

# RADIOACTIVE CONTAMINATION EXTERIOR TO BUILDINGS AT DECOMMISSIONING FACILITIES LICENSED BY THE U.S. NUCLEAR REGULATORY COMMISSION - CAUSES AND CHARACTERIZATION

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## ABSTRACT

U.S. Nuclear Regulatory Commission waste disposal regulations under Title 10, U.S. Code of Federal Regulations, Part 20, provides ways in which limited amounts of radioactive material may be disposed directly at or from NRC licensed facilities. The intention of these disposal methods are to allow limited waste disposal at a facility while at the same time keeping doses to offsite individuals below the dose guidelines in Part 20. In a very few unique instances, these waste disposal practices have led to contaminated onsite areas outside of buildings at some licensed facilities, that used dispersible radioactive material, and that are now undergoing decommissioning. Revisions to Part 20, over the past 13 years, reduce the possibility that any on-going operation will have contamination problems at decommissioning.

## INTRODUCTION

Facilities licensed by the U.S. Nuclear Regulatory Commission are required to leave their sites suitable for unrestricted use after decommissioning. The current NRC remediation criteria for the unrestricted release of surfaces and volumes are referenced in the "Action Plan to Ensure Timely Cleanup of Site Decommissioning Management Plan Sites" (1). The surfaces and volumes contaminated above these standards need to be characterized and remediated before the NRC license can be terminated. However, a small minority of the NRC licensed facilities that used dispersible radioactive material could have exterior surfaces (concrete pads and the insides of sewer systems) or volumes (soils, sludges, and ground water) that are contaminated with radionuclides above acceptable levels. The occurrences of contamination at this small group of sites was caused by the application, under unique circumstances, of the waste disposal practices authorized under 10 CFR Part 20.

The waste disposal practices of 10 CFR Part 20 consist of: releases of effluents to air or water; releases to sanitary sewerage systems; or onsite incineration. A now deleted section of Part 20 also allowed onsite burial. The purpose of these waste disposal methods are, or were, to allow limited waste disposal at a facility while at the same time keeping doses to offsite individuals to below the dose guidelines in Part 20. Waste disposal practices allowed under Part 20 were not specifically designed to prevent the possibility of subsequent onsite contamination from the disposals. However, the vast majority of Part 20 disposals have left no detectable residual contamination either on- or offsite.

Since current NRC decommissioning sites were primarily licensed under the previous version of Part 20, the regulations cited in this paper will refer to the previous version of Part 20 as "previous Part 20," to distinguish it from the regulations in the current Part 20 or "revised Part 20," which became mandatory on January 1, 1994. Table I shows the equivalent sections of the previous Part 20 and revised Part 20 regulations cited in this paper.

The waste disposal regulations in the previous versions of Part 20 are summarized and some general examples are given regarding the characteristics of the unique instances of exterior contamination found at some NRC licensed decommissioning sites. Also summarized are the changes to Part 20, recently and over the past 13 years, that further reduce the probability of onsite contamination.

## PREVIOUS PART 20 REGULATIONS FOR WASTE DISPOSAL AND UNIQUE EXAMPLES OF ONSITE CONTAMINATION

Before January 1, 1994, previous Part 20 regulations for waste disposal were contained in 10 CFR 20.301 to 20.311. These regulations included provisions for waste disposal by release of airborne and waterborne effluents (10 CFR 20.301); release into sanitary sewerage systems (10 CFR 20.303); treatment or disposal by incineration (10 CFR 20.305); or in a manner not otherwise authorized in the regulations in Title 10, Chapter I of the U.S. Code of Federal Regulations (10 CFR 20.302). Before 1981, there was also a regulation (10 CFR 20.304) that allowed waste disposal by burial in soil.

### Release of Effluents

Under previous versions of Part 20, effluents were allowed to be released under 10 CFR 20.106 and 20.301. Under these regulations, both airborne effluents, in the form of stack or vent releases, and waterborne effluents, in the form of releases to water bodies, were allowed to unrestricted areas as long as the concentrations of radioactive material released were less than the limits specified in Appendix B, Table II, of previous Part 20. These concentration limits had to be met at the boundary of the restricted area. The allowable concentrations established for air and water effluents were based on the dose that these effluents would cause if they were either inhaled or ingested by an individual at these concentrations.

