Organization and Responsibility

Specific individuals of the radiological SAP LF leachate team were assigned the following project positions during performance of the monitoring activities:

PADEP Bureau of Radiation Protection (BRP) Sponsor – David J. Allard
PADEP Bureau of Waste Management Point of Contact (POC) - Steve Socash
Sampling Surveillance/Laboratory Shipments – PADEP Regional Offices

1.4.1 PADEP Regional Office Solid Waste Contacts

Region I (Southeast) POC – Ronald Furlan
Region II (Northeast) POC – William Tomayko

Region III (South Central) POC – John Krueger

Region IV (North Central) POC – James Miller

Region V (Southwest) POC – David Eberle

Region VI (Northwest) POC – Todd Carlson

1.4.2 SAP Operations and Data Management

Civil and Environmental Consultants, Inc. POC – Rick Orthen

1.4.3 Laboratory Operations

Pace Analytical Services POC - Ed Forrai

2.0 Field Sampling Plan and Laboratory Analyses

2.1 Sampling Locations, Frequency, and Media

Sampling and sample packaging for shipment were performed by properly trained and qualified LF site representatives and/or authorized PADEP representatives. Representative samples of untreated leachate from each leachate management system were collected using sampling kit instructions provided to each LF. The LF facility and media to be sampled was determined by PADEP and specified on the Chain of Custody (COC) record (see below and Attachment C) accompanying each sampling kit. Additional details of each of these sampling methods are presented in the following subsections.

Table 1

	SAP ID	Facility Name	City	County
Southeast RI	1	Bethlehem Steel Corp RWLF	Coatesville	Chester
	3	GROWS MWLF	Morrisville	Bucks
	4	Pottstown MWLF	Pottstown	Montgomery
	5	SECCRA MWLF	West Grove Kennett Square	Chester
	6	Tullytown Resource Recovery MWLF	Tullytown	Bucks
Northeast RII	11	Alliance Sanitary LF/MWLF	Taylor	Lackawanna
	12	Chrin Brothers Inc. MWLF	Easton	Northampton
	13	Commonwealth Environmental Systems MWLF	Foster Township Hegins	Schuylkill
	15	Grand Central Sanitary LF/MWLF	Pen Argyl	Northampton
	16	IESI Bethlehem LF/MWLF	Bethlehem	Northampton
	17	Keystone Sanitary LF/MWLF	Dunmore	Lackawanna
	18	Pine Grove LF/MWLF	Pine Grove	Schuylkill
Southcentral RIII	38	Cumberland County MWLF	Shippensburg / Newburg	Cumberland
	39	Conestoga MWLF	Morgantown	Berks
	40	Greater Lebanon Refuse Authority MWLF	Lebanon	Lebanon
	41	IESI Blue Ridge MWLF	Scotland	Franklin
	42	Lancaster County Solid Waste (Frey Farm) Resource Recovery LF/Transfer Station	Bainbridge / Conestoga	Lancaster
	43	Lanchester MWLF	Narvon	Lancaster
	44	Mifflin County SWA MWLF	Lewistown	Mifflin

	SAP ID	Facility Name	City	County
Southcentral RIII	45	Milton Grove C/DLF	Mt. Joy Township	Lancaster
	46	Modern MWLF	York	York
	47	Mountain View MWLF	Greencastle	Franklin
	48	Pioneer Crossing MWLF	Birdsboro / Harleysville	Berks
	49	Rolling Hills MWLF	Boyertown	Berks
	50	Sandy Run MWLF	Hopewell	Bedford
	51	Western Berks RA MWLF	Birdsboro	Berks
Northcentral RIV	54	Allenwood MWLF	Brady Township	Lycoming
	56	Northern Tier MWLF #2	West Burlington Township	Bradford
	59	Wayne Township MWLF	Wayne Township	Clinton
	60	White Pines MWLF	Pine Township	Columbia
Southwest RV	64	Arden Inc. MWLF	Washington	Washington
	65	BFI Imperial MWLF	Imperial	Allegheny
	66	Brunner MWLF	Zelienople	Beaver
	67	Deep Valley C/DLF	North Fayette Township	Allegheny
	68	Evergreen MWLF	Coral	Indiana
	69	Greenridge Reclamation MWLF	Scottdale	Westmoreland
	70	J & J MWLF - CBF Inc.(Onyx Chestnut)	McClellandtown	Fayette
	71	Kelly Run Sanitation MWLF	Elizabeth	Allegheny
	72	Laurel Highland MWLF	Johnstown	Cambria
	73	MAX Environmental Tech (Noncaptive RW Disposal Impoundment)	South Huntington	Westmoreland
	74	Monroeville (Chambers Development) MWLF	Monroeville	Allegheny
	75	Mostoller MWLF	Somerset	Somerset
	76	Paris Flyash Noncaptive RWLF	Hanover Township	Beaver
	77	Westmoreland (Rostraver) MWLF	Belle Vernon	Westmoreland
	78	Shade MWLF	Caimbrook	Somerset
	79	South Hills MWLF	South Park / Library	Allegheny
	80	Southern Alleghenies MWLF	Davidsville	Somerset
	81	Valley MWLF	Irwin	Westmoreland

