DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Radiation Protection and
Bureau of Waste Management

DOCUMENT NUMBER:	250-3100-001
TITLE:	Guidance Document on Radioactivity Monitoring at Solid Waste Processing and Disposal Facilities.
EFFECTIVE DATE:	XXXX YY, 2019
AUTHORITY:	Solid Waste Management, Act of July 7, 1980, P.L., No. 97, as amended, 35 P.S. Sections 6018.101-6018.1003 (SWMA); Radiation Protection Act, Act of July 10, 1984, P.L. 688, No. 147, 35 P.S. Sections 7110.101-7131.1101; Clean Streams Law, Act of June 22, 1937; and The Administrative Code of 1929, Section 1917-A, 71 P.S. Section 510-17; Municipal and Residual Waste Regulations, 25 Pa. Code, Articles VIII and IX; Radiological Health Regulations, 25 Pa. Code Chapters 215-240; Oil and Gas Regulations, 25 Pa. Code Section 78a.58.
POLICY:	To protect the environment and the public health, safety and welfare from the possible dangers of radioactive material that is delivered to waste processing or disposal facilities or generated by the exploration or development of oil and gas wells.
PURPOSE:	This guidance document is intended to assist the solid waste and oil and gas regulated communities with the development of Radiation Protection Action Plans as required in the regulations.
APPLICABILITY:	This guidance document applies to all owners and operators of solid waste processing and disposal, oil and gas well development and waste treatment facilities that are required by regulation to monitor for radiation from incoming loads of waste, and to those facilities that choose to monitor even though not required. This guidance document also applies to all Department personnel and activities involved with waste facility permitting, operations and enforcement, radiation protection, grants, monitoring, administration and emergency response.
DISCLAIMER:	The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of the Department to give the rules in these policies that weight or deference. This document establishes the framework within which the Department will exercise its administrative discretion in the future. The Department reserves the discretion to deviate from this policy statement if circumstances warrant.

GUIDANCE DOCUMENT ON RADIOACTIVITY MONITORING AT SOLID WASTE PROCESSING AND DISPOSAL FACILITIES

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I. DEFINITIONS

Absorbed Dose: Measure of energy absorbed by material interacting with radiation. The unit in the older conventional system is the rad, which is equal to the energy of 100 ergs per gram of irradiated material. In the System International (SI), the unit for absorbed dose is the gray (Gy), which is equal to 100 rads.

Activity: Rate of decay for radioactive material. The older conventional unit is the curie (Ci). The SI unit is becquerel (Bq), where 1 Ci = 3.7 x 10^{10} Bq or 3.7E10 Bq.

Agreement State (AS): A State that has signed a formal agreement with the U.S. Nuclear Regulatory Commission, under which that State has assumed regulatory responsibility over certain byproduct and source material, as well as small quantities of special nuclear material. Pennsylvania became an Agreement State in March 2008.

BRP: The Bureau of Radiation Protection.

BWM: The Bureau of Waste Management.

Byproduct Material: (1) Radioactive material, except special nuclear material, yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium or thorium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material' within this definition. (10 CFR §20.1003)

Characterization: A process by which a material's structure and properties are probed and measured.

Decay: Transformation of atoms of a radioactive element to atoms of another element by emission of alpha or beta particles (positive or negative), or gamma rays from its nucleus. The resulting decay product may be radioactive or stable.

Department or DEP: The Pennsylvania Department of Environmental Protection.

Dose Equivalent: The dose of an ionizing radiation that will cause the same biological effect as one rad of X-rays or gamma-rays. In the older conventional system, the unit is the rem. In the SI system, the unit is the sievert (Sv), 1Sv = 100 rem. Dose equivalent is calculated by multiplying absorbed dose (rad, Gy) by a quality factor (QF) that accounts for the effectiveness of the radiation, relative to gamma or X-rays, in causing a biological effect, i.e., rem = rad x QF; Sv = Gy x QF. (Note: For this guidance, and X-ray or gamma radiation, a rem = rad = R (roentgen).)

DOE: The U.S. Department of Energy.

DOT: The U.S. Department of Transportation.

DOT Special Permit: This special permit authorizes the one-way transportation in commerce by highway or rail of shipments of scrap metal or solid waste which have been found, during or at the

conclusion of transportation or during inspection of the shipment following its receipt, to contain unexpected and unidentified radioactive material or contamination. The one-way transportation authorized by this special permit is exempted from the classification, packaging, and hazard communication requirements normally required for transportation of radioactive material. However, the shipment is subject to the conditions of the special permit.

EPA: The U.S. Environmental Protection Agency. *(Note: According to National Response Framework – Nuclear Radiological Incident Annex, EPA is responsible for providing assistance to states in managing incidents involving radioactive material of unknown origin that is found outside of Nuclear Regulatory Commission (NRC) or Agreement State (AS) licensed facilities unless the radioactive material is clearly associated with an NRC licensee, in which case the NRC or AS assumes responsibility for assistance. In general, federal agencies provide assistance at the request of the state.)*

Exposure Rate: An older measurement quantity of intensity for X-ray or gamma radiation causing ionization of air. It is still in practical use in the U.S., measured in roentgen (R) or microroentgen (μR) per unit time, usually an hour, as in R/h, μR/h. 1 R = 2.58 E-4 C/kg of air.

Facility: Land, structures and other appurtenances or improvements where municipal or residual waste disposal or processing is permitted or takes place. The term includes land thereby used or affected during the lifetime of operations, including areas where solid waste management actually occurs, support facilities, offices, equipment sheds, air and water pollution control and treatment systems, access roads, associated onsite or contiguous collection, transportation and storage facilities, closure and post-closure care and maintenance activities, contiguous borrow areas and other activities in which the natural land surface has been disturbed or used as a result or incidental to operation of the facility.

Half-life: The time required for half the atoms of a quantity of a radioactive material to decay or become transformed to another nuclide.

Isotope: Any two or more species of atoms of a chemical element with the same atomic number (i.e., number of protons) and nearly identical chemical behavior but with different atomic mass or mass number and different physical properties.

LLRW: (Low-Level Radioactive Waste) Radioactive waste that (1) is not high-level radioactive waste, spent nuclear fuel, or byproduct material as defined in section 11(e)(2) of the Atomic Energy Act of 1954 (68 Stat. 922, 42 U.S.C. § 2014(e)(2)), waste generated as a result of atomic energy defense activities of the Federal Government, and waste for which the Federal Government is responsible under section 3(b)(1) of the Low-Level Radioactive Waste Policy Amendments Act of 1985; and (2) is classified by the Federal Government as low-level waste, consistent with the Low-Level Radioactive Waste Policy Amendments Act of 1985; or (3) contains naturally occurring or accelerator-produced radioactive material, which is not excluded by paragraph (1) or (2).

Multichannel Analyzer (MCA): An electronic instrument which, when coupled with an appropriate detector, can determine the energy associated with various gamma radiations and thereby identify the radioactive material emitting the radiation.

NARM: Naturally occurring or accelerator-produced radioactive material. The term does not include source or special nuclear material.

NORM: Naturally occurring radioactive material is a radioisotope that is radioactive in its natural physical state, not man-made, but does not include source or special nuclear material.

NRC: The U.S. Nuclear Regulatory Commission, which is the federal agency responsible for the regulation of power and research reactors, and radioactive materials produced in nuclear reactors, and certain quantities of uranium and thorium.

Occupational Dose: The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public.

Radioactive Material (RAM): A material—solid, liquid or gas—which emits radiation spontaneously.

Radiation: The ionizing particles (alpha, beta, others) or photons (X or gamma ray) emitted by radioactive materials in the process of decay or nuclear transformation.

Radioisotope: A radioactive isotope of an element.

Source Material: (1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or (2) ores which contain, by weight, 0.05 percent or more of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material. (10 CFR § 20.1003)

Special Nuclear Material: (1) Plutonium, uranium-233, uranium enriched in the isotope 233 and in the isotope 235, and in any other material that the Department of Environmental Protection, pursuant to the provisions of Section 51 of the Atomic Energy Act of 1954 (42 U.S.C. §2011 et seq.), determines to be special nuclear material but does not include source material; or (2) any material artificially enriched by any of the foregoing but does not include source material.

TEDE: Total effective dose equivalent. Means the sum of the deep dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). (10 CFR § 20.1003.)

TENORM: Technologically enhanced naturally occurring radioactive materials. It is naturally occurring radioactive material not specifically subject to regulation under the laws of the Commonwealth or Atomic Energy Act of 1954 (42 U.S.C. §2011 et seq.), but whose radionuclide concentrations or potential for human exposure have been increased above

	levels encountered in the undisturbed natural environment by human activities. When disposed, TENORM-containing wastes are managed under the Solid Waste Management Act (SWMA).
Transuranic (TRU) Radioactive Material:	Material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium and curium. TRU waste disposal is strictly regulated by the NRC and DOE.

II. TECHNICAL GUIDANCE

A. Background

The Department of Environmental Protection (DEP) has the responsibility of protecting the health and safety of the citizens of the Commonwealth and the environment from toxic and hazardous materials in the environment. This includes most sources of radiation. Radioactive material (RAM) can appear in both the municipal and residual waste streams. RAM in waste can come from naturally occurring radioactive material (NORM), technologically enhanced naturally occurring radioactive material (TENORM), or man-made radioisotopes. Man-made radioisotopes are regulated by the U.S. Nuclear Regulatory Commission (NRC) and/or the individual Agreement States. Accelerator-produced radioactive materials have traditionally been regulated by the Commonwealth. NORM and TENORM are not regulated in Pennsylvania unless resulting radiation doses exceed the limits set forth in Title 25, Chapter 219 of the Pennsylvania Code. However, in the case of radium-226, the Commonwealth did regulate individual discrete sources above 0.1 microcurie (μCi), as set forth in 25 Pa. Code Chapter 217. There are also federal Department of Transportation (DOT) and Occupational Safety and Health Administration (OSHA) regulations that apply to these materials.

In March 2008, DEP assumed authority to regulate man-made RAM (i.e., byproduct, source, and small quantities of special nuclear material). DEP regulates man-made RAM as set forth in 25 Pa. Code Chapters 215—237. The licensing of RAM may be through specific or general license, or the RAM may be unregulated, deregulated, or exempted from regulation by a variety of federal and state regulatory authorities. When disposed, certain types of RAM, including NORM and TENORM, are regulated by DEP's Bureau of Waste Management under authority granted by the SWMA. In 2015, DEP completed an extensive technologically enhanced naturally occurring radioactive material (TENORM) Study.[1] This Study and ongoing operational experience with TENORM generation, handling and waste disposal have contributed significantly to the update of this guidance.

State and federal regulations require that those who are licensed to handle radioactive materials will maintain strict controls relative to the use and disposal of the material and will take appropriate actions to prevent unauthorized releases of radioactive materials in solid waste. Licensees are encouraged to investigate ways of effectively monitoring institutional waste streams coming from facilities using radioactive material before the waste leaves the facility. The NRC has issued guidance to RAM licensees for the "Management of Wastes Contaminated with Radioactive Materials" in Information Notice 99-33 (Dec. 1999).

There are a number of consumer and industrial items containing RAM in general use that are distributed under a regulatory "exemption" or "general license"; that is, the fabricator or distributor must be licensed, but the individual owner/user does not have a "specific license." Sources of RAM that are exempt are assumed by the NRC to be discarded in municipal waste during their normal life cycle. All generally licensed RAM is to be returned to the manufacturer for proper recycling or shipped for low-level radioactive waste (LLRW) disposal (e.g., self-luminous tritium EXIT signs). For the more hazardous higher-activity, specifically licensed RAM and sources, the NRC and DEP require disposal at a licensed LLRW facility.

Some rocks, bricks, gypsum wall board, slag from metal processing, waste from coal ash or coke processing, rock cuttings and sludges from oil and gas (O&G) wastewater treatment and similar residuals may contain some natural radioactivity. Depending on their origin, these materials may emit enough radiation to set off the radiation alarms at solid waste facilities. These examples may be considered NORM or TENORM.

Pennsylvania's municipal and residual waste management regulations require the following types of facilities to develop an action plan which specifies the procedures for monitoring for and responding to RAM entering the

facility, as well as related procedures for training, notification, recordkeeping and reporting, in accordance with this policy:

- Municipal waste landfills. (25 Pa. Code Ch. 273)
- Construction/demolition waste landfills. (25 Pa. Code Ch. 277)
- Municipal Waste transfer facilities. (25 Pa. Code Ch. 279)
- Commercial municipal waste composting facilities that will receive sewage sludge or unseparated municipal waste, or both. (25 Pa. Code Ch. 281)
- Resource recovery and other municipal waste processing facilities. (25 Pa. Code Ch. 283)
- Commercial infectious or chemotherapeutic waste processing facilities. (25 Pa. Code Ch. 284)
- Noncaptive residual waste landfills. (25 Pa. Code Ch. 288)
- Noncaptive residual waste disposal impoundments. (25 Pa. Code Ch. 289)
- Noncaptive residual waste transfer facilities. (25 Pa. Code Ch. 293)
- Noncaptive residual waste composting facilities. (25 Pa. Code Ch. 295)
- Noncaptive residual waste incinerators and other noncaptive residual waste processing facilities. (25 Pa. Code Ch. 297)

In addition to the above-listed facilities under 25 Pa. Code Chapter 78a, operators of certain waste processing facilities, including wastewater treatment facilities that treat wastewater from O&G drilling, exploration and production of oil or natural gases, are also required to develop an action plan and monitor for RAM in accordance with this policy. The plan must be submitted to and approved by the Department.