Allowed releases to air, of radioactive material within specified concentration limits, at NRC licensed facilities, has generally resulted in the radioactive material being dispersed into the air without any residual contamination exterior to buildings. However, in one case, an apparently allowed release to air resulted in the radioactive material being deposited on the roof of the licensed facility, and nearby buildings, in concentrations above unrestricted release standards.

Releases of some waterborne effluents have also led to rare instances of exterior contamination. For example, before the Clean Water Act of 1977 (CWA), licensees were allowed to discharge liquid effluents, which could have contained NRC licensed material within specified concentration limits, and/or non-NRC licensed material, to water bodies on or near their sites. This generally resulted in the material being widely dispersed in the receiving water body. However, in the case of one NRC licensee who discharged liquid effluents containing radioactive material to a river, the discharge pipe outfall was a few meters from the edge of the river. This resulted in a small

TABLE I  
Summary of Previous Part 20 Regulations on Waste Disposal and  
Equivalent Revised Part 20 Regulations

Type of disposal	Previous Part 20 Sections	Revised Part 20 <sup>a</sup> Sections	Concentration or Quantity Limits from Previous Part 20
Airborne effluent	20.106 & 20.301	20.1302 & 20.2001	App. B, Table II, Col. 1
Waterborne effluent	20.106 & 20.301	20.1302 & 20.2001	App. B, Table II, Col. 2
Sanitary sewerage systems	20.303	20.2003	App. B, Table I, Col. 2 or 10 times App. C
Treatment or disposal by incineration	20.106 <sup>b</sup> , 20.302 & 20.305	20.2002 & 20.2004	App. B, Table II
Burial in soil	20.304 <sup>b</sup>	none	1000 times App. C up to 12 times/yr
<sup>a</sup> Mandatory January 1, 1994 <sup>b</sup> Deleted in 1981			

area of contaminated soil on the river's bank. This contaminated soil area was detected and remediated many years later, at decommissioning.

After promulgation of the CWA, some licensees began to impound their waterborne effluents onsite. In some instances this led to contamination of onsite impoundments (liners, sludges, and soils) or, if the impoundments leaked, contaminated ground water. These types of contamination problems are also being dealt with at decommissioning.

#### Release to Sanitary Sewerage Systems

Disposal, by release into sanitary sewerage systems, of specified quantities of radioactive material has also led, in a few unique situations, to instances of contamination at NRC licensed sites. These types of releases were authorized under 10 CFR 20.303. A sanitary sewerage system could have been anything from an onsite septic leach field to an offsite public sanitary sewerage system. The material released had to be readily soluble or dispersible in water. The concentration limits for these types of releases were listed in Appendix B, Table I, Column 2 of previous Part 20. These limits were based on a daily average concentration limit. They could also have been based on a monthly average, provided that the monthly quantity of radioactive material released remained below 10 times the quantities specified in Appendix C of previous Part 20.

The unusual occurrence of residual contamination at decommissioning sites, because of releases to sanitary sewerage systems, is partially due to the variety of forms that sanitary sewerage systems can take. For instance, some sites contained onsite leach fields consisting of a series of horizontal parallel pipes buried a few feet underground, or vertical, large-diameter dry wells. Both of these types of leach fields worked on the principle of treating the sewerage by discharging it into the subsurface soil. Unfortunately, this type of system, combined with a dispersible, but insoluble, radioactive material

has, in some unusual situations, led to localized contamination in the subsurface.

A small number of contamination problems have also been encountered offsite, when discharges of radioactive material were made to public sewerage systems. These have usually taken the form of contaminated sludge found at intermediate sewerage pumping stations, pipe junctions, in sludge digesters, or incinerators at sewage treatment plants.