	SAP ID	Facility Name	City	County
Northwest RVI	90	Clarion County MWLF	Leeper	Clarion
	91	McKean Kness MWLF	Kane	McKean
	92	Lake View MWLF	Erie	Erie
	94	Northwest Sanitary MWLF	West Sunbury	Butler
	95	Seneca MWLF	Evans City / Mars	Butler
	96	Superior Greentree MWLF	Kersey	Elk

2.1.1 Sample Collections and Analyses

Each LF facility received up to two sample containers: 1 glass bottle for the unfiltered sample, and as necessary, 1 QC duplicate glass bottle. Each glass bottle was appropriately marked or labeled with the sample identification code and the analysis required. The sample containers were not pre-preserved with a small volume of nitric acid since tritium adsorption onto container walls is negligible and the 5-day holding time limit is therefore not applicable. Samples were not filtered because the laboratory analysis procedure utilizes evaporation during sample preparation.

Each sample collected was analyzed by the laboratory for tritium concentration using EPA Method 906.0 with a *Packard* TriCarb 2900TR liquid scintillation counter. The TriCarb counter is an ultra low-background analyzer offering automatic window optimization to provide a high efficiency-to-background ratio. Internal quench correction is also provided to determine sample-specific detection efficiencies.

2.1.2 Sample Identification

Systematic 11-character sample identification (ID) codes were used to uniquely identify all samples. The ID code format was "AAbbCCCCdEf" meaning:

- AA – a two-digit LF identification number: 01 to 97 (see Table 1, column "SAP ID").
- bb – a two-letter sample matrix designator: LE (Untreated Leachate)
- CCCC – a four-digit project sequential sample number beginning 0194.
- d – a single letter sample analysis designator: C (^{3}H).
- E – a single-digit sample type designator: 1 (original), 2 (field QC duplicate).
- f – a single letter designating analysis turn around time: N (normal 15 day TAT), Z (archive without analysis).

An LF SAP Excel® Workbook was used to record and maintain all pertinent information associated with each sample ID code marked/labeled on sample bottles and COC records issued to field personnel.

2.2 Quality Control Samples

Quality assurance objectives were specified so that the data produced are of a known and sufficient quality for determining whether a risk to human health or the environment exists. Because this investigation was an update to a previous preliminary effort, all data was considered noncritical; accordingly, an extensive effort to validate the precision and accuracy of field sampling adversely affecting results produced in the laboratory setting was not warranted or justifiable. By design, the SAP assured representative sampling because all sample aliquots were taken from a single composite sample. In the field, precision was affected by sample collection procedures and by the natural heterogeneity encountered in the environment. Overall, both field and laboratory precision was evaluated by examining the results of field duplicate samples and laboratory quality control (QC) samples. Laboratory precision was based on the use of laboratory-generated duplicate samples or matrix spike/matrix spike duplicate samples. The field QC duplicate sample load used for this investigation was 10% of the total samples collected (i.e., five duplicate sample sets). Each duplicate sample was analyzed for the same radiological parameters as the original paired sample.

Trip blanks were unnecessary since no volatile organic compound analyses were included in the SAP. Since sampling equipment was not reused, equipment rinsate samples were not obtained and analyzed to identify instances of sample cross-contamination.

The analytical laboratory chosen for this investigation has extensive experience analyzing tritium and sample matrices required by this investigation. Further, the laboratory maintains and implements an approved quality assurance program (QAP) to provide objective evidence that all measurements satisfy specific quality assurance objectives. Accordingly, performance evaluation samples (e.g., samples spiked with known concentrations of radionuclides in levels similar to those expected in the actual samples or blanks) were not to be prepared beyond those included in the laboratory's QAP to further document the accuracy and precision of their measurements process.

2.3 Chain of Custody Record

The chain-of-custody record serves as a written record of sample handling from the field through laboratory receipt. When a completed sample changes custody, those relinquishing and receiving the sample signed the chain-of-custody record. Each change of possession was documented, from the

sampler to sample courier, and finally from the courier to the laboratory. The completed chain-of-custody records are included with the laboratory analytical reports (Attachment C).

2.4 Handling and Disposition of Investigation-Derived Waste

All waste dispositions were coordinated with the appropriate LF site representative to ensure compliance with applicable waste storage, characterization, treatment, and disposal requirements. The investigation-derived waste produced during sampling included spent and unused sample material, personal protective equipment, miscellaneous sampling supplies, decontamination water, purge water, and samples. The LF site representative provided a determination for the disposition of all waste (including purge water) that is based on a waste determination.