Appendix A provides a summary of the radiation monitoring and RP Action Plan requirements contained in the municipal and residual waste management regulations and the unconventional oil and gas operator regulations that reference this policy. As noted above, there are numerous natural, man-made, exempt, licensed and non-licensed RAM that may be detected by a facility's radiation monitoring procedures. The intent of this policy is to monitor for and manage RAM such that workers, the public and the environment remain protected.

Operators of affected facilities must comply with the regulatory requirements, equip facilities with suitable gamma radiation detection devices to monitor incoming loads of waste for radioactive materials in the waste, and have an appropriate Radiation Protection Action Plan (RP Action Plan) that is developed in accordance with this policy and approved by DEP. The facility should have access to equipment with the ability to characterize and identify isotopes. For Pennsylvania facilities that are not required to monitor for RAM (e.g., metal recyclers), but choose to do so as a best management practice, this guidance document should also be followed. This guidance document is intended to assist the solid waste and O&G regulated communities with the development of RP Action Plans.

[1]PA DEP TENORM Study, see: http://www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/Oil-and-Gas-Related-Topics/Pages/Radiation-Protection.aspx.

B. Radiation Protection Action Plans

Fundamentally, the RP Action Plan should be designed to detect and validate the presence of radioactive material, identify the type of radioactivity present, measure radiation emitted, and determine the actions needed to protect workers, the public, and the environment. Staff implementing an RP Action Plan should keep in mind the phrase 'detect, identify and determine' (or 'DID') when monitoring for radioactivity.

Detecting radiation and dealing with radioactive materials in the waste stream is a multiple-phase process. RP Action Plans should include information relating to how the facility plans to address the following:

- Monitoring and detection of gamma radiation;
- Personnel training;
- Awareness of items that may contain RAM;
- Initial response to the detection of RAM;
- Notifications - within the company, to DEP, and to others as necessary;
- Characterization of the radioactivity;
- Determination of disposition; and
- Record-keeping.

Below is a basic outline for an RP Action Plan:

- A description of the facility or operation;
- A layout map showing the 'designated area,' should one be needed;
- A list of what types of radioactive material may be present in the waste;
- A description of what radiation detectors will be used and how they are calibrated and maintained;
- Procedures for surveying, monitoring, and responding to detected radioactive material;
- A description of instruments used for identification and characterization of radioactive material;
- Staff training plan for radiation monitoring and use of detection equipment;
- A description of the proposed processing or disposal of the radioactive material or waste;
- Emergency contact list;
- Notifications to management and DEP if required; and
- Records and reporting.

This plan will give direction to operating staff and facility users regarding procedures for detecting and dealing with radioactive material. The details of these plans will vary somewhat with the type of facility; however, in most respects they are similar, except for disposition of the radioactive material. In some cases, the facility may have the option of onsite processing or disposal of RAM with DEP concurrence or pre-approval. Alternately, the waste load may be rejected. However, once RAM has been identified in the waste, it may not be transported on public roads without an evaluation for compliance with U.S. Department of Transportation (DOT) regulations. If the detected RAM cannot be processed or disposed of onsite, DEP has the authority to issue transporters a DOT 'Special Permit' allowing the waiver of some federal DOT regulations if certain conditions are satisfied. However, DEP cautions O&G well development and wastewater treatment operators to fully evaluate the levels of RAM (e.g., radium-226) in fluids and sludges. Transport of these materials on public roads shall comply with the federal DOT regulations in Title 49 of the Code of Federal Regulations as related to Class 7 hazmat "radioactive material."

Approved RP Action Plans become part of the facility's permit and shall be followed by the facility. Revisions to a facility's approved RP Action Plan shall also be approved by DEP through a permit modification.

As part of the submission of a proposed RP Action Plan for solid waste facilities, DEP may approve the processing and/or disposal of deregulated short-lived RAM (e.g., I-131, Tc-99m, Tl-201, etc.) from a patient having undergone a medical procedure, low concentration and small quantities of TENORM solid waste, and consumer products containing exempt RAM. This will require providing appropriate justification and/or pathway analysis for modeling potential public and facility staff radiation exposure. If large volumes and high-concentration TENORM wastes are routinely disposed of in a Commonwealth landfill, DEP may require long-term monitoring of leachate and ground water for total radium-226 plus -228.

C. Dose Limits for the Public and Workers

The public and occupational annual dose limits that will be utilized by DEP in evaluating proposed RP Action Plans are as follows:

Affected Group	Regulatory Limit	Description
General Public	4 pCi/L radon	considered a member of the "public"
Facility staff	30 pCi/L radon	if considered as "occupationally" exposed
Facility staff	5,000 mrem	if considered as "occupationally" exposed
Facility staff	100 mrem	considered member of the "public"
Vehicle driver	100 mrem	considered member of the public
General Public	4 mrem	for the drinking water pathway
General Public	10 mrem	for the air pathway
General Public	25 mrem	from TENORM disposal, and all pathways combined

The above radiation concentrations are based on NRC and U.S. Environmental Protection Agency (EPA) regulations and guidance, respectively. The radiation dose limits are all total effective dose equivalent (TEDE), where an external deep dose and internal committed dose is summed. It is important to emphasize that all public and facility staff exposure to radiation should be maintained as low as reasonably achievable (ALARA). Facility staff will be considered members of the "public," as it is unlikely they will exceed the 100 mrem per year public dose limit In a case where the 100 mrem/yr dose limit could be exceeded, DEP's Bureau of Radiation Protection (BRP) could license the RAM or operation that is causing such a scenario. However unlikely, certain personnel may be considered occupationally exposed radiation workers if higher exposures are anticipated.An Action Plan should include consideration of relevant requirements outlined in DEP's Standards for Protection Against Radiation (25 Pa. Code Ch. 219) and Notices, Instructions, and Reports to Workers (25 Pa. Code Ch. 220) if personnel are to be considered occupationally exposed.

In all reviews of proposed RP Action Plans, DEP will perform evaluations to ensure solid waste processing or disposal and O&G operations do not endanger the environment, facility staff, or public health and safety. Therefore, proposed RP Action Plans should describe the potential radiation exposure pathways for workers and members of the general public and how these expected doses were modeled. DEP will only accept modeling that shows the radon pathway turned on. For certain solid waste facilities where processing or disposal of solid waste may release RAM to the environment, DEP recommends the use of computer codes commonly used by regulators for such pathway analysis and dose modeling, e.g., the EPA's CAP88 or U.S. Department of Energy (DOE)/NRC's family of RESRAD codes. These codes and support documentation can be downloaded from various Internet websites. However, valid manual calculations using dispersion equations and published dose conversion factors are equally acceptable to DEP. To validate TENORM landfill waste disposal calculations, DEP may require long-term monitoring of leachate and ground water for total radium-226 plus -228, and possible uranium.

D. Detection of Radiation

Measurements should be made in accordance with guidance provided in Appendix E. Radiation detector elements shall be as close as practical to the waste load and in an appropriate geometry to monitor the waste. The regulations require an alarm set-point, at any detector element, from a gamma exposure rate from a cesium-137 source, no higher than 10 microroentgen per hour (μR/h) above the average local background. Instrument background shall be kept below 10 μR/h using shielding if needed, and the system shall be set to detect gamma ray energies of 50 kiloelectron volts (keV) and higher. RP Action Plans must address the following two basic scenarios, or Action Levels, when radiation is detected. These Action Levels are designed to alert the facility or operators that radioactive material may be present and, if so, the level of radiation exposure for which they should call DEP for notification and possible technical support.

1. Action Level One: A radiation monitor alarm at the facility indicating the potential presence of radioactive material in a waste load.

The regulations require an alarm set-point, at any detector element, from a gamma exposure rate from a cesium-137 source, no higher than 10 μR/h above the average local background. Instrument background shall be kept below 10 μR/h using shielding if needed, and the system, if capable, shall be set to detect gamma ray energies of 50 keV and higher.

2. Action Level Two: Radiation dose rates of 20 μSv/h (2 mrem/h) or greater in the cab of the waste transport vehicle, 500 μSv/h (50 mrem/h) or greater from any other surface, or the detection of contamination on the outside of the vehicle requires immediate notification to DEP and isolation of the vehicle.

An RP Action Plan requires immediate notification to DEP for conditions specified in the regulations (i.e., radiological conditions noted above in Action Level Two). When prohibited or licensed RAM is detected, or when a waste load is to be rejected, a DOT Special Permit must be issued.

III. IDENTIFICATION AND DISPOSITION OF RAM FOUND IN A WASTE STREAM

A. RAM from Patients Having Undergone a Nuclear Medicine Procedure

Thousands of nuclear medicine procedures are performed each year in Pennsylvania. Licensed medical facilities, such as hospitals, doctors' offices, and outpatient treatment facilities, that perform such procedures are prohibited by DEP regulations from disposal of RAM in their solid waste stream. However, when patients who have undergone a nuclear medical procedure are discharged, some of the radioactivity from the treatment may be carried over into personal health care items that are discarded as part of regular household waste. Therefore, many of the radiation alarms at waste disposal facilities are a result of short-lived RAM from residential households, where a resident of the household has recently undergone a nuclear medical procedure.

If an Action Level Two has not been exceeded, and the vehicle only contains household municipal waste, it's likely that the RAM is from a patient having undergone a medical procedure. Such material is deregulated by the NRC and DOT, and the disposal does not endanger the health or safety of the facility staff, the public, or the environment. If the gamma spectroscopy or other measurement indicates the radiation is located in household municipal waste and is from a common medical radioisotope (e.g., I-131 or Tc-99m) with a half-life of 65 days or less, the facility may process or dispose of the RAM. Alternatively, the Radiation Health Physicist in the appropriate DEP Regional Office having jurisdiction over the facility may be contacted to authorize the contents of the waste load to be processed or disposed. (See Appendix B for telephone numbers during normal and non-business hours.)

For reference, the total estimated radioactivity that may be released in a patient is detailed in NRC Regulatory Guide 8.39[1], which is duplicated in Appendix C as Table 1. The solid waste facility operator will always have the option to reject any waste load causing a radiation alarm; however, no vehicle containing RAM shall leave the facility without written approval and an authorized DOT Special Permit issued by DEP (see above section relating to the detection of radiation).

Upon formal request and appropriate environmental analysis, DEP's BRP Director may authorize disposal of RAM with a half-life greater than 65 days, if the material is suitable under state or federal regulatory controls and meets the criteria and restrictions for 'alternate disposal.' (See Appendix E for additional guidance.)

B. RAM from TENORM-containing Wastes

TENORM is a material in which radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities. TENORM is not directly regulated by any federal agency or under DEP's Radiation Protection Program. However, when disposed of, TENORM-containing waste is regulated under the SWMA and DEP's Bureau of Waste Management. There are many sources of TENORM-containing wastes, including residual wastes from industrial and resource extraction activities, demolition wastes, and waste resulting from municipal and industrial wastewater treatment.

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[1]Regulatory Guide 8.39, Release of Patients Administered Radioactive Materials. U.S. Nuclear Regulatory Commission, Washington, DC April 1997. A copy of the relevant table from Regulatory Guide 8.39 is attached to this document as Appendix C.

Wastes generated by the O&G industry such as the following may contain TENORM:

a. Drill cuttings;
b. Fracturing water, flow-back water and produced water;
c. Treatment sludge generated from the treatment of liquid waste from O&G drilling operations;
d. Filter socks; and
e. Sediments formed in tank bottoms and impoundments.

Wastes generated by other industries, such as drinking water or wastewater treatment facilities, refractory material, thermal insulation wastes, demolition wastes, and wastes generated from ceramics manufacturing may also contain TENORM.

All generators shall follow DEP's Request to Process or Dispose of Residual Waste (Form U) process.

Although there are multiple waste streams that may contain TENORM from both conventional and unconventional gas wells, including sediments, drill cuttings, filter socks, and other materials from drilling sites, most of the relatively higher volumes and activity levels of TENORM are found in the sludge generated by facilities processing used fracturing water or brines for reuse or disposal. For this reason, facilities that process wastewater from O&G drilling operations shall develop and submit for approval an RP Action Plan in accordance with this guidance. It is recommended that O&G well developers and wastewater treatment operations generating TENORM waste (with potentially high levels of radium) utilize standard radiochemistry methods to assay waste prior to transport on public roads.

Landfills that accept TENORM-containing waste for disposal shall provide justification in the proposed RP Action Plan demonstrating that it can adequately handle TENORM-containing waste, taking into consideration the facility's design and operational plan (e.g., considering the facility's engineered barriers, leachate collection and treatment, and environmental monitoring) and apply for approval to dispose of TENORM-containing waste at the facility through a permit modification. The monthly and annual volume of TENORM-containing waste that the facility is permitted to accept may be limited by DEP to ensure that the dose to a member of the public residing on the landfill in the future will not exceed 25 mrem/yr with all exposure pathways (including radon) considered. DEP monitors the disposal of TENORM-containing wastes annually to ensure its disposal protocol is followed. DEP issues guidelines annually to all landfills outlining the monitoring and tracking requirements for the acceptance of TENORM-containing waste.