#### Treatment or Disposal by Incineration

Previous Part 20, Section 20.305, allowed the treatment or disposal of radioactive materials by incineration, if specifically approved by the Commission. Approval by the Commission required, in part, adherence to 10 CFR 20.106(b) and 10 CFR 20.302. Adherence to 10 CFR 20.106(b) required the licensee to demonstrate that: 1) reasonable efforts were made to minimize the radioactivity contained in effluents to unrestricted areas; and that 2) it was not likely that radioactive material discharged in the effluent would result in an individual's exposure to concentrations of radioactive material, in air or water, exceeding the limits of Appendix B, Table II of previous Part 20. Adherence to 10 CFR 20.302 required, among other things, that the licensee analyze and evaluate pertinent general-area environmental information, the nature and location of other potentially affected facilities, and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

Experience at one NRC decommissioning facility, that used incineration as a method by which to dispose of radioactive material, showed some residual contamination in the soil around and under the incinerator pad. This may have resulted from improper handling of the incinerator ash and/or leaching of contamination from the incinerator.

### Burial in Soil

Before January 28, 1981, regulation 10 CFR 20.304 allowed the disposal of radioactive material by burial in soil. These burials were restricted by the total quantity of licensed material that could be buried at any one location and time. The quantity buried could not exceed 1000 times the amount specified in Appendix C of previous Part 20, and not more than 12 such burials could be made in any year. Therefore, past use of 10 CFR 20.304 has resulted in a few instances of residual subsurface contamination, usually with uranium or thorium, above the current unrestricted release standards.

One-thousand times the previous Part 20, Appendix C, amount for natural uranium is  $3.7E+09$  Bq (0.1 Ci). Therefore, up to  $4.4E+10$  Bq (1.2 Ci) of natural uranium could have been buried onsite per year. Although this was never the case, that could represent an extreme volume of  $80,000$  m<sup>3</sup>, assuming a uranium-contaminated material at the unrestricted release limit of  $3.7E-01$  Bq (10 pCi)/g (2) and at a bulk density of  $1.5$  g/cm<sup>3</sup> representative of a sandy soil (3). The burials had to be at a minimum depth of 1.22 m (4 ft) and successive burials had to be separated by distances of at least 1.83 m (6 ft).

Although 10 CFR 20.304 did not stipulate where the burials had to be located, generally it was on the licensee's site. They contain anything from bulk contaminated slag to duct work, machinery, or drummed waste.

### CHARACTERIZATION

Characterization of surface exposures of residual contamination (i.e., a contaminated incinerator pad, surface impoundment, soil around an outfall, or a roof) is straightforward and accomplished by taking samples from the surface and by surveying with appropriate instruments. Survey and characterization methods for residual contamination at decommissioning sites are described in NRC's "Manual for Conducting Radiological Surveys in Support of License Termination" (4). Characterization of subsurface contamination (i.e., septic leach fields or disposals in soil) is more problematic. Institutional knowledge from long-time employees, licensing documents, or plant drawings can be used to locate potential subsurface contamination areas.

The characterization of septic leach fields must first begin by properly locating the buried leach field structures. This can be relatively easy if the leach field is newer and design drawings still exist. If the leach field is old and/or abandoned, near-surface geophysical methods may need to be employed to locate it. Once it is located, samples need to be taken in and around the structures, focusing on areas that contain residual sludge.

In cases of 10 CFR 20.304 burials, the old licensing documents may indicate that 10 CFR 20.304 burials were approved, but records showing the location of these burials may be incomplete or may no longer exist. In these situations, interviews of plant personnel who may have been present at the time, review of aerial photos, or use of near-surface geophysical methods may need to be used to locate the burials. Ideally, there will be documentation on the quantities and/or concentrations buried that may help to characterize the contamination and avoid having to disturb the waste. However, subsurface boring may need to be performed around the burials, to determine if the contamination has migrated away from the burial location.

### CHANGES IN REVISED PART 20 AFFECTING WASTE DISPOSAL

The "Method for Obtaining Approval of Proposed Disposal Procedures," Section 20.2002 of the revised 10 CFR Part 20 waste disposal regulations, now requires inclusion of an analysis and proposed procedures for any requested waste disposal, not otherwise authorized in Chapter I of Title 10 of the U.S. Code of Federal Regulations. This is required by 20.1101(b) to ensure that doses are maintained as low as is reasonably achievable (ALARA) within the dose limits given in revised Part 20. Therefore, releases of airborne and waterborne effluents not only have to be within the concentration limits of revised Part 20 (most of which have been lowered from previous Part 20), but will also have to include an analysis showing that any dose to an individual is ALARA.