2.5 Sample Handling, Packaging, and Shipping

All personnel handling samples wore personal protective equipment commensurate with the level of hazard and facility procedures. The exterior of the filled sample container(s) was decontaminated as appropriate. Sample containers were properly secured pending shipment. The sample custodian/shipper was responsible for ensuring that bottle caps were checked for tightness, a tamper-evident seal placed across bottle caps, and samples were properly packaged for custody transfer and shipment to the laboratory. Samples for radioactivity analysis did not require refrigeration.

2.6 Field Screening for Radioactivity

Screening filled sample containers for radioactivity was not performed prior to sample shipment.

3.0 Leachate Tritium Analysis Results

The leachate samples collected at 54 landfills, and an additional five QC duplicate samples, were analyzed for tritium (for a total of 59 samples/results). The laboratory processed nine method blanks to accompany the initial batch processing of the 59 samples. The tritium results ranged from -62.1 to 182,000 pCi/L, with a mean concentration of 20,900 pCi/L. [For comparison, the 2004 SAP data showed tritium ranging from 7 to 93,500 pCi/L, with a mean concentration of 24,400 pCi/L.] The corresponding tritium MDC's ranged from 297 to 406 pCi/L with a mean of 339 pCi/L (55 or 93% of the 59 results were positive determinations). A positive determination was concluded if the upper bound of the result (result and its 2σ counting uncertainty) equaled or exceeded the corresponding minimum detectable concentration reported by the laboratory for that measurement. [For comparison, the 2004 SAP data showed tritium MDC's ranging from 275 to 512 pCi/L with a mean of 334 pCi/L (57 or 97% of the 59 results were positive determinations).]

The differences between the 2005 and 2004 tritium SAP results ranged from -75,000 (-99%) to 126,000 (870%) pCi/L, with an average difference of -4,100 (19%) pCi/L. The landfills showing the greatest increases were SAP ID 39 (125,000 pCi/L, a 225% increase), SAP ID 78 (82,000 pCi/L, a 385% increase), and SAP ID 72 (81,000 pCi/L, a 165% increase). Those showing the greatest decreases were SAP ID 16 (-56,000 pCi/L, a 99% decrease), SAP ID 50 (also -56,000 pCi/L, a 64% decrease), and SAP ID 65 (-48,000 pCi/L, a 75% decrease).

For the five duplicate samples submitted for tritium analysis, there were four positive determination result pairs. The precision of these duplicate analyses was evaluated by determining the relative percent difference (RPD) of duplicate measurements that resulted in paired positive determination results. The RPD is equal to the positive difference of the paired positive determination results multiplied by 100 and divided by the average of the two measured values. The RPD calculated for these four result pairs ranged from 3.2% to 56.1%, with an average RPD of 34.5%. [For comparison, for the 5 duplicate samples submitted for tritium analysis during the 2004 SAP campaign, there were 5 positive determination result pairs. The RPD calculated for these result pairs ranged from 0.6% to 12.8%, with an average RPD of 7.1%.] The 2005 RPD's were elevated and, although a specific cause was not apparent, deemed inconsequential for properly interpreting investigation SAP results.

The tritium concentration results, clustered with tritium results from the fall 2004 SAP, are displayed in Attachment A. The same data is also presented in a table in Attachment B.

4.0 Conclusions

Any conclusions about the leachate results are subject to the following principal limitations:

- The sampling campaign was performed as a single grab sample composite of raw leachate at each LF. Variation in recent rainfall and LF infiltration is expected to have the greatest impact on tritium concentrations in leachate. Temporal compositing would provide samples more representative of changes in leachate quality due to seasonal and operational influences.
- Other factors that mitigate the tritium source term (i.e., the extent to which disposed tritium is available for release to the environment) were not evaluated. The principal factors are: LF disposal cells may be capped and thus lessen the fraction of tritium released, new sources of tritium may be disposed in a LF cell, the physical decay of tritium, and hydrogeological features.
- No LF-specific environmental control (precipitation, groundwater, surface water) samples were planned to be obtained as part of the sampling campaign. Consequently, it was not possible to establish a concurrent baseline against which these leachate results may be compared

As presented earlier, positive determinations for tritium were observed in 55 (93%) of the 59 samples analyzed. The corresponding tritium MDC range was 297 to 406 pCi/L, with a mean of 339 pCi/L. The 59-sample range was -6 to 182,000 pCi/L, with a mean concentration of 20,900 pCi/L[2] [16 (27%) of the 59 sample results exceeded 20,000 pCi/L, a limit discussed in section 4.1.2 of this report]. The differences between the 2005 and 2004 tritium SAP results ranged from -75,000 (-99%) to 126,000 (870%) pCi/L, with an average difference of -4,100 (19%) pCi/L. Differences in tritium concentrations were expected when planning the 2005 SAP and such differences were observed. The magnitude and 'scatter' of the differences suggests that the concentrations are affected by more than annual variations in weather (namely precipitation).