C. RAM from NORM-containing Wastes

If the gamma spectroscopy or other measurement indicates the radiation is NORM and results from the undisturbed natural environment of the Commonwealth, then there are no disposal restrictions and the material can be accepted at the facility. Similarly, if the source is determined to be potassium or any related compound (e.g., potassium permanganate used for odor control), with a natural abundance K-40, there are no processing or disposal restrictions. This is to be excluded from Source Term Allocation.

D. RAM from Consumer Products and Other Devices Containing Radioactive Material

Certain consumer products containing radioactive material or exempt RAM sources, such as smoke detectors, radium dial watches or clocks, exit signs, exempt thorium metal alloys (i.e., welding rods), or uranium glaze/glass products, can be visually observed in solid waste or may activate a radiation alarm at a landfill or transfer facility. A life cycle analysis of these consumer products and exempt RAM sources by the NRC notes that the public dose limits, referenced earlier, will not be exceeded when individual items are immediately accepted and disposed (see

NRC NUREG-1717). The facility's RP Action Plan can allow the disposal of the specific individual items noted above when those items are found individually in a waste stream. However, the RP Action Plan shall prohibit the disposal of aggregate quantities of these items without first obtaining written approval by DEP. DEP also recommends that smoke detectors, when visually observed in the waste, be returned to the manufacturer for appropriate disposal. If a smoke detector is identified as containing Ra-226, it is most likely a general license device and shall be returned to the manufacturer or shipped to a licensed LLRW disposal facility. Similarly, if a general license tritium EXIT sign is visibly observed in the waste, it shall be returned to a licensed manufacturer for recycling or shipped for proper LLRW disposal.

Consumer products containing exempt radioactive materials may be recovered by the facility and stored for ultimate disposal as LLRW by the operator.

E. Rejecting Waste Loads Containing RAM from Any Source

A facility may accept waste containing RAM in accordance with this policy and the facility's approved RP Action Plan, or it can choose to reject any waste load containing RAM. If rejected, no vehicle containing RAM can leave the facility without written approval from the Radiation Health Physicist in DEP's regional office having jurisdiction over the facility and an authorized DOT Special Permit. If the driver of the vehicle does not comply with this requirement, the Radiation Health Physicist in DEP's regional office having jurisdiction over the facility and the Pennsylvania State Police shall be immediately notified and provided the vehicle's license plate number.

In addition, a waste disposal facility shall complete the supplemental waste tracking form when a load of waste is rejected for disposal at the facility. The completed supplemental waste tracking form should be sent by email to DEP's Municipal and Residual Waste Division at ra-epmuniresidwaste@pa.gov with "SWTF" in the subject line. The waste program in DEP's regional office having jurisdiction over the facility and the generator of the rejected waste should receive a copy of the email.

F. Records and Reports

F.1. Overview: Each person or municipality who operates an O&G processor or waste processing or disposal facility that has detected radioactive materials in any manner, or radiation levels in excess of Action Level One, to cause an alarm shall maintain records of each incident, containing the information set forth in section F.2. below, in the facility's daily operational record.

F.2. Daily Operational Records: Operators of municipal or residual waste processing and disposal facilities shall maintain daily operational records that record each incident in which radioactive material is detected in a waste load and shall include the following:

a) The date, time and location of the occurrence;
b) A brief narrative description of the occurrence;
c) Specific information on the origin of the material, if known;
d) A description of the RAM involved, if known;
e) The name, address and telephone number(s) of the supplier, handler or transporter of the RAM contaminated waste, and name of the driver;
f) The final disposition of the material (processed, disposed, or rejected);
g) For rejected waste loads, a record of each rejected load and the reason for the rejection. Facilities are required to complete and submit supplemental waste tracking forms in accordance with Section E above relating to rejecting waste loads containing RAM from any source.

F.3. Monthly Operational Reports: Operators of municipal or residual waste disposal facilities that accept TENORM-containing waste for disposal shall also track and report detected RAM on a monthly basis, by completing a monthly TENORM report on forms provided by DEP. The report should be submitted to DEP by the fifth day of each month for the RAM detected in the previous calendar month. The following information should be included for each TENORM-containing waste load that triggers landfill radiation detection monitors:

a) The date of the occurrence;
b) The ticket number, Form U approval number (EC #), and waste code for the waste load;
c) The name of the generator of the waste;
d) If the waste load is transported directly to a landfill from the O&G well site, then the well name, municipality, and county related to the well site;
e) The µR/hr reading from a handheld device for the center-line mid-point of the right and left sides of the waste load;
f) The name of the radioactive isotope that triggered the landfill radiation detection monitor alarms that was identified during the waste analysis using the handheld device; and
g) The tonnage of the TENORM-containing waste load.

F.4. Annual Operation Report: Operators of municipal and residual waste processing, O&G, or disposal facilities shall submit to DEP an annual operation report in accordance with 25 Pa. Code § 273.313 or 25 Pa. Code § 288.283 (relating to annual operation report). The Annual Operation Report shall include a record of detected RAM and summarize the information required in the daily operational records. A letter shall be provided to DEP if no radioactive materials are found during the reporting year.

G. Monitoring Equipment

Facilities required to monitor for radiation emitted from radioactive material must have appropriate monitoring equipment onsite. (See Appendix D for more information). Employees should be trained on the proper use of all fixed and portable equipment. Additionally, facility operational staff should be trained to visually monitor waste during transfer or unloading for the potential presence of RAM. Specifically, they should be able to identify the "Caution Radiation" symbol (below) on containers and items that may not be detected by gamma monitors (e.g., tritium "EXIT" signs).

CAUTION RADIATION SYMBOL

TRITIUM EXIT SIGN

(Photo from Wikimedia)

APPENDIX A. SUMMARY OF DEP SOLID WASTE AND OIL AND GAS RADIATION MONITORING REGULATIONS

There are numerous chapters and sections in the Land Resources (Article I), Municipal Waste (Article VIII) and Residual Waste (Article IX) Management regulations that contain the requirements for radiation monitoring. Below are the regulatory citations and language that direct the regulated community to this guidance document on radiation monitoring.

Map and grid requirements.

- § 273.133(a)(14)
- § 277.133(a)(14)
- § 279.103(a)(18)
- § 281.112(a)(20)
- § 283.103(20)
- § 288.133(a)(14)
- § 289.133(a)(13)
- § 293.103(a)(18)
- § 295.112(a)(20)
- § 297.103(20)

An application shall contain a topographic map of the proposed permit and adjacent areas showing a designated area for vehicles for use in the event of the detection of waste containing radioactive material. The designated area shall, by location or shielding, protect the environment, facility staff and public from radiation originating in the vehicle. This guidance document describes various factors to consider in determining an appropriate designated area.

Radiation protection action plan.

- § 78a.58(d)
- § 273.140a
- § 277.140
- § 279.110
- § 281.119
- § 283.113
- § 288.139
- § 289.138
- § 293.111
- § 295.120
- § 297.113

(a) An application shall contain an action plan specifying the procedures for monitoring for and responding to radioactive material entering the facility, as well as related procedures for training, notification, recordkeeping and reporting.

(b) The action plan shall be prepared in accordance with this guidance document or in a manner at least as protective of the environment, facility staff, and public health and safety and which meets all statutory and regulatory requirements.

(c) The action plan shall be incorporated into the landfill's approved waste analysis plan

Basic limitations.

- § 273.201(l), (m), and (n)
- § 277.201(m), (n), and (o)
- § 279.201(i), (j), and (k)
- § 281.201(g), (h), and (i)
- § 283.201(k), (l), and (m)
- § 288.201(g), (h), and (i)
- § 289.201(f), (g), and (h)
- § 293.201(g), (h), and (i)
- § 295.201(g), (h), and (i)
- § 297.201(g), (h), and (i)

(a) The following radioactive material controlled under specific or general license or order authorized by any Federal, State or other government agency may not be disposed at the facility, unless specifically exempted from disposal restrictions by an applicable Pennsylvania or federal statute or regulation:

(1) Naturally occurring and accelerator-produced radioactive material;
(2) Byproduct material;
(3) Source material;
(4) Special nuclear material;
(5) Transuranic radioactive material; and

(6) Low-level radioactive waste.

(b) The following radioactive material may not be disposed at the facility, unless approved in writing by DEP and the disposal does not endanger the environment, facility staff or public health and safety:

(1) Short-lived radioactive material from a patient having undergone a medical procedure;
(2) TENORM; and
(3) Consumer products containing radioactive material.

(c) The limitations in subsections (a) and (b) above do not apply to radioactive material as found in the undisturbed natural environment of the Commonwealth.

Radiation monitoring and response.

- § 273.223
- § 277.222
- § 279.222
- § 281.221
- § 283.220
- § 288.222
- § 289.230
- § 293.223
- § 295.222
- § 297.223

(a) An operator shall implement the approved action plan.

(b) An operator shall monitor incoming waste in accordance with this guidance document or in a manner at least as protective of the environment, facility staff and public health and safety. Monitoring shall meet the requirements of this section and the facility's approved radiation protection action plan.

(c) Radiation detector elements shall be as close as practical to the waste load and in an appropriate geometry to monitor the waste. The radiation monitoring system shall be set to alarm at a level no higher than 10 µR/hr above the average background at the facility when any of the radiation detector elements are exposed to a cesium-137 gamma radiation field. Radiation detector elements shall be shielded to maintain the average background below 10 µR/hr. If capable of energy discrimination, the radiation monitoring system shall be set to detect gamma rays of a 50 keV energy and higher.

(d) An operator shall have portable radiation monitors capable of determining the radiation dose rate and presence of contamination on a vehicle that has caused an alarm. Upon a confirmed exceedance of the alarm level in subsection (c) above, a radiological survey of the vehicle shall be performed.

(e) An operator shall notify DEP immediately and isolate the vehicle when radiation dose rates of 2 mrem/hr or greater are detected in the cab of a vehicle, 50 mrem/hr or greater are detected from any other surface, or contamination is detected on the outside of the vehicle.

(f) Monitoring equipment shall be calibrated at a frequency specified by the manufacturer, but not less than once a year.

(g) If radioactive material is detected, the vehicle containing the radioactive material may not leave the facility without written DEP approval and an authorized federal DOT Special Permit.

Daily operational records.

- § 273.311(b)(10)
- § 277.311(b)(10)
- § 279.251(b)(11)
- § 281.271(b)(9)
- § 283.261(b)(11)
- § 288.281(b)(8)
- § 289.301(b)(7)
- § 293.251(b)(11)
- § 295.271(b)(7)
- § 297.261(b)(11)

The daily operational record shall include a record of each incident in which radioactive material is detected in waste loads. The record shall include:

(a) The date, time and location of the occurrence;

(b) A brief narrative description of the occurrence;

(c) Specific information on the origin of the material, if known;

(d) A description of the radioactive material involved, if known;

(e) The name, address and telephone numbers of the supplier or handler of the radioactive material and the name of the driver; and

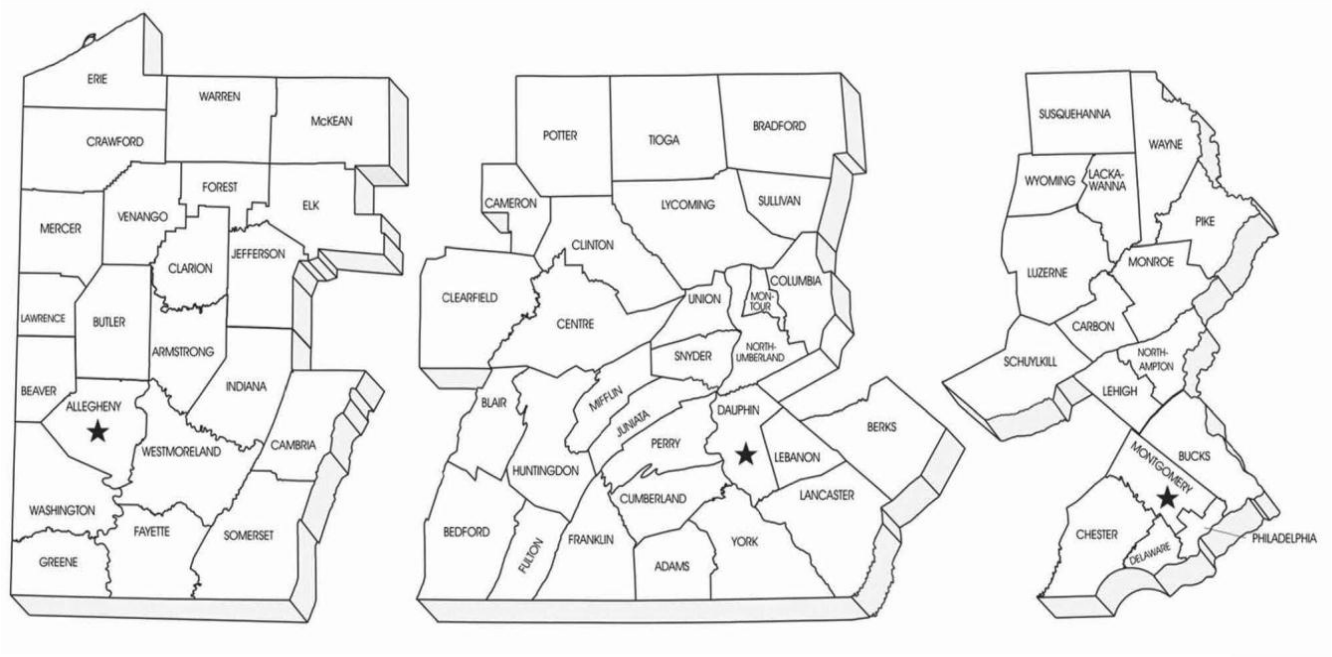
(f) The final disposition of the material.