The rest of the significant changes concerning waste disposal regulations in revised Part 20 pertain to releases to sanitary sewerage systems. A definition of a sanitary sewerage system is now included. It is defined as a system of public sewers for carrying off waste water and refuse, but specifically excludes sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee. This definition will eliminate certain past problems, with onsite sanitary sewerage systems, that have led to some residually contaminated lagoons or subsurface areas. The requirement of discharge to a public sewerage system helps to ensure that there is more dilution of the released material over what would occur in an onsite licensee-owned or -operated sewerage leaching or treatment facility.

Other changes in the release to sanitary sewerage systems regulations are that: 1) dispersible material is no longer allowed to be released to sanitary sewerage systems unless it is readily dispersible biological material [NRC now also has criteria (5) for soluble material]; 2) there is a factor of 10 reduction in the concentration limits for releases to sanitary sewerage systems; and 3) in cases of discharge of more than one radioactive isotope to a sanitary sewerage system, a sum-of-the-fractions calculation needs to be performed, to limit potential public dose of the release to below or equal that which would be allowed from one radionuclide. These changes will help to reduce the likelihood of contamination of public sanitary sewerage systems.

### SUMMARY AND LESSONS LEARNED

Experience at some NRC decommissioning sites has shown that there can be rare instances of onsite contamination, exterior to buildings, that occurred because of waste disposal practices allowed under previous Part 20, the purpose of which was to prevent offsite doses to individuals and not necessarily to prevent onsite contamination. Therefore, when an NRC licensed facility begins decommissioning, it is important that the licensing files be reviewed for any previous Part 20 waste disposals that took place onsite.

Some lessons learned from decommissioning at NRC licensed facilities are:

- If waterborne discharges were allowed, it is important to determine the path that the discharges took, both on- and offsite. This entire discharge path should be treated as an area potentially affected by onsite operations.
- For releases to sanitary sewerage systems, it is important to determine: 1) the type of system it was (i.e., onsite septic leach field, onsite treatment, or offsite

treatment); 2) the location and radiological characteristics of all subsurface sanitary sewerage system structures; and 3) if the release was of dispersible or soluble material. In the case of releases of dispersible material, it cannot be assumed that the contamination is "gone" once it leaves the facility. Therefore, sampling along the entire sanitary sewerage system, both on- and offsite, may need to be performed.

- The locations of any onsite incinerators should be checked for any residual contamination that may have leached or spilled from the incinerator.
- Experience with the handful of decommissioning sites which allowed 10 CFR 20.304 burials has shown that the burials are not usually well documented. Therefore, it is important that the location of any 10 CFR 20.304 burials be determined either through licensing record searches, interviews, aerial photos, or with near-surface geophysical methods. Subsurface sampling may then be required to adequately characterize the burials.

### CONCLUSIONS

An awareness and investigation of even the slight potential for onsite contamination arising from previous Part 20 waste disposal methods should reduce the chance that any contamination above unrestricted release standards will be overlooked at NRC licensed facilities undergoing

decommissioning. Likewise, recent revisions to Part 20 should further reduce the possibility that any future decommissioning actions will involve unacceptable onsite contamination.

### REFERENCES

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2. U.S. NUCLEAR REGULATORY COMMISSION, "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations," Federal Register, v. 46, 52061-52063, Oct. 23, 1981.
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4. J.D. BERGER, "Manual For Conducting Radiological Surveys In Support of License Termination," NUREG/CR-5849, U.S. Nuclear Regulatory Commission (June 1992).
5. U.S. NUCLEAR REGULATORY COMMISSION, "Solubility Criteria for Liquid Effluent Releases to Sanitary Sewerage Under the Revised 10 CFR Part 20," NRC Information Notice 94-07, Jan. 28, 1994.