Despite the fact that tritium has ubiquitous environmental presence[3], most of the observed 2005 leachate tritium concentrations exceed typical environmental concentrations, which are generally below an MDC

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[2] Tritium assay at the very low levels in the environment is often given in tritium units (TU), an absolute concentration requiring no reference standard. One TU represents a tritium/hydrogen atom ratio of 10^{-18}; in water of 1 TU, the specific activity is equal to 3.2 pCi/L. For comparison, groundwater seldom has more than 50 TU (160 pCi/L) and is typically in the <1 to 10 TU (<3 to 32 pCi/L) range.

[3] Tritium is produced naturally in the upper atmosphere by cosmic ray interaction with ^{14}N in air. Tritium is also produced artificially during nuclear weapons explosions, as a byproduct in nuclear power production, and in defense production reactors via neutron activation of ^{6}Li. In the atmosphere, tritium exists in low concentrations in three different chemical forms: hydrogen (HT), water vapor (HTO) and hydrocarbons (CH_3T). The steady-state

of 200 pCi/L in surface water and precipitation samples. Possible sources of this leachate tritium include NRC "generally licensed" gaseous tritium light source (GTLS) devices that are unused and no longer needed or wanted ("disused sources"), and that are unknowingly disposed of as a solid waste. It is not an uncommon occurrence for disused GTSL to be accidentally disposed in landfills.[4] Most notable among these devices are GTLS emergency 'EXIT' signs that are used to satisfy the National Fire Protection Association (NFPA) Life Safety Code 101 mandate for illuminated exit markers. The October 3, 2005 report[1] of the 2004 tritium SAP results contains additional information on GTLS devices.

Manufacturers of GTLS devices are licensed to do so under NRC in 10 CFR 32.51. Restrictions for transfer from the manufacturer to the user, who is granted a general license under 10 CFR 31.5, require that each device bear a clearly visible label stating the instructions and precautions necessary to assure: safe installation, operation, and servicing of the device; identification of radioactive material by isotope, quantity of radioactivity, and date of determination of the quantity; and specific wording notifying the reader of the regulations governing the use of the device and the words "Caution – Radioactive Material." In addition to labeling, the manufacturer must provide the user, or general licensee, with information stating the regulations applicable to the use, transfer or disposal of the device. Specifically, the owner must be made aware that ownership of the device may be transferred only to those persons specifically licensed or to another general licensee if the device remains in place.

4.1 Applicable or Relevant and Appropriate Requirement Standard of Consideration

The introduction of above-normal concentrations of tritium to the environment from leachate effluent may have regulatory implications that are best understood in the context of applicable or relevant and appropriate requirement (ARAR) standards for radioactive effluents. Both the NRC and the EPA have promulgated ARARs for tritium in liquid effluents. The NRC's effluent limits apply to licensed operations and are contained in Appendix B to 10 CFR Part 20, *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage*.

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global inventory is approximately 2.65 kilograms. By comparison, total U.S. tritium production since 1955 has been approximately 225 kilograms, an estimated 150 kilograms of which have decayed into helium-3, leaving a current (1996) artificial inventory of approximately 75 kilograms.

[4] December 2005 NRC Event Notification Report 42225 (http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2005/20051229en.html, accessed April 5, 2006). A licensee removed 56 exit signs from a building prior to demolition and subsequently lost control of the signs. The licensee reported that "No paperwork was found for the disposal and it appears they were sent to a landfill with the general trash." The total activity was estimated at 1,680 Ci.

The EPA limits the annual average concentration of tritium in drinking water under authority of the *National Primary Drinking Water Regulations* (NPDWR; 40 CFR 141). The NRC and EPA limitations and possible inferences prompted by the leachate results are discussed below.

4.1.1 NRC Limitations

In Subpart K of 10 CFR 20, the NRC authorizes licensees to dispose of licensed material in effluents (§20.2001(a)(3)) and to sanitary sewers ((§20.2001(a)(4)) within nuclide-specific effluent concentration limitations. The effluent concentration limits were established to ensure that the total effective dose equivalent (TEDE) to individual members of the public from all licensed operation radiation sources does not exceed 100 mrem (1 mSv) in a year (§20.1301(a)(1)). To accomplish this objective, the NRC derived annual average liquid effluent concentration limits (e.g., 1×10^6 pCi/L as ^{3}H) corresponding to a 'Reference Man' TEDE of 50 mrem/year. In contrast, the monthly average concentration sanitary sewer limits (e.g., 1×10^7 pCi/L as ^{3}H) were derived to correspond to a 'Reference Man' committed effective dose equivalent (CEDE) of 500 mrem. It is notable that §20.1301(a)(1) specifically excludes dose contributions attributed to radionuclides in sanitary sewer discharges from licensee compliance demonstrations with the 100 mrem/year public TEDE limit. The practice of radionuclide disposal by release into sanitary sewerage is limited by several §20.2003 conditions, most importantly that the:

- Released materials are readily soluble (or dispersible biological material).
- Quantity of material released in month, divided by the average monthly volume of water released into the sewer by the licensee, does not exceed the Appendix B, Table 3 monthly average sewer concentration limits (e.g., 1×10^7 pCi/L as ^{3}H).
- Total annual quantity of radioactive material released into sanitary sewerage does not exceed 5 Ci of ^{3}H, 1 Ci of ^{14}C, and 1 Ci of all other radioactive material combined.