Annual operation report.

- § 273.313(b)(9)
- § 277.312(b)(9)
- § 279.252(b)(6)
- § 281.272(b)(9)
- § 283.262(b)(6)
- § 288.283(b)(12)
- § 289.303(b)(10)
- § 293.252(b)(9)
- § 295.272(b)(10)
- § 297.262(b)(9)

The annual operation report, which shall be submitted on a form supplied by DEP, shall include a record of detected radioactive materials.

APPENDIX B. NOTIFICATION OF INCIDENTS OF RAM IN SOLID WASTE AND/OR REQUEST FOR DOT SPECIAL PERMIT



Department of Environmental Protection		
Area Health Physicist Business hours: (412) 442-4227 Non-business hours: (412) 442-4000	Area Health Physicist Business hours: (717) 705-4700 Non-business hours: (866) 825-0208	Area Health Physicist Business hours: (484) 250-5900 24 hrs./day
Northwest Region: Butler, Clarion, Crawford, Elk, Erie Forest, Jefferson, Lawrence, McKean, Mercer, Venango and Warren Counties	**Northcentral Region:** Bradford, Cameron, Clearfield, Centre, Clinton, Columbia, Lycoming, Montour, Northumberland, Potter, Snyder, Sullivan, Tioga and Union Counties	**Northeast Region:** Carbon, Lackawanna, Lehigh, Luzerne, Monroe, Northampton, Pike, Schuylkill, Susquehanna, Wayne and Wyoming Counties
Southwest Region: Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland Counties	**Southcentral Region:** Adams, Bedford, Berks, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York Counties	**Southeast Region:** Bucks, Chester, Delaware, Montgomery and Philadelphia Counties

APPENDIX C. ACTIVITIES AND DOSE RATES FOR AUTHORIZING PATIENT RELEASE FROM MEDICAL FACILITIES[2]

Table 1. Activities and Dose Rates for Authorizing Patient Release†				
Radioactive Material	**COLUMN 1 Activity at or Below Which Patients May Be Released**		**COLUMN 2 Dose Rate at 1 Meter, at or Below Which Patients May Be Released***	
	(GBq)	(mCi)	(mSv/hr)	(mrem/hr)
Ag-111	19	520	0.08	8
Au-198	3.5	93	0.21	21
Cr-51	4.8	130	0.02	2
Cu-64	8.4	230	0.27	27
Cu-67	14	390	0.22	22
Ga-67	8.7	240	0.18	18
I-123	6.0	160	0.26	26
I-125	0.25	7	0.01	1
I-125 implant	0.33	9	0.01	1
I-131	1.2	33	0.07	7
In-111	2.4	64	0.2	20
implant	0.074	2	0.008	0.8
Pd-103 implant	**	**	**	**
Re-186	1.5	40	0.03	3
Re-188	28	770	0.15	15
Sc-47	29	790	0.20	20
Se-75	11	310	0.17	17
Sm-153	0.089	2	0.005	0.5
Sn-117m	26	700	0.3	30
Sr-89	1.1	29	0.04	4
Tc-99m	**	**	**	**
Tl-201	28	760	0.58	58
Y-90	16	430	0.19	19
Yb-169	**	**	**	**
	0.37	10	0.02	2

† The activity values were computed based on 5 millisieverts (0.5 rem) total effective dose equivalent.

* If the release is based on the dose rate at 1 meter in Column 2, the licensee must maintain a record as required by 10 CFR 35.75(c) because the measurement includes shielding by tissue. See Regulatory Position 3.1, "Records of Release," for information on records.

** Activity and dose rate limits are not applicable in this case because of the minimal exposures to members of the public resulting from activities normally administered for diagnostic or therapeutic purposes.

[2] **Source:** Regulatory Guide 8.39, Release of Patients Administered Radioactive Materials. U.S. Nuclear Regulatory Commission, Washington, D.C. April 1997.

APPENDIX D. GUIDELINES FOR RADIOLOGICAL MONITORING AND CHARACTERIZATION EQUIPMENT

1. General Information About Radiation Detectors

In general, radiation detection equipment consists of the detector and electronics to convert the signal received by the detector into meaningful values. The passage of radiation through the detector (or probe) causes an impulse to be generated within the detector, which is converted into a preset unit, usually counts per minute (cpm). The following two general types of detectors likely to be used in municipal and residual waste monitoring:

1) The first, called a Geiger-Muller (G-M) counter with thin window probe, converts electrical discharge pulses into counts, which are displayed on a meter. This is the best type of detector for detecting beta particles because most of the beta particles that pass into the detector will register. However, certain low-energy beta particles will not penetrate through the outer wall of the detector and, therefore, will not be detected. Examples of radioactive materials emitting such low-energy beta particles include carbon-14 and tritium (hydrogen-3), which are commonly used in medical research programs and may inadvertently be disposed of in waste. This type of detector is gas-filled and is less efficient at detecting gamma radiation because most of it passes through the detector without generating a pulse. Nevertheless, G-M counters are normally used in hand-held instruments, and a "pancake" type thin window G-M probe can be used for alpha, beta, and gamma measurements when properly calibrated.

2) The second type of radiation detector also uses a probe that converts the impulses caused by the radiation striking the detector surface into counts, which are recorded on the meter. However, this type of detector differs from the G-M counter in that the signal transferred to the meter is dependent upon the radiation type and energy striking the detector. Typically, this type of radiation detector is called a scintillation detector. Scintillation detectors convert the radiation energy into a light impulse within the probe. The amount of light generated is based on the amount of radiation that strikes the probe. This light impulse is then converted to a measurement that may be used to determine the energy of the radiation and the total amount of radiation. Because of this capability, scintillation detectors are useful in determining the type of radioactive material present in the waste as well as the relative radiation hazard associated with the material. Scintillation detectors are also more efficient at detecting gamma radiation than a G-M counter because they are solid material (i.e., a greater number of interactions occur between the detector and the radiation yielding a greater number of counts). Zinc sulfide scintillation detectors may be used to quantify the amount of alpha particle radiation from contamination materials, although this is often conducted in laboratories rather than field settings. In addition, the scintillation medium may be liquid, thus allowing greater contact of the medium with the radioactive material and further increasing the efficiency of the measurement. Liquid scintillation is often used to quantify the amount of radioactive materials that emit low-energy beta particles, such as carbon-14 and tritium. However, this technique is employed exclusively in laboratories, rather than in the field.

   Sodium iodide (NaI) crystals, germanium crystals, zinc sulfide coatings, and specially formulated plastic materials are the most common media used in solid scintillation detectors. Plastic scintillation detectors may be more sensitive to beta/gamma radiation than NaI detectors due to size and window thickness; however, neither detect alpha radiation. In addition, plastic

detectors are usually more resistant to environmental stresses than NaI detectors and can be purchased in larger sizes, allowing better geometry for detection of radioactive material in waste. However, though plastic detectors may be less expensive than NaI detectors, they may not offer the same degree of discrimination in terms of identifying the energies of the gamma radiation. Solid state germanium detectors are often used in laboratories for precise determination of the type and amount of radioactive materials present. Although some germanium detectors are sufficiently rugged to be used in the field, most are designed for use in laboratories.

2. Facility Monitoring

Many solid waste facilities have installed radiation detection equipment at the entrance portal to the facility or in conjunction with other onsite facilities, such as scales. In such installations, the radiation detector elements (e.g., NaI crystals or plastic scintillator) are typically installed to screen incoming waste and should be installed, operated, and maintained in a manner that ensures that the measurements are meaningful and fulfill the objectives for detecting radiologically contaminated waste. The detectors should be positioned as close as practical to the waste load and calibrated so that they measure radiation [in μR/h, or equivalent counts per unit time] emitted from vehicles that are used to haul the solid waste into or out of the facility. The waste load portal detectors are normally scintillation type detectors. In the scenario where time permits (e.g., waste loads are infrequent and O&G operations) or fixed portal monitors become inoperable, hand-held microR meters may be used to scan incoming waste loads.

Both fixed and portable scintillation and G-M detectors can be calibrated to display radiation in units of exposure rate (μR/h), or dose equivalent rate (μrem/h). Equipment that displays counts per unit time should have calibration factors that can be related to these qualities. The radiation unit displayed by the detector is less important than the selection of the appropriate type of radiation detector element or probe and the proper subtraction of background radiation. Factors that should be considered when developing radiation detection and monitoring programs are:

- Area background radiation level;
- Detector efficiency and ruggedness;
- Detector calibration and response checks;
- Detector positioning and shielding;
- Detector element physical protection;
- Counting time;
- Alarm set point;
- Overall system sensitivity; and
- Alarm response procedures and training.

Because of the complex nature of radiation detection instrumentation and the multiple objectives for which such instruments may be deployed, facility staff should be trained to determine the appropriate type of instrument and/or detector probe to be used at a facility based on the established operational objectives. In addition, it is recommended that only individuals with proper experience and training (e.g., manufacturer's representative or knowledgeable health physicist) should be permitted to initially install and calibrate fixed radiation detection equipment.

3. Monitoring Equipment - General Recommendations

Facilities shall comply with specific regulatory requirements, but the following general recommendations for monitoring equipment may be used for initial detection of radioactive material at solid waste facilities:

A. The monitoring equipment used at O&G operations and solid waste facilities should be calibrated no less frequently than annually, and (if utilized) its function should be tested daily using a check source for which the instrument's expected response has been previously determined.

B. Monitoring equipment should consist of both portable (hand-held) and fixed radiation monitoring equipment. Portable instrumentation should have multiple probes for contamination and a range of gamma dose rate measurements from 10 µR/h to over 50 mrem/h.

C. Fixed monitoring equipment should be capable of detecting and displaying ambient background radiation levels. For both portable and fixed instrumentation, the equipment should provide a visual readout of the µSv/h, µrem/h, µR/h or count rate (e.g., cpm) level. Should the background radiation level be above 10 µR/h, the detector elements will require shielding to maintain the rate below this level.

D. The readout on the instrumentation should allow either scale multiplying factors or logarithmic scales to display higher radiation levels.

E. Portable instrumentation should be powered either by replaceable batteries or power cells with charging units and provide indication if battery/power cell capacity is not at levels for proper unit function. Fixed instrumentation should be line operated (e.g., 110V AC).

F. Radiation monitors should be installed according to the manufacturers' recommendations, with the detector elements as close as practicable to the waste load (i.e., close as possible and preventing physical damage). The alarm set-point for fixed monitoring equipment can be no higher than 10 µR/h above background, with a cesium-137 gamma radiation field at the radiation detector element(s). The ambient gamma background in Pennsylvania ranges from about 5 µR/h to 25 µR/h. Instrument readings in µR/h, or equivalent counts per unit time (e.g., cpm), will need to be averaged during calibration to determine the appropriate alarm set point. If capable of energy discrimination, the radiation monitor shall be set to detect gamma rays of a 50 keV energy or higher. The alarm should provide an audible signal to the operator and may provide a visible signal that the alarm set point has been exceeded. The operator should be able to reset the audible signal from the readout position. Written indication of radiation levels, such as by a data log printout or chart recording, may be available as an option for the readout.

G. The detector element assemblies for fixed monitoring may be located at or near the weigh scale for vehicles. Provision should be made to stop or slow the vehicle during the monitoring for radioactive material, with a geometry and collimation of the radiation detectors to maximize system sensitivity. It is recommended an appropriate housing and other barriers be installed to protect the detector assembly from physical damage due to vehicles and from environmental conditions, such as precipitation, high humidity, and thermal variation.

H. If the detector assembly for fixed monitoring equipment is supplied with electrical power other than the monitoring unit, provision should be made to display power condition or availability to the detector assembly.

I. The range of readout for portable (hand-held) monitoring equipment and various probes should be 0.01 mrem/h to approximately 100 mrem/h and have a known gamma energy response. A "pancake" type G-M probe will be adequate for gross counting of wipes taken for gross

contamination evaluations of vehicles. Again, hand-held micoR meters would be suitable for O&G operations and temporary vehicle monitoring if fixed systems become inoperable.

