UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 25, 1996

MEMORANDUM FOR: David L. Meyer, Chief
Rules Review and Directives Branch
Division of Freedom of Information
and Publications Services
Office of Administration

FROM: Michael F. Weber, Chief
Low-Level Waste and Decommissioning
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

SUBJECT: NOTICE OF ISSUANCE OF BRANCH TECHNICAL POSITION

Attached please find one signed original of the subject Federal Register notice for your transmittal to the Office of the Federal Register for publication. Also attached are five additional copies of the signed notice and a 3.5" diskette with the notice in WordPerfect.

Attachments: As stated

B/28

AGENCY: Nuclear Regulatory Commission

ACTION: Notice Of Issuance Of Branch Technical Position On Screening Methodology For Assessing Prior Land Burials Of Radioactive Waste Authorized Under Former 10 CFR 20.304 and 20.302 For Interim Use And Comment

---

SUMMARY: This notice is to advise the public of the U.S. Nuclear Regulatory Commission's issuance of a Branch Technical Position (BTP) which provides a screening methodology that the staff finds acceptable to determine the need for further characterization and/or remediation of prior low-level radioactive waste disposal conducted under the provisions of former 10 CFR 20.304 and 20.302.

Burial of certain quantities of radioactive waste in soil, by licensees, without prior NRC approval, was authorized on January 29, 1959 (22 FR 548). This authorization was codified in former 10 CFR 20.304. On January 28, 1981, the NRC concluded that it was inappropriate to continue generic authorizations of burials pursuant to 10 CFR 20.304 without regard to factors such as location of burial, concentrations of radioactive material, form of packaging, and notification of NRC. Therefore, NRC rescinded 10 CFR 20.304 (45 FR 71761). As of January 28, 1981, licensees wishing to perform on-site disposal of the type previously authorized under 10 CFR 20.304 were required to obtain prior NRC approval in accordance with 10 CFR 20.302.

Disposals made pursuant to former 10 CFR 20.304 and 20.302 at facilities licensed under 10 CFR Parts 30, 40, and 70, and that have been unused for NRC licensed

operations for a period of 24 months, are subject to the requirements of the "Final Rule on Timeliness in Decommissioning Nuclear Facilities" (59 FR 36026, effective August 15, 1994) (hereinafter called the "Timeliness Rule"). Licensees who have unused outside areas (e.g., burial areas) containing elevated levels of licensed radioactive materials, are required to notify NRC, that they are in possession of these areas and must begin following a schedule for decommissioning these areas. For timing provisions related to decommissioning, see 10 CFR 30.36(d), 40.42(d), 70.38(d), and 72.54(d).

On August 19, 1996, NRC published Information Notice 96-47 "Recordkeeping, Decommissioning Notifications for Disposal of Radioactive Waste by Land Burial Authorized under Former 10 CFR 20.304, 20.302, and Current 20.2002." This notice re-emphasized NRC's position that former burials are covered under the Timeliness Rule, outlined the decommissioning schedule required by the rule, and stated that NRC would develop a screening methodology for assessing former burials. This screening methodology is being issued as a draft BTP and is attached to this notice.

Because of the deadlines associated with the Timeliness Rule, this BTP is being issued for public use and comment for 90 days. At the end of the 90 day period, the comments received will be evaluated to determine if the BTP should be revised. Since there is a possibility that the comments could result in a substantial change to the BTP, NRC will not make any decisions regarding the assessment of prior burials until after the comments can be evaluated.

All comments should be addressed to Heather Astwood, Mail Stop T-7F-27, U.S. Nuclear Regulatory Commission, Washington, DC 20555. A copy of the BTP is also located in the NRC's Public Document Room, 2120 L Street NW., Washington, DC 20555.

A copy is also on the NRC homepage which can be accessed at www.nrc.com.

FOR FURTHER INFORMATION CONTACT: Heather Astwood, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Mail Stop T-7F-27, Washington, DC 20555, telephone (301) 415-5819.

Dated at Rockville, MD this [illegible] th day of October 1996.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Michael F. Weber, Chief
Low-Level Waste and Decommissioning
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

DRAFT

BRANCH TECHNICAL POSITION

SCREENING METHODOLOGY FOR ASSESSING PRIOR LAND BURIALS OF RADIOACTIVE WASTE AUTHORIZED UNDER FORMER 10 CFR 20.304 and 20.302

October 1996

Low-Level Waste and Decommissioning Projects Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards

Table of Contents

DRAFT

SCREENING METHODOLOGY FOR ASSESSING PRIOR LAND BURIALS OF RADIOACTIVE WASTE AUTHORIZED UNDER FORMER 10 CFR 20.304 AND 20.302

1.0 PURPOSE

This Branch Technical Position (BTP) provides a screening methodology that the staff finds acceptable to determine the need for further characterization and/or remediation of prior low-level radioactive waste disposals conducted under the provisions of former 10 CFR 20.304 and 20.302. This BTP is intended to be a final evaluation for former burials. Decisions made based on this BTP are not expected to change because of the issuance of future rules or standards.