Although none of the landfills sampled are NRC-licensed facilities (and if the leachate is released as an effluent to waters of the state or a sewer), all of the leachate tritium concentrations measured by this sampling campaign are below the NRC effluent and sewer concentration limits discussed above, assuming those grab sample results are indicative of actual average monthly concentrations. In addition, if the observed highest leachate tritium activity concentration (182,000 pCi/L) persisted as a sanitary sewerage discharge over the course of a year, the total leachate volume released would have to approach seven million gallons before the §20.2003 5 Ci limitation would be of concern.

4.1.2 US EPA Limitations

In a final rulemaking for Subpart G of the NPDWR (40 CFR 141) in 2000, the EPA established maximum contaminant levels (MCLs) for radionuclides (§141.66) in drinking water furnished by any community water system (CWS)[5] including an MCL for 'beta particle and photon radioactivity' (§141.66(d)). This CWS MCL indirectly limits the beta particle and photon radioactivity in drinking water to annual average concentration not to exceed an annual dose equivalent to the total body or any internal organ of 4 mrem/year. For all radionuclides except ^{3}H and ^{90}Sr, conversion of activity concentration to dose equivalent must be performed assuming a drinking water ingestion rate of 2 L/day and the National Bureau of Standards (NBS) Handbook 69 (published 1959 and amended 1963; also referred to as NCRP Report 22) compilation of maximum permissible concentrations (MPCs) in water.

In Table A of §141.66, the EPA directly established 20,000 pCi/L as the annual average concentration of tritium in drinking water that was assumed to produce a total body or organ dose of 4 mrem/year, the MCL. The concentrations for these contaminants were derived from a historical dosimetry model (ICRP Publication 2) used at the time the Subpart G rule was promulgated in 1976. When these risks are calculated in accordance with the latest dosimetry models described in Federal Guidance Report 13 (FGR 13)[6], the risks associated with these concentrations, while varying considerably, generally fall within the EPA's current risk target range for drinking water contaminants of 10^{-4} to 10^{-6}. Accordingly, the EPA did not change the MCL for beta particle and photon radioactivity during its final rulemaking in 2000. Using contemporary ICRP Publication 30 dosimetry, the concentration of tritium [as HTO] needed to deliver the MCL 4 mrem in one year is approximately 86,000 pCi/L, over four times the concentration in the current NPDWS. Thus, the current EPA 20,000 pCi/L MCL appears to be conservative by over a factor of four.

Sixteen (27%) of the 59 leachate tritium concentrations measured by this sampling campaign are above 20,000 pCi/L, the EPA NPDWS assumed to equal the 4 mrem/year MCL. The highest measured tritium activity concentration exceeds the MCL by a factor of 9.1. It is apparent, then, that a potential exists for CWS to be adversely affected if the CWS influent is developed within the treated leachate 'watershed.' However, the scope of the leachate sampling campaign does not permit a determination of which, if any, CWS are vulnerable under the NPDWS and the implications for CWS distribution point radionuclide

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[5] Community water systems are privately or publicly-owned and provide water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serve an average of at least 25 people year-round.

[6] http://www.epa.gov/radiation/docs/federal/402-r-99-001.pdf accessed March 28, 2006.