4. Characterization Equipment

Characterization equipment can be significantly more complex and expensive than detection equipment. Therefore, it is acceptable for facilities to merely have prompt access to characterization equipment (e.g., through a health physics consultant) rather than owning it. In this case, it must be explicitly stated in the RP Action Plan.

If a radiation alarm is determined to be valid at a solid waste or O&G facility, evaluation of waste may require supplies, calibrated survey meters with capabilities similar to those specified above, and any of the following to determine the specific radioisotope, and if contamination is present:

A. Portable multichannel analyzer (MCA) coupled to an NaI detector or solid-state detector. Appropriate calibration source(s) will also be needed to check the library of spectra.

B. Probes for survey meter capable of detecting beta and gamma radiation. Depending upon the survey meter and probe(s) used for beta/gamma monitoring, a different probe could be obtained for alpha monitoring, if desired.

C. Supplies for taking samples for laboratory analysis, such as wipes (or smears), containers for water and soil/waste samples, plastic bags, indelible markers, trowels, tongs, etc., would be useful to have on hand.

D. Plastic tarps, disposable protective clothing, and gloves for personnel handling potentially contaminated waste. *(Note: The use of some types of protective masks requires that the employing firm have an approved respirator qualification program.)*

E. A supply of radiation warning signs, rope, tape, etc.

F. Supplies and information for data analysis, e.g., scientific calculator, survey forms, tables of radioisotopes with half-life, etc.

APPENDIX E. GUIDELINES FOR RP ACTION PLANS FOR DETECTION AND HANDLING OF RADIOACTIVITY AT SOLID WASTE FACILITIES AND BY OIL AND GAS WELL DEVELOPMENT OPERATIONS

1. Procedures for Development and Review of RP Action Plans

A. Qualifications of Persons Preparing the RP Action Plan

Plans should be prepared by individuals having, at a minimum, the following qualifications:

1) Two years of on-the-job training in health physics; or one year of on-the-job training in health physics plus one year of formal college-level study in health physics, physics, chemistry, biology, engineering, or radiation science.

2) Experience with radiation detection and measurement, and in developing radiation safety procedures and plans.

Comprehensive certification by the American Board of Health Physics satisfies numbers 1 and 2, above. It is recommended that facilities employ a certified health physicist (CHP) as a consultant for developing and implementing their Action Plan.

B. Implementation of the RP Action Plan

The provisions of the RP Action Plan should be activated whenever situations arise in which the pre-established action levels are exceeded. Provided onsite operational facility personnel can appropriately respond to the radiological scenarios at Action Levels One and Two, the Action Plan may reference the use of corporate or consultant health physics support staff for further RAM characterization.

C. Persons Responsible for Implementation of the RP Action Plan

Each facility should designate an individual responsible for implementation of the RP Action Plan. This individual should have adequate authority to implement the Plan. If the individual(s) implementing the RP Action Plan is/are different from the individual(s) who prepared the RP Action Plan, the RP Action Plan should specify a minimum one-day training session in the fundamentals of radiation safety and detection.

D. Revision of the Plan

The plan should be reviewed and updated periodically by the permittee. Revisions shall be submitted to DEP for review and approval for O&G facilities, or through a permit modification for facilities operating under a permit issued under the municipal or residual waste regulations. At a minimum, this should occur when any of the following occurs:

1) Applicable DEP regulations or policies are revised.

2) The RP Action Plan fails during an incident.

3) The facility operation changes in a manner that would interfere with implementation of the RP Action Plan.

4) The individual responsible for implementing the plan changes.

5) The monitoring equipment used is changed.

6) The designated area for vehicles in which RAM has been detected changes.

7) As otherwise required by DEP or permittee.

2. Content and Format of RP Action Plans

A. General Instructions

The main elements of the RP Action Plan should cover all appropriate regulatory requirements and are described in this basic guidance document. Details are outlined below.

Certain RP Action Plan elements may not be entirely applicable or appropriate for a specific facility, operation or type of incident. In these cases, the person preparing the RP Action Plan should act accordingly and *provide a brief explanation as to why the RP Action Plan element(s) in question are not applicable or appropriate and explain how the proposed plan as at least as protective*.

The most important thing to remember in developing an RP Action Plan is that the actual effectiveness of the Plan will depend upon its simplicity, readability, summary instructions, and implementation training for facility operational staff.

B. Detection, Action Levels, and Initial Response

Fixed and portable radiation monitoring systems shall be calibrated annually to a traceable cesium-137 source. This radiation standard shall be traceable to the U.S. National Institute of Standards and Technology. Radiation monitors may be response-checked daily on a relative basis. Monitoring systems shall be operated in a manner that addresses Action Levels One and Two and provides appropriate notifications for each as described in Section II.D. of this technical guidance document (relating to detection of radiation).

Solid Waste Vehicles

Each vehicle transporting waste that is leaving the site of generation and suspected of containing TENORM, and each vehicle entering a solid waste processing or disposal facility should be monitored for RAM. If the alarm level of 10 μR/h over background is exceeded when a vehicle is at the monitoring location, the following procedures are recommended:

1) Reset the monitor alarm and evaluate the vehicle or container a second time.

2) If the alarm level is still exceeded, promptly survey the vehicle surfaces at a distance of 5 cm with a portable radiation survey meter to determine if Action Level Two levels are exceeded, and if an area of highest radiation level can be determined. Mark this location with chalk if other gamma spectroscopy measurements are to be performed.

3) If surveying the vehicle with a portable survey meter at 5 cm fails to reveal the presence of radioactive material, scan the driver with a portable survey meter (or have him/her stand between the monitor detectors) to determine if the driver has triggered the alarm.

Alarms have been triggered by drivers who have undergone nuclear medicine procedures involving radioactive material. If this is the case, and the driver alone has triggered the alarm, make a record of the alarm; however, no further action under this guidance document is necessary.

4) Action Level One: If the radiation monitor alarm activated on a second count, the following procedures are recommended:

   a) Remove the vehicle to the Designated Area for vehicles found to contain RAM (see section D below). Contact the individual responsible for supervising response to alarms at the facility. If the waste load is to be rejected, contact the appropriate DEP Area Health Physicist for approvals. If disposal or processing is considered, keep the load onsite until the nature of the RAM and proper actions are determined. Do not allow the vehicle or container to leave the facility without the permission of DEP and the driver being issued a DOT Special Permit signed by DEP's Area Health Physicist or their authorized representative. If a driver leaves the facility with a contaminated waste load, the driver must carry a copy of the signed DOT Special Permit. *(Note: Once a solid waste facility has an approved Action Plan, it is anticipated that facility survey data and the DOT Special Permit can be exchanged electronically to allow for immediate action on the part of DEP.)*

   b) If the driver leaves with the vehicle without a DOT Special Permit and before the RAM can be evaluated, contact the Pennsylvania State Police and DEP's Area Health Physicist listed in Appendix A and apprise that individual of the situation. Provide them with any information you may have on the vehicle such as make, model, color, company name, license plate number, time of departure, direction in which the vehicle was traveling and, if possible, the intended destination. This is to ensure that the driver is safe but does not dispose of the contaminated waste improperly.

5) Action Level Two: If the dose rates indicated by a radiation survey at a distance of 5 cm equal or exceed either limit in this Action Level on the exterior or in the cab of the vehicle, remove the driver and all other personnel from the immediate area. Similarly, if contamination is detected by wiping vehicle areas that may have contacted the waste during loading, or through seams that may leak liquid, isolate the vehicle and call DEP's Area Health Physicist for your location as listed in Appendix B. Proceed as directed by the Area Health Physicist.

O&G Vehicles

Where detection is unlikely (e.g., water tanker trucks), surveying a fraction of loads entering and leaving the facility may be allowed. The RP Action Plan must clearly state the frequency of surveys. These surveys must follow the procedure listed above for solid waste vehicles. Examples of reduced frequency may be: one load per new water source; one load per day; or, one load out of every 20.

An example of a typical 'decision tree' for determining appropriate steps when radioactivity is detected is in Appendix I.

O&G Facilities Fixed Equipment and Tanks

Surveying of fixed equipment such as tanks and pipes should initially be performed monthly. The survey schedule may be reduced to quarterly after one year. Surveys should be performed as close as practical to the item being surveyed, but not exceeding 20 cm.

C. Designated Area

For solid waste facilities, the RP Action Plan should include the location of a Designated Area for vehicles found to contain RAM. This area is to be used for surveys and, if needed, to isolate a vehicle or container to maintain personnel radiation exposure ALARA. If surveys show that either exterior dose rate limit in Action Level Two is exceeded, but there is no removable contamination on the exterior of the vehicle and the dose rate in the cab is below 50 mrem/hr, the vehicle should be promptly moved to the Designated Area for an additional characterization or evaluation by facility or DEP staff. The area should be appropriate for the various types of RAM potentially found in waste, size of facility, size of truck, employees in the proximity of the truck, and any other suitable steps warranted by the potential situation at hand and site-specific facility layout. Protection of the health and safety of facility operators and the environment may be achieved through consideration of time, distance, shielding, and contamination containment.

It is understood that on O&G sites equipment is frequently moved. Therefore, it is acceptable that those facilities do not have a singular designated area. There must be a procedure outlined in the RP Action Plan for establishing one.

D. Characterization

Immediate disposal or processing of waste with short-lived RAM from patients or individual consumer products containing exempt RAM (i.e., smoke detectors) is typical at solid waste facilities. The RP Action Plan must have procedures for characterizing the type of radioactive material present in the waste. It is acceptable for facilities to just have prompt access to characterization equipment (e.g., through a health physics consultant) instead of owning the equipment, if it is stated in the RP Action Plan. Characterization is best executed under the direct supervision of the person who prepared the RP Action Plan or another similarly trained and qualified individual able to use a portable MCA. The RP Action Plan should address steps to confirm the radiation level detected by the monitoring device and identify the radioisotope(s).

At Action Level One, the procedure to identify the radioisotope must include means to determine the gamma ray spectrum. Procedures used in the characterization phase should be situation specific and will be determined by many factors including the type of truck and how it is loaded, the nature of the waste, radiation levels indicated by the survey, highest dose rate, location of RAM in the load, instrumentation, personnel available, weather, and other factors.

At Action Level Two, radiation protection personnel from DEP and perhaps federal agencies may come onsite to provide additional guidance and assistance.

In general, appropriate characterization procedures should include the following:

1) If the cab radiation level is over 2 mrem/hr, the vehicle surface radiation level is over 50 mrem/hr, or radioactive contamination is detected, the facility should - immediately notify DEP's Area Health Physicist.

If there is no radioactive contamination, vehicle surface is less than 50 mrem/hr and the cab radiation level is less than 50 mrem/hr, the facility should implement the following procedure:

a. Promptly relocate the vehicle or container to the Designated Area.
b. Using appropriate instrumentation and measurement set-up, identify the radioisotope (i.e., via gamma spectroscopy).
c. If the gamma spectroscopy indicates the radiation is from RAM with a half-life of 65 days or less, and the vehicle is only transporting household waste, the detected RAM is most likely from a patient having undergone a medical procedure, and the facility may process or dispose of the waste load.
d. If the gamma spectroscopy indicates the radiation is from RAM with a half-life greater than 65 days, or if the vehicle is transporting waste that is not comprised solely of household waste, then the facility should contact DEP.
e. If the waste load is rejected, the facility should contact DEP for a DOT Special Permit.

2) In the designated area, survey the exterior of the vehicle with a portable survey meter set at the most sensitive setting and hold meter no more than two inches (5 cm) from all vehicle surfaces. Mark areas where radiation levels appear to be the highest. If containerized, monitor the waste during unloading from the vehicle. If the radiation levels from the vehicle or any container exceed 50 mrem/hr at any time during unloading, stop removing the waste, remove personnel from the area and call the DEP Area Health Physicist at the telephone numbers provided in Appendix B.

3) If contamination is found or the dose rate on the vehicle or cab exceeds Action Level Two, DEP staff will oversee surveying of the waste, vehicle or containers (if waste is containerized in the vehicle). Personnel who are handling the waste to isolate the source should have appropriate training, wear radiation monitoring devices, protective clothing including coveralls, boots, gloves, and dust masks to avoid skin contamination, inhalation, or ingestion with the radioactive material or other potentially hazardous material. The Action Plan and facility should provide for personal protective equipment for facility or consultant personnel if waste off-loading is anticipated.

4) If the waste is containerized, remove the individual waste containers (if not contaminated) from the vehicle and survey each with a survey meter. Look for signs and container labels that might identify the radioactive material or other hazards and the point of origin. Caution should be exercised to ensure that injuries do not occur during removal of the waste containers. Do not attempt to open containers and sort through the waste. The waste may contain sharps, biological waste, and other pathological or hazardous waste that could cause immediate and more significant risks to the workers. If contamination is detected, contact DEP.

5) If the waste load is in bulk form and cannot be processed or disposed of in the facility or is rejected, remove the bulk waste until the estimated location of the radioactive source is approached. Survey bulk waste removed with the portable meter to isolate the RAM. When the source is located, attempt to separate the RAM from the waste, provided it can

be done without jeopardizing the health and safety of workers due to other hazards present in the waste. The RP Action Plan should specify precautions to be taken to monitor external exposure and prevent workers from becoming contaminated by the radioactive material in this process. The contaminated material should be placed in containers and taken to the Designated Area where it can be stored safely and in a manner that protects facility staff and prevents environmental contamination (e.g., due to runoff, infiltration, pests, etc.) until the means of disposition is determined.