2.0 INTRODUCTION

Burial of certain quantities of radioactive waste in soil, by licensees, without prior NRC approval, was authorized on January 29, 1959 (22 FR 548). This authorization was codified in former 10 CFR 20.304. On January 28, 1981, NRC concluded that it was inappropriate to continue generic authorizations of burials pursuant to 10 CFR 20.304 without regard to factors such as location of burial, concentrations of radioactive material, form of packaging, and notification of the Nuclear Regulatory Commission. Therefore, NRC rescinded 10 CFR 20.304 (45 FR 71761). As of January 28, 1981, licensees wishing to perform on-site disposals of the type previously authorized under 10 CFR 20.304 were required to obtain prior NRC approval in accordance with 10 CFR 20.302.

On May 21, 1991, 10 CFR Part 20 was revised (56 FR 23360) and 10 CFR 20.302 was replaced by 20.2002. According to 10 CFR 20.1008(b), licensees were required to comply with the new 10 CFR 20.2002 exclusively on January 1, 1994. The requirements of 10 CFR 20.2002 are similar to the original requirements in former 10 CFR 20.302, with the addition of requirements for submitting analyses and procedures for maintaining doses within established dose limits and as low as reasonably achievable (ALARA).

Disposals made pursuant to former 10 CFR 20.304 and 20.302 at facilities licensed under 10 CFR Parts 30, 40, and 70, and that have been unused for NRC licensed operations for a period of 24 months, are subject to the requirements of the "Final Rule on Timeliness in Decommissioning Nuclear Facilities" (59 FR 36026, effective August 15, 1994) (hereinafter called the "Timeliness Rule"). Licensees who have unused outside areas (e.g., burial areas) containing elevated levels of licensed radioactive materials, are required to notify NRC, that they are in possession of these areas and must begin following a schedule for decommissioning these areas. For timing provisions related to decommissioning, see 10 CFR 30.36(d), 40.42(d), 70.38(d), and 72.54(d).

The evaluations required before the Commission terminates a license or releases a former burial area from a license related to disposed material were discussed in the supplemental information to the final rule on the "General Requirements for Decommissioning Nuclear Facilities" (53 FR 24021), published June 27, 1988. In the statement of considerations for the final rule, NRC stated that it "... will take a hard look at the extent to which the site has been previously used to dispose of low-level radioactive waste by land burial and decide what remedial measures, including removal of such soil off-site, are appropriate before the site can be released for unrestricted use and the license terminated."

On August 19, 1996, NRC published Information Notice 96-47 "Recordkeeping, Decommissioning Notifications for Disposals of Radioactive Waste by Land Burial Authorized under Former 10 CFR 20.304, 20.302, and Current 20.2002." This notice re-emphasized NRC's position that former burials are covered under the Timeliness Rule, outlined the decommissioning schedule required by the rule, and stated that NRC would develop a screening methodology for assessing former burials.

3.0 DISCUSSION

During decommissioning, NRC will evaluate disposals authorized under former 10 CFR 20.304 and 20.302, to determine whether they are acceptable for release for unrestricted use, based on their potential impact on the health and safety of the public. The acceptability of a disposal will depend on the potential for significant exposure to members of the public who may, at some time in the future, develop and use the disposal site for a private residence, farm, business, or other purpose.

This methodology is intended to be used by the licensee as a screening tool to determine which burial sites, in general, are acceptable for release for unrestricted use, recognizing that exceptions may be identified by NRC and/or the licensee. This screening tool will be based on the total activity disposed of in the burial ground and the potential for that activity to produce a significant dose to a member of the public. Although this methodology estimates doses, they are very conservative estimates. Actual doses produced by a site would be a fraction of the doses estimated using this screening.

For those sites which pass this screening, in general, the staff will require no further characterization or remediation effort. Those sites that do not pass the screening would require more detailed analysis. This may consist of site characterization and dose assessments by the licensee and NRC. Remediation may also be necessary. This is not to say that sites that do not pass the screening will be required to remediate. This process is intended to screen out simple sites with small inventories. More detailed evaluations can then be performed for the more complex sites, or sites with unique circumstances (i.e., no records, or burial located under a building). It is recognized that spot concentrations in the waste may exceed NRC's radiological criteria for decommissioning (57 FR 13389, "Action Plan to Ensure Timely Cleanup of Site Decommissioning Management Plan Sites"), but the overall risk to the public is limited by the total inventory, site characteristics, or other factors. It is also recognized that these burials may not be the only residual activity contained at a site. This screening is intended to evaluate the risks posed by an on-site burial independent of any other evaluations of dose contributions from other areas of the site. A facility which contains larger quantities of contamination would be required to

complete a site and facility characterization program and a detailed dose assessment that accounts for doses from all sources. Because such a site/facility could conceivably have