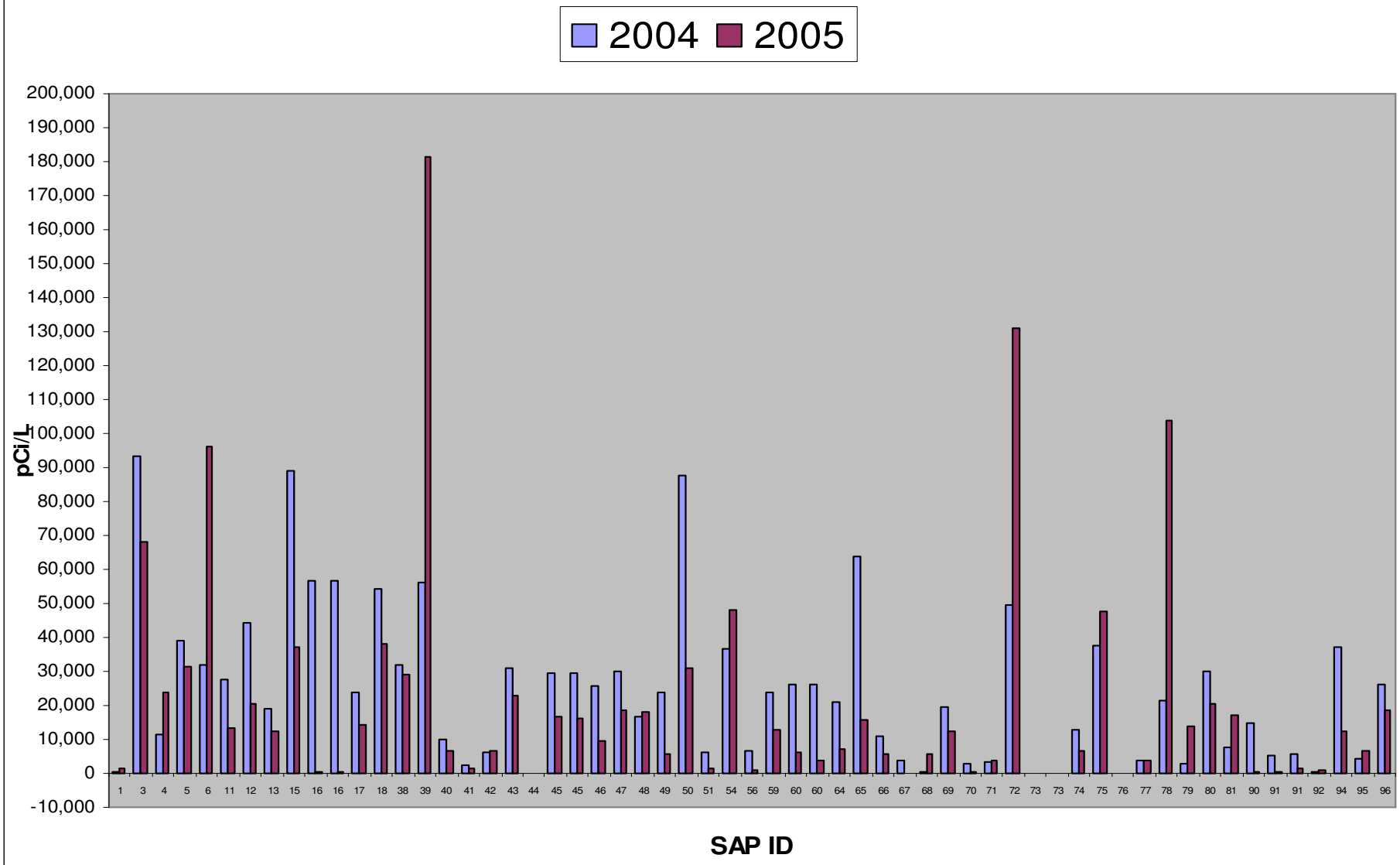
monitoring frequency pursuant to §141.26(b) and §141.26(c). These considerations are being pursued as a separate initiative, as concluded in the 2004 tritium SAP report.

[For each landfill with a sampled leachate tritium activity concentration above 20,000 pCi/L that is discharged to surface waters of the Commonwealth, DEP determined the approximate dilution available from the leachate discharge structure to the nearest downstream drinking water intake. The dilution factors ranged from 0.000004 (278,000:1) to 0.11 (9:1), with resulting concentrations of tritium calculated at less than 200 pCi/L, a value that is below the minimum detectable concentration reported by the laboratory for all measurements.]