6) If radiation is detected at more than 50 mrem/h above background levels on the surface of any container, isolate this area within the facility property and contact the DEP Area Health Physicist.

7) The area(s) where radioactive material is identified per (5) and (6) above should be roped off or otherwise secured to prevent persons from entering areas where radiation levels exceed 0.02 mSv/h (2 mrem/h) and labeled with appropriate signs. Radiation levels in areas occupied by operational staff should be kept ALARA. The contaminated waste should be physically secured against removal or inadvertent disposal, or it should be under observation by facility staff at all times.

8) If radioactive material is not detected in any of the waste containers or in the bulk waste, resurvey the exterior of the vehicle. Mark any areas where radiation levels exceed background levels. The source of the radiation may be the transport vehicle itself (i.e., contamination or a small sealed source).

E. Determination of Origin

The Plan should include procedures to determine the place where the waste originated that contained RAM. These procedures should be thorough (e.g., interview driver) and capable of providing the best attempt to determine the origin of the waste. This effort is most likely to be successful with monitoring at the transfer station.

F. Disposition and/or Storage

The Plan should have procedures for rejection, disposition, or perhaps storage for decay of the waste containing RAM in accordance with the requirements and recommendations set forth in this guidance document. The procedures must take into account the radiation level, the type and amount of waste involved, the radioactive material present in the waste, the form in which the radioactive material is present, availability of the storage option at the waste processing site, and the health and safety of personnel handling such waste or present in the immediate area.

Experience to date indicates that many, if not most, alarms at solid waste facilities involve radioactive materials used in medical procedures which have half-lives sufficiently short (i.e., less than 65 days) that it is practical to either process or dispose of the waste immediately, or to store the waste in a secure area until it has decayed to a nonradioactive form. If the waste is contaminated with short-lived radioisotopes from medical procedures, and the facility operator requests a DOT Special Permit to dispose or process at a solid waste facility immediately, the proposed RP Action Plan should contain a justification and/or pathway analysis indicating that the RAM will decay in place or not cause a radiation dose to the general public above respective limits noted above. Similarly, for NORM, TENORM or individual consumer products containing

RAM, the disposal or processing shall not cause a radiation dose to the general public above applicable limits.

Alternative disposal for licensed radioactive material may be requested under 10 CFR 20.2002 and applicable NRC and Agreement State regulations.

G. Training

The RP Action Plan should provide for training of individuals responsible for implementing the Plan in the areas of:

1) Fundamentals of radiation safety;

2) Operation of the monitoring instrumentation used by the facility, including daily operation and other response checks; and

3) All aspects of the RP Action Plan.

H. Other Items to be Included

1) Provision for written alarm procedures to be posted where they can be seen by the personnel performing the waste monitoring. The alarm procedures should be coordinated in advance with facility personnel, including appropriate notification of DEP or other applicable state or local agencies and authorities.

2) Posting of notices so that waste haulers will be aware of the procedures that will be followed if radiation and radioactive material is detected in their vehicle, including notification of out-of-state radiation protection authorities and declaration of where the waste will be returned. Again, any rejected waste load must have an approved DOT Special Permit from DEP.

3) Procedures to ensure that at least one individual per shift is trained in and responsible for the implementation of response procedures in the event an alarm is activated.

4) Informing customers in advance of the procedures in the event that an alarm point is exceeded, especially if the procedures include "waste load rejection" provisions under which the suspect waste may be promptly returned to the shipper.

5) Instructing facility personnel on the appropriate procedures to be followed in the event the alarm is activated. The instructions should include graduated contingency plans in the event that RAM in waste is detected, or criteria of Action Level Two is exceeded.

I. Long-term Monitoring and Termination of Operations

At landfill sites and facilities that are handling and processing O&G liquids (e.g., flow-back wastewater or produced water) containing elevated levels of radium, the Action Plan should include procedures for monitoring and mitigation of spills or leaks of wastewater. Similarly, O&G liquid storage tanks once drained and taken out of service should be surveyed for radiological contamination. Survey records must be maintained for five years. Landfills that have accepted large volumes of TENORM waste should have long-term environmental monitoring programs in place to monitor leachate and detection of radiological groundwater

contamination. Appendix H provides a table of Applicable or Relevant and Appropriate Requirements (ARARs).

Radiation Protection Action (and Monitoring) Plan Checklist

Various Solid Waste and Oil & Gas regulations state "The action plan shall be prepared in accordance with the Department's *Guidance Document on Radioactivity Monitoring at Solid Waste Processing and Disposal Facilities*, Commonwealth of Pennsylvania, Department of Environmental Protection, No. 250-3100-001…." As stated in the Guidance, "Certain RP Action Plan elements may not be entirely applicable or appropriate for a specific facility or type of incident. In these cases, the person preparing the RP Action Plan should act accordingly and provide a brief explanation as to why the RP Action Plan element(s) in question are not applicable or appropriate" and state an alternative that is equally protective. This checklist was developed to assist the regulated community with the requirement.

Page #	Plan Element
	Completion of data entry portion of Form X (2500-FM-BWM0430).
	Description of qualifications of person preparing the plan.
	Description of what the facility does / is proposing to do. • Types and forms of waste expected
	Description of licensed radioactive material, NORM, and TENORM.
	The name and/or title of the person responsible for implementing the Radiation Protection Action Plan. Also, there must be a responsible individual for each and every shift.
	List of contact phone numbers, AKA, Emergency Contact list.
	Description of action levels and how the facility will implement them.
	Description of DOT Special Permit.
	Commitment to contact State Police if alarming vehicle leaves.
	Description of isolation area (and / or identified on site area drawing).
	Description of worker training.
	Description of detection ***and*** identification equipment. • What equipment is on site and what is it used for. • Radiation Equipment calibration frequency • Radiation Equipment response check • Identification equipment, e.g., multichannel analyzer (can be possessed by others)
	Survey and sampling protocols. • Types of surveys, e.g., piping, building, area, vehicle, etc. • Frequency
	Dosimetry - In use or not, and why.
	Consideration to call a Certified Health Physicist consultant for assistance.
	Description of when and when not to contact DEP. • When: licensable radioactive material identified; DOT Special Permit • When NOT: K40, short-lived medical isotopes, anything with a half-life less than 65 days
	Records and reports.
	RPAP revision.
Page #	**Non-landfill Plan Elements**
	Coordination with landfill before putting trucks on the road. This gives the receiving landfill a chance to confirm they have TENORM allotment available and reduces the likelihood of a DOT Special Permit.
	Revise the RPAP when needed.

APPENDIX F. BACKGROUND INFORMATION ON RADIOACTIVE MATERIAL IN SOLID WASTE

1. Introduction

Radioactive material is used for a variety of beneficial purposes in the United States, including medical diagnosis and treatment and materials testing. The use and disposal of most types of radioactive material are regulated by the NRC and individual states. Other types of radioactive material are regulated by the EPA and the States. Although LLRW must be disposed of in a licensed radioactive waste disposal facility, occasionally unregulated RAM (e.g., from patients having undergone a medical procedure) is found at solid waste processing sites that are not licensed by the NRC or states for the control radiation hazards. Additionally, with increasing frequency, TENORM or consumer products are detected as well as less frequent lost or improperly discarded higher hazard radioactive sources.

Radioactive materials in municipal waste have been detected with increasing frequency at landfills, incinerators, transfer stations, and associated facilities. This increase can be partially attributed to increased use of radiation detection instruments at the solid waste facilities. The operators of facilities have been installing such instruments in response to concerns by regulatory agencies and the public or in an attempt to limit liability for potentially costly remedial actions for radioactive contamination. When radioactive contamination is detected, it often prompts an emergency response until the potential hazards posed by the waste are determined and the material is properly controlled.

2. Sources of the Contamination

It should be noted just about everything contains some trace amount of radioactivity, and the earth is continually bathed in cosmic radiation from space. Radioactive materials exist naturally in soil, rocks, and water. There are a great many of these radioactive materials in construction materials, food, and waste. These materials may also be concentrated artificially above naturally occurring levels in their use or industrial operations and production (e.g., O&G-generated TENORM). In addition to these naturally occurring radioactive materials, municipal waste may also contain radioactive materials that have been introduced in consumer products (e.g., most domestic smoke detectors contain the radioactive material americium-241). These detectors enter the waste stream when consumers dispose of them in municipal waste.

Although the NRC and the Agreement States (States that have assumed regulatory control over certain nuclear materials through an agreement with NRC) strictly control the possession, use, storage, transportation, and disposal of certain radioactive materials through their licensing and inspection activities, on occasion, radioactive material can find its way into municipal solid waste streams. Over the last several years, DEP and NRC have monitored event reports involving detection of radioactive materials in municipal wastes. Based on reported incidents, the principal man-made sources of radioactively contaminated waste in municipal waste landfills are medical facilities, private and university laboratories, and radiopharmaceutical manufacturers.

The radioactive materials reported in contaminated waste have consisted primarily of the following radioisotopes: iodine-131, technetium-99, thallium- 201, gallium-67, iodine-123, indium-111, etc. In most cases, such RAM has been legitimately released within medical patients in accordance with the NRC and state requirements. Often, old timepieces or military gauges with Ra-226 are detected. However, in other cases the event has been caused in violation of applicable requirements, such as lost sealed sources of cobalt-57 and iridium-192.

In the practice of nuclear medicine, radioactive materials are administered to patients for the diagnosis or treatment of illnesses such as thyroid cancer or dysfunction. NRC and Agreement State regulations allow patients receiving radiopharmaceuticals to leave the hospital or clinic when the amount of radioactive material present in their bodies has dropped to certain levels or they present a low exposure potential to members of their family and the public. (See Appendix C.) After these patients leave the hospital, they may inadvertently contaminate ordinary trash that is then disposed of in municipal solid waste disposal facilities. Contaminated materials that have been generated by nuclear medicine practices and detected at municipal solid waste facilities include diapers, bed linens, disposable medical supplies, and general trash (e.g., food, plastic and paper dishes and utensils, newspapers, and magazines). Again, these items often become contaminated with radioactive materials when they are contacted by patients that have received the nuclear medicine administration, either while the patient is in the hospital or after the patient has returned home. Although the amount of radioactivity in the municipal waste is often small, detection systems used by solid waste facilities are often sensitive enough to detect the radioactive contamination.

Hospitals, clinics, laboratories, and universities use radioactive materials in research, including the marking and detection of molecules in genetic research, the study of human and animal organ systems, and in the development of new drugs. There is a potential that municipal wastes may become contaminated with radioactive materials when contaminated laboratory trash is inadvertently mixed with municipal waste. Contaminated materials may include contaminated glass or plastic, gloves, animal bedding, or paper lab countertop protectors. Waste from radiopharmaceutical manufacturers is similar to the waste produced by laboratories and universities. On rare occasions, sealed sources are mistakenly discarded from such facilities and shall be retrieved when detected.

In addition to radioactive material that may inadvertently be included in municipal solid waste, solid waste facilities may detect NORM, which is found in a variety of common household or construction materials. NORM, such as radium, thorium, or uranium, is often found in bricks, wall board, or building rubble containing these construction materials. It should be noted that this NORM was present in the base material that was used to produce these construction materials. Natural potassium also contains trace amounts of the radioisotope potassium-40 (K-40). In sufficient quantities, NORM potassium salts may trigger radiation alarms. In no case, because of radiological concerns, shall the presence of potassium or any related compound (with K-40 at natural abundance levels) prevent the immediate disposal or processing of solid waste.

The NRC and most Agreement States allow licensees with waste contaminated with radioactive material having a short half-life (e.g., less than 65 days) to be held for at least ten half-lives onsite at licensed facilities. After this period, the licensees are allowed to dispose of the decayed waste if it is indistinguishable from background radiation levels based on an appropriate survey. There have been occasions when municipal waste becomes contaminated when a licensee fails to properly monitor radioactively contaminated waste before releasing it for disposal as ordinary trash. In other reported detection incidents, licensees may have properly managed the waste, but the disposal facility's detection equipment was more sensitive than the licensee's equipment.

The NRC and some Agreement State regulations also allow small quantities of specific radioactive materials used in clinical or laboratory tests to be disposed of as if they were not radioactive. Although no incidents involving the disposal of these types of radioactive material have been reported, incidents involving medical waste have shown that detection systems are capable of detecting the low levels of radioactivity associated with these exempted materials.

Some radioactive materials that could contaminate solid waste include:

Radioisotope	Half-Life	Radiation Type
Iodine-131	8 days	Beta, Gamma
Iodine-125	60 days	Gamma
Iodine-123	13 hours	Gamma
Technetium-99m	6 hours	Gamma
Indium-111	2.8 days	Gamma
Thallium-201	73 hours	Gamma
Gallium-67	3.3 days	Gamma
Cobalt-57	270 days	Gamma
Hydrogen-3	12 years	Beta
Iridium-192	74 days	Beta, Gamma
Potassium-40	1.3×10^9 years	Beta, Gamma
Radium-226	1600 years	Alpha, Gamma
Uranium-238	4.5×10^9 years	Alpha, Gamma
Thorium-232	1.4×10^{10} years	Alpha, Gamma
Americium-241	432 years	Alpha, Gamma

As noted above, under NRC and Agreement State regulations, some sources and devices may be possessed under a GL. These items include industrial gauging equipment, old smoke detectors with Ra-226, tritium "EXIT" signs, etc. There is a real potential for such items to be present in solid waste streams. When they are identified through radiation alarms, or visual observation of a GL device or radiation warning symbol, the waste processing facility shall investigate, isolate the item, and contact DEP, if needed. RP Action Plans should contain procedures for the appropriate response if a tritium (hydrogen-3) EXIT sign or other package with a "caution radiation" symbol is observed during processing or disposal of solid waste.

3. What is Radioactivity and Radiation?

The term "radiation" as it relates to "radioactive materials" means the energetic emissions given off by the material as it decays. Ionizing radiation produces charged particles, or ions, in the material that it encounters. Potential adverse effects from radiation on humans are caused by these charged particles and the energy they deposit in tissues and organs.

Detailed information on radioactivity and radiation is provided in Appendix G.

If you have questions about radiation or require more information, please contact DEP's BRP in Harrisburg at (717) 787-2480 or the Area Health Physicist listed in Appendix B for your location.

APPENDIX G. RADIATION PROTECTION FUNDAMENTALS

1. What is Radiation?

Radiation is energy that comes from a source and travels through any kind of material and through space. Light, radio, and microwaves are types of radiation. The kind of radiation discussed in this appendix is called *ionizing radiation* because it can produce charged particles (ions) in matter.

Ionizing radiation is produced by unstable atoms. Unstable atoms differ from stable atoms because unstable atoms have an excess of energy or mass or both. Radiation can also be produced by high voltage devices (e.g., X-ray machines).

Unstable atoms are said to be *radioactive*. In order to reach stability, these atoms give off, or emit, the excess energy or mass. These emissions are called *radiation*. The kinds of radiation are electromagnetic (like light) and particulate (i.e., mass given off with the energy of motion). Gamma radiation and X-rays are examples of electromagnetic radiation. Beta and alpha radiation are examples of particulate radiation.

Interestingly, there is a "background" of natural radiation everywhere in our environment. It comes from space (i.e., cosmic rays) and from naturally occurring radioactive materials contained in the earth and in living things. Background radiation levels are typically 5 to 10 μR/h depending on location, but may be as high as 25 μR/h.

Radiation from Various Sources

External Background Radiation	60 mrem/yr, U.S. Average
Natural K-40 Radioactivity in Body	40 mrem/yr
Air Travel Round Trip (NY- LA)	5 mrem
Chest X-ray Internal Dose	10 mrem per film
Radon in the Home	200 mrem/yr (variable)
Man-made (medical X-rays, etc.)	300 mrem/yr (average)

2. Types of Radiation

The radiation one typically encounters is one of four types: alpha radiation, beta radiation, X, and gamma radiation.

A. Alpha Radiation

Alpha radiation is a heavy, very short-range particle—an ejected helium nucleus. Some characteristics of alpha radiation are:

1) Alpha radiation is not able to penetrate human skin.

2) Alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds.

3) A variety of instruments have been designed to measure alpha radiation. Special training in the use of these instruments is essential for making accurate measurements.

4) A thin window Geiger-Mueller (G-M) probe can detect the presence of alpha radiation.

5) Instruments cannot detect alpha radiation through even a thin layer of water, dust, paper, or other material because alpha radiation is not penetrating.

6) Alpha radiation travels only a short distance (a few inches) in air but is not an external hazard.

7) Alpha radiation is not able to penetrate clothing.

Examples of some alpha emitters: radium, radon, uranium, and thorium.

B. Beta Radiation

Beta radiation is a light, short-range particle — an ejected electron. Some characteristics of beta radiation are:

1) Beta radiation may travel several feet in air and is moderately penetrating.

2) Beta radiation can penetrate human skin to the "germinal layer," where new skin cells are produced. If high levels of beta-emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury.

3) Beta-emitting contaminants may be harmful if deposited internally.

4) Most beta emitters can be detected with a survey instrument and a thin window G-M probe (e.g., "pancake" type). Some beta emitters, however, produce very low energy, poorly penetrating radiation that may be difficult or impossible to detect. Examples of these difficult-to-detect beta emitters are hydrogen-3 (tritium), carbon-14, and sulfur-35.

5) Clothing provides some protection against beta radiation.

Examples of some pure beta emitters: strontium-90, carbon-14, tritium, and sulfur-35.

C. Gamma and X Radiation

Gamma radiation or X-rays are very long range, penetrating electromagnetic radiation. Some characteristics of gamma radiation are:

1) Gamma radiation or X-rays are able to travel many feet in air, and many inches in human tissue. It readily penetrates most materials and is sometimes called "penetrating" radiation.

2) X-rays are like gamma rays. X-rays, too, are penetrating radiation. Sealed radioactive sources and machines that emit gamma radiation and X-rays respectively constitute mainly an external hazard to humans.

3) Gamma radiation and X-rays are electromagnetic radiation like visible light, radiowaves, and ultraviolet light. These electromagnetic radiations differ only in the amount of energy they have. Gamma rays and X-rays are the most energetic of these.

4) Dense materials are needed for shielding from gamma radiation. Clothing provides little shielding from penetrating radiation but will prevent contamination of the skin by these materials.

5) Gamma radiation is easily detected by survey meters with an NaI detector probe.

6) Gamma radiation and/or characteristic X-rays frequently accompany the emission of alpha and beta radiation during radioactive decay.

Examples of some gamma emitters are: iodine-131, cesium-137, cobalt- 60, radium-226, and technitium-99m.

3. How is Radiation Measured?

In the United States, radiation dose or exposure is often measured in the older, 'conventional' units called rad, rem, or roentgen (R). For practical purposes with gamma and X-rays, these units of measure for exposure or dose are considered equal.

Smaller fractions of these measured quantities often have a prefix, such as milli (m) means 1/1000. For example, 1 rad = 1,000 mrad. Micro (μ) means 1/1,000,000. So, 1,000,000 μrad = 1 rad, or 10 μR = 0.000010 R.

The "System International" of units (SI system) for radiation measurement is now the official system of measurement and uses the "gray" (Gy) and "sievert" (Sv) for absorbed dose and equivalent dose, respectively.

1 Gy = 100 rad
1 mGy = 100 mrad
1 Sv = 100 rem
1 mSv = 100 mrem

With radiation counting systems, radioactive transformation events can be measured in units of "disintegrations per minute" (dpm) and, because instruments are not 100% efficient, "counts per minute" (cpm). Background radiation levels are typically less than 10 μR/h, but due to differences in detector size and efficiency, the cpm reading on a fixed portal monitor and various hand-held survey meters will vary considerably.

4. How Much Radioactive Material is Present?

The size or weight of a quantity of material does not indicate how much radioactivity is present. A large quantity of material can contain a very small amount of radioactivity, or a very small amount of material can have a lot of radioactivity.

For example, uranium-238, with a 4.5-billion-year half-life, has only 0.00015 curies of activity per pound, while cobalt-60, with a 5.3-year half-life, has nearly 513,000 curies of activity per pound. This "specific activity," or curies per unit mass, of a radioisotope depends on the unique radioactive half-life, and dictates the time it takes for half the radioactive atoms to decay.

In the U.S., the amount of radioactivity present is traditionally determined by estimating the number of curies present. The more curies present, the greater the amount of radioactivity and emitted radiation.

Common fractions of the curie are the millicurie (1 mCi = 1/1000 Ci) and the microcurie (1 μCi = 1/1,000,000 Ci). In terms of transformations per unit time, 1 μCi = 2,220,000 dpm.

The SI system uses the unit of becquerel (Bq) as its unit of radioactivity. One curie is 37 billion Bq. Since the Bq represents such a small amount, one is likely to see a prefix noting a large multiplier used with the Bq as follows:

37 GBq = 37 billion Bq = 1 Curie
1 MBq = 1 million Bq = ~ 27 microcuries
1 GBq = 1 billion Bq = ~ 27 millicuries
1TBq = 1 trillion Bq = ~ 27 Curies

5. How Can You Detect Radiation?

Radiation cannot be detected by human senses. A variety of instruments are available for detecting and measuring radiation. The most common of these are:

Geiger-Mueller (G-M) Tube or Probe -- A gas-filled device that creates an electrical pulse when radiation interacts with the gas in the tube. These pulses are converted to a reading on the instrument meter. If the instrument has a speaker, the pulses also give an audible click. Common readout units are: roentgens per hour (R/hr), milliroentgens per hour (mR/hr), rem per hour (rem/hr), millirem per hour (mrem/hr) and counts per minute (cpm). G-M probes (e.g., "pancake" type) are most often used with hand-held radiation survey instruments.

Sodium Iodide (NaI) Detector -- A solid crystal of NaI creates a pulse of light when radiation interacts with it. This pulse of light is converted to an electrical signal, which gives a reading on the instrument meter. If the instrument has a speaker, the pulses also give an audible click. Common readout units are: microroentgens per hour (μR/hr) and counts per minute (cpm). NaI detectors are often used with hand-held instruments and large stationary radiation monitors. Special plastic "scintillator" materials are also used in place of NaI.

(Note: For practical purposes, consider the rad, roentgen, and the rem to be equal with gamma or X-rays. So, 1 mR/hr is equivalent to 1 mrem/hr.)

6. How Can You Keep Radiation Exposure Low?

Although some radiation exposure is natural in our environment, it is desirable to keep radiation exposure as low as reasonably achievable (ALARA) in an occupational setting. This is accomplished by the techniques of time, distance, and shielding.

Time: The shorter the time in a radiation field, the less the radiation exposure you will receive. Work quickly and efficiently. Plan your work before entering the radiation field.

Distance: The farther a person is from a source of radiation, the lower the radiation dose. Levels decrease by a factor of the square of the distance. Do not touch radioactive materials. Use shovels, or remote handling devices, etc., to move materials to avoid physical contact.

Shielding: Shielding behind a massive object (such as a truck, dumpster, or pile of dirt) provides a barrier that can reduce radiation exposure.

7. What is Radioactive Contamination?

If radioactive material is not in a sealed source container, it might be spread onto other objects. Contamination occurs when material that contains radioactive atoms is deposited on materials, skin, clothing, or any place where it is not desired. It is important to remember that radiation does not spread or get "on" or "in" people; rather, it is radioactive contamination that can be spread. A person contaminated with radioactive material will receive radiation exposure until the source of radiation (the radioactive material) is removed.

--A person is *externally* contaminated if radioactive material is on the skin or clothing.

--A person is *internally* contaminated if radioactive material is breathed in, swallowed, or absorbed through wounds.

-- The *environment* is contaminated if radioactive material is spread about or is unconfined.

8. How Can You Work Safely Around Radiation or Contamination?

You can work safely around radiation and/or contamination by following a few simple precautions:

A. Use time, distance, and shielding to reduce exposure;

B. Avoid contact with the contamination;

C. Wear protective clothing that, if contaminated, can be removed;

D. Wash with non-abrasive soap and water any part of the body that may have come in contact with the contamination; and

E. Assume that all materials, equipment, and personnel that came in contact with the contamination are contaminated. Radiological monitoring is recommended before leaving the scene.

9. Is it Safe to be Around Sources of Radiation?

A single high-level radiation exposure (i.e., greater than 10,000 mrem) delivered over a very short period of time may have potential health risks. From follow-up of the atomic bomb survivors, we know acutely delivered very high radiation doses can increase the occurrence of certain kinds of disease (e.g., cancer) and possibly negative genetic effects. To protect the public, radiation workers and the environment from the potential effects of chronic low-level exposure (i.e., less than 10,000 mrem), the current radiation safety practice is to prudently assume similar adverse effects are possible with low-level protracted exposure to radiation. Thus, the risks associated with low-level medical, occupational and environmental radiation exposure are conservatively calculated to be proportional to those observed with high-level exposure. These calculated risks are compared to other known occupational and environmental hazards, and appropriate safety standards have been established by international and national radiation protection organizations (e.g., ICRP and NCRP) to control and limit potential harmful radiation effects.

Annual Radiation Dose Limits- TEDE

Facility staff -	5,000 mrem	(if considered as "occupationally" exposed)
Facility staff -	100 mrem	(considered member of the "public")
Vehicle driver -	100 mrem	(considered member of the public)
General Public -	4 mrem	(for the drinking water pathway)

General Public -	10 mrem	(for the air pathway)
General Public -	25 mrem	(all pathways combined, including radon)

Both public and occupational dose limits are set by federal (i.e., EPA and NRC) and state agencies (i.e., DEP) to limit cancer risk. For radon, we limit the concentration in air to 4 and 30 pCi/L for residential and occupational exposure scenarios.