Attachment A

Radioactivity Concentration Data Display

Leachate Tritium Concentration



Attachment B

Analytical Data Summary

Landfill Leachate Tritium Concentrations

Bold *results exceed the corresponding MDC.*

LF SAP ID	Sample COC ID	Fall 2005 Result	Fall 2005 2σ Unc.	Fall 2005 MDC	Fall 2004 Result	Fall 2004 2σ Unc.	Fall 2004 MDC	*Difference* pCi/L	*Difference* %
1	01LE0194C1N	**1.34E+03**	3.19E+02	3.13E+02	**2.82E+02**	1.98E+02	3.09E+02	1,061	376%
3	03LE0195C1N	**6.81E+04**	8.92E+03	3.56E+02	**9.35E+04**	1.23E+04	5.12E+02	-25,396	-27%
4	04LE0196C1N	**2.36E+04**	3.16E+03	3.14E+02	**1.12E+04**	1.56E+03	3.08E+02	12,378	110%
5	05LE0197C1N	**3.13E+04**	4.15E+03	3.10E+02	**3.92E+04**	5.17E+03	3.29E+02	-7,902	-20%
6	06LE0198C1N	**9.60E+04**	1.25E+04	3.11E+02	**3.17E+04**	4.21E+03	3.80E+02	64,258	203%
11	11LE0199C1N	**1.33E+04**	1.83E+03	3.21E+02	**2.78E+04**	3.71E+03	4.17E+02	-14,516	-52%
12	12LE0200C1N	**2.05E+04**	2.75E+03	3.43E+02	**4.44E+04**	5.84E+03	4.23E+02	-23,905	-54%
13	13LE0201C1N	**1.24E+04**	1.74E+03	4.06E+02	**1.91E+04**	2.58E+03	3.30E+02	-6,749	-35%
15	15LE0202C1N	**3.74E+04**	4.93E+03	3.43E+02	**8.91E+04**	1.16E+04	4.73E+02	-74,960	-84%
16	16LE0203C1N	**2.84E+02**	2.16E+02	3.43E+02	**5.67E+04**	7.43E+03	4.23E+02	-56,420	-99%
16	16LE0204C2N	**4.09E+02**	2.27E+02	3.43E+02	**5.67E+04**	7.43E+03	4.23E+02	-56,295	-99%
17	17LE0205C1N	**1.42E+04**	1.94E+03	3.19E+02	**2.38E+04**	3.18E+03	2.77E+02	-9,618	-40%
18	18LE0206C1N	**3.83E+04**	5.06E+03	3.59E+02	**5.43E+04**	7.11E+03	2.96E+02	-16,002	-29%
38	38LE0207C1N	**2.89E+04**	3.85E+03	3.18E+02	**3.18E+04**	4.22E+03	3.06E+02	-2,923	-9%
39	39LE0208C1N	**1.82E+05**	2.35E+04	3.02E+02	**5.60E+04**	7.33E+03	3.06E+02	125,681	225%
40	40LE0209C1N	**6.72E+03**	9.95E+02	3.14E+02	**9.77E+03**	1.38E+03	2.78E+02	-3,045	-31%
41	41LE0210C1N	**1.51E+03**	3.38E+02	3.12E+02	**2.30E+03**	4.75E+02	3.85E+02	-796	-35%
42	42LE0211C1N	**6.54E+03**	9.71E+02	3.13E+02	**6.41E+03**	9.46E+02	2.80E+02	127	2%
43	43LE0212C1N	**2.26E+04**	3.04E+03	3.38E+02	**3.09E+04**	4.09E+03	2.82E+02	-8,222	-27%
44	44LE0213C1N	**1.60E+02**	2.02E+02	3.38E+02	**2.12E+02**	1.90E+02	3.06E+02	-52	-24%
45	45LE0214C1N	**1.66E+04**	2.26E+03	3.33E+02	**2.93E+04**	3.89E+03	3.08E+02	-12,699	-43%
45	45LE0215C2N	**1.61E+04**	2.20E+03	3.31E+02	**2.93E+04**	3.89E+03	3.08E+02	-13,226	-45%
46	46LE0216C1N	**9.67E+03**	1.37E+03	3.38E+02	**2.59E+04**	3.46E+03	4.01E+02	-16,253	-63%
47	47LE0217C1N	**1.84E+04**	2.49E+03	3.22E+02	**2.98E+04**	3.96E+03	3.80E+02	-11,388	-38%
48	48LE0218C1N	**1.79E+04**	2.43E+04	3.26E+02	**1.65E+04**	2.24E+03	3.02E+02	1,478	9%
49	49LE0219C1N	**5.81E+03**	8.80E+02	3.36E+02	**2.36E+04**	3.16E+03	2.77E+02	-17,789	-75%
50	50LE0220C1N	**3.11E+04**	4.13E+03	3.27E+02	**8.75E+04**	1.14E+04	3.80E+02	-56,338	-64%
51	51LE0221C1N	**1.49E+03**	3.41E+02	3.32E+02	**6.07E+03**	9.01E+02	2.80E+02	-4,575	-75%
54	54LE0222C1N	**4.82E+04**	6.33E+03	3.44E+02	**3.68E+04**	4.86E+03	3.28E+02	11,390	31%
56	56LE0223C1N	**1.01E+03**	2.99E+02	3.64E+02	**6.70E+03**	9.87E+02	3.27E+02	-5,690	-85%
59	59LE0224C1N	**1.27E+04**	1.77E+03	3.75E+02	**2.38E+04**	3.19E+03	3.32E+02	-11,062	-46%
60	60LE0225C1N	**6.10E+03**	9.21E+02	3.70E+02	**2.62E+04**	3.49E+03	3.30E+02	-20,070	-77%
60	60LE0226C2N	**3.97E+03**	6.50E+02	3.65E+02	**2.62E+04**	3.49E+03	3.30E+02	-22,209	-85%
64	64LE0227C1N	**7.20E+03**	1.06E+03	3.59E+02	**2.12E+04**	2.85E+03	3.28E+02	-13,980	-66%
65	65LE0228C1N	**1.57E+04**	2.15E+03	3.62E+02	**6.37E+04**	8.32E+03	3.84E+02	-47,949	-75%
66	66LE0229C1N	**5.77E+03**	8.75E+02	3.58E+02	**1.09E+04**	1.53E+03	3.31E+02	-5,120	-47%
67	67LE0230C1N	-6.21E+01	1.96E+02	3.57E+02	**3.58E+03**	5.92E+02	3.30E+02	n.a.	n.a.
68	68LE0231C1N	**5.68E+03**	8.65E+02	3.64E+02	**5.85E+02**	2.39E+02	3.32E+02	5,090	870%
69	69LE0232C1N	**1.24E+04**	1.72E+03	3.60E+02	**1.97E+04**	2.65E+03	3.27E+02	-7,297	-37%
70	70LE0233C1N	**6.79E+02**	2.62E+02	3.60E+02	**2.99E+03**	5.09E+02	2.78E+02	-2,311	-77%
71	71LE0234C1N	**3.95E+03**	6.45E+02	3.60E+02	**3.41E+03**	5.66E+02	3.04E+02	539	16%
72	72LE0235C1N	**1.31E+05**	1.70E+04	3.25E+02	**4.94E+04**	6.49E+03	3.79E+02	81,366	165%
73	73LE0236C1N	5.72E+01	1.85E+02	3.24E+02	4.54E+01	1.58E+02	2.79E+02	n.a.	n.a.
73	73LE0237C2N	5.91E+01	1.71E+02	2.97E+02	4.54E+01	1.58E+02	2.79E+02	n.a.	n.a.
74	74LE0238C1N	**6.54E+03**	9.70E+02	3.22E+02	**1.29E+04**	1.78E+03	3.07E+02	-6,344	-49%

Landfill Leachate Tritium Concentrations

***Bold** results exceed the corresponding MDC.*

LF SAP ID	Sample COC ID	Fall 2005 Result	Fall 2005 2σ Unc.	Fall 2005 MDC	Fall 2004 Result	Fall 2004 2σ Unc.	Fall 2004 MDC	*Difference* pCi/L	*Difference* %
75	75LE0239C1N	**4.78E+04**	6.28E+03	3.21E+02	**3.75E+04**	4.95E+03	2.75E+02	10,277	27%
76	76LE0240C1N	1.28E+02	1.91E+02	3.23E+02	6.86E+00	1.86E+02	3.32E+02	n.a.	n.a.
77	77LE0241C1N	**3.92E+03**	6.31E+02	3.06E+02	**3.74E+03**	6.11E+02	3.26E+02	181	5%
78	78LE0242C1N	**1.04E+05**	1.35E+04	3.21E+02	**2.13E+04**	2.87E+03	4.08E+02	82,266	385%
79	79LE0243C1N	**1.38E+04**	1.90E+03	3.20E+02	**2.94E+03**	5.12E+02	3.29E+02	10,858	370%
80	80LE0244C1N	**2.05E+04**	2.77E+03	3.21E+02	**2.99E+04**	3.97E+03	3.09E+02	-9,356	-31%
81	81LE0245C1N	**1.71E+04**	2.33E+03	3.25E+02	**7.53E+03**	1.09E+03	2.77E+02	9,590	127%
90	90LE0246C1N	**6.28E+02**	2.56E+02	3.58E+02	**1.46E+04**	2.00E+03	3.30E+02	-13,948	-96%
91	91LE0247C1N	**6.91E+02**	2.69E+02	3.70E+02	**5.36E+03**	8.30E+02	3.65E+02	-4,665	-87%
91	91LE0248C2N	**1.23E+03**	3.27E+02	3.73E+02	**5.57E+03**	8.61E+02	3.77E+02	-4,336	-78%
92	92LE0249C1N	**1.02E+03**	2.97E+02	3.68E+02	**4.18E+02**	2.11E+02	3.08E+02	604	144%
94	94LE0250C1N	**1.24E+04**	1.71E+03	3.50E+02	**3.72E+04**	4.91E+03	3.06E+02	-24,835	-67%
95	95LE0251C1N	**6.89E+03**	1.02E+03	3.71E+02	**4.11E+03**	6.56E+02	3.07E+02	2,774	67%
96	96LE0252C1N	**1.87E+04**	2.54E+03	3.75E+02	**2.60E+04**	3.46E+03	2.76E+02	-7,275	-28%
	Results N	59			59				
	Result +2σ Unc. ≥MDC	55	93%		57	97%			
	Min	-6.21E+01	1.71E+02	2.97E+02	6.86E+00	1.58E+02	2.75E+02	-74,960	-99%
	Max	1.82E+05	2.43E+04	4.06E+02	9.35E+04	1.23E+04	5.12E+02	125,681	870%
	Mean	2.09E+04	3.20E+03	3.39E+02	2.44E+04	3.27E+03	3.34E+02	-4,102	18.7%
	StdDev	3.35E+04	4.62E+04	2.34E+01	2.30E+04	3.37E+04	5.21E+01	32,165	165%
	Range	1.82E+05	2.42E+04	1.09E+02	9.35E+04	1.21E+04	2.37E+02	200,641	970%
	Median	1.24E+04	1.71E+03	3.38E+02	2.13E+04	2.87E+03	3.27E+02	-6,344	-35%
	Above 20,000 pCi/L	16	27%		31	53%			

Attachment C

Laboratory Analysis Reports

[15.8 MB]

(Copies of these reports are on file and available upon request)