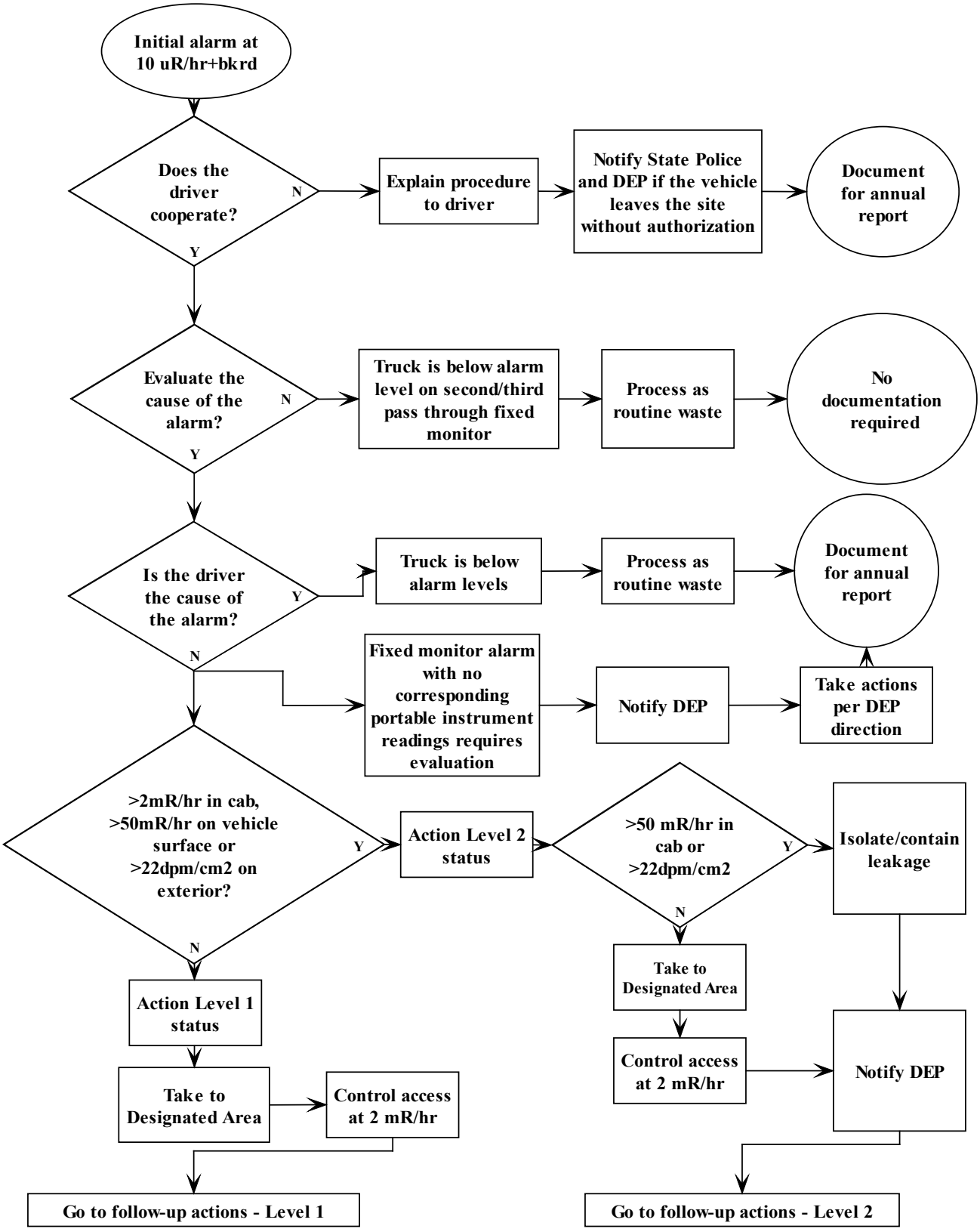
Lastly, it is important to remember when dealing with radiation sources in other materials or waste that there may be chemical or biological hazards separate and distinct from the radiation hazard. These chemical or biological hazards are often more dangerous to humans than the radiation hazard.

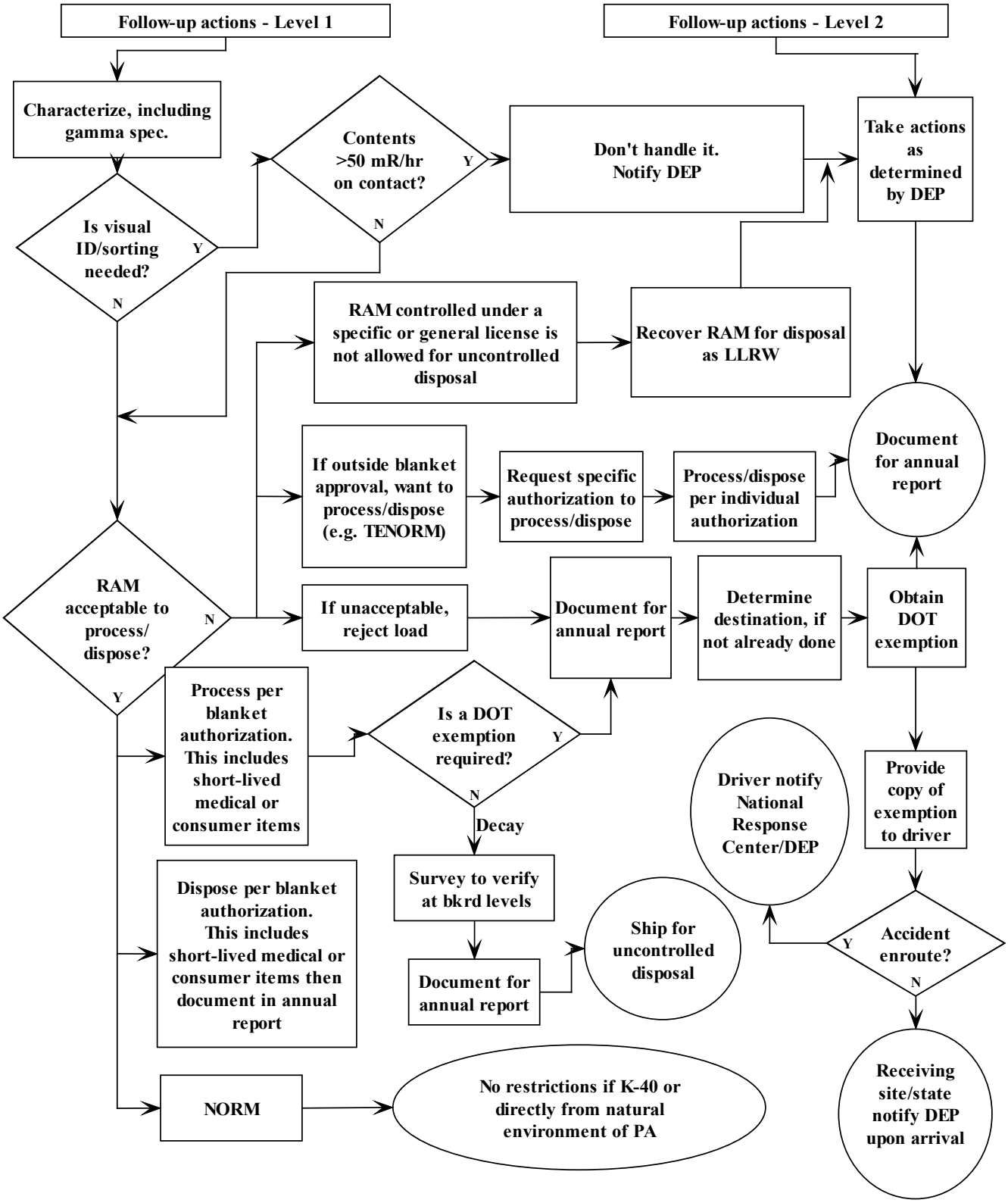
APPENDIX H. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS USED FOR RADIUM, RADON, AND TENORM

Parameter:	Criteria:	Reference:	Potentially Apply to:
Volumetric Solids, e.g., Cleanup Criteria	3 pCi/g Total Radium (Ra-226 + Ra-228) above background	ANSI/HPS N13.53-2009, Control and Release of TENORM	Spills, Sediment, Beneficial Use Surface Soil, Surface Soil on Well Pads
Volumetric Solids, e.g., Cleanup Criteria	5 pCi/g Total Radium (Ra-226 + Ra-228) above background	US EPA Directive No. 9200.4-35, Remediation Goals for Radioactively Contaminated CERCLA Sites	Spills, Sediment, Beneficial Use Surface Soil, Surface Soil on Well Pads
Volumetric Solids, e.g., Transport Criteria	270 pCi/g and 0.27 μCi Total Radium (Ra-226 + Ra-228)	US DOT 49CFR173.4, Radioactive Material (with regards to transportation)	Sludge, Filter Cake, Filter Socks, Scale, Cuttings, Soil, and other TENORM
Volumetric Liquids, e.g., Groundwater	5 pCi/L Total Radium (Ra-226 + Ra-228) in drinking water	US EPA Drinking Water Standard	Effluent Water from Well Pads
Volumetric Liquids, e.g., Discharges	60 pCi/L Total Radium (Ra-226 + Ra-228) direct discharge	US NRC 10CFR20 Appendix B, Table 2, Liquid Effluent	Effluent Water from Well Pads and Wastewater Facilities
Volumetric Liquids, e.g., Discharges	600 pCi/L Total Radium (Ra-226 + Ra-228) discharge to sanitary sewer	US NRC 10CFR20 Appendix B, Table 2, Liquid Effluent (assumes dilution and solubility of radium)	Effluent Water from Well Pads and Wastewater Facilities
Total Alpha Surface Contamination, e.g., Release Criteria	100 dpm/100cm^2	US NRC RG 8.23, Table 3, Criteria for Ra-226	Structural surfaces on well pads and within wastewater facilities, and equipment released from sites.
Total Beta Surface Contamination, e.g., Release Criteria	1,000 dpm/100cm^2	US NRC RG 8.23, Table 3, Criteria for natural Thorium including Ra-228	Structural surfaces on well pads and within wastewater facilities, and equipment released from sites.
Removable Alpha Surface Contamination, e.g., Release Criteria	20 dpm/100cm^2 (of surface area smear sampled)	US NRC RG 8.23, Table 3, Criteria for Ra-226	Structural surfaces on well pads and within wastewater facilities, and equipment released from sites.
Removable Beta Surface Contamination; e.g., Release Criteria	200 dpm/100cm^2 (of surface area smear sampled)	US NRC RG 8.23, Table 3, Criteria for natural Thorium including Ra-228	Structural surfaces on well pads and within wastewater facilities, and equipment released from sites.
Volumetric Gas, e.g., Room Criteria	4 pCi/L Radon-222	US EPA, Indoor Radon Abatement Act, 1988	Buildings, General Public Exposure
Volumetric Gas, e.g., Room Criteria	30 pCi/L Radon-222 (DAC)	US NRC 10CFR20 Appendix B, Table 2	Occupational Exposure
Volumetric Gas, e.g., Air Effluents from an Operation or Facility	9E-4 pCi/L Ra-226	US NRC 10CFR20 Appendix B, Table 2	General Public

Parameter:	Criteria:	Reference:	Potentially Apply to:
Volumetric Gas, e.g., Air Effluents from an Operation or Facility	2E-2 pCi/L Ra-228	US NRC 10CFR20 Appendix B, Table 2	General Public
Annual Exposure, e.g., Release and Disposal Criteria	25 mrem/year Radon and All Other Pathways "On," plus ALARA	US NRC 10CFR20 Subpart E, Radiological Criteria for Unrestricted Use	General Public
Annual Exposure	100 mrem/year	US NRC 10CFR20 Subpart D, Radiation Dose Limits for Members of the Public	General Public, Workers not trained as Radiation Workers, i.e. well pad and water facilities workers.
Annual Exposure	5,000 mrem/year	US NRC 10CFR20 Subpart C, Occupational Dose Limits	Trained Radiation Workers

APPENDIX I. FLOWCHART OF RECOMMENDED IMMEDIATE ECTIONS FOR A SOLID WASTE FACILITY RADIATION ALARM.




Follow-up actions - Level 1
Follow-up actions - Level 2
Characterize, including gamma spec.
Contents >50 mR/hr on contact?
Y
N
Don't handle it. Notify DEP
Take actions as determined by DEP
Is visual ID/sorting needed?
Y
N
RAM controlled under a specific or general license is not allowed for uncontrolled disposal
Recover RAM for disposal as LLRW
Document for annual report
If outside blanket approval, want to process/dispose (e.g. TENORM)
Request specific authorization to process/dispose
Process/dispose per individual authorization
RAM acceptable to process/ dispose?
N
Y
If unacceptable, reject load
Document for annual report
Determine destination, if not already done
Obtain DOT exemption
Process per blanket authorization. This includes short-lived medical or consumer items
Is a DOT exemption required?
Y
N
Decay
Driver notify National Response Center/DEP
Provide copy of exemption to driver
Dispose per blanket authorization. This includes short-lived medical or consumer items then document in annual report
Survey to verify at bkrd levels
Ship for uncontrolled disposal
Accident enroute?
Y
N
Document for annual report
NORM
No restrictions if K-40 or directly from natural environment of PA
Receiving site/state notify DEP upon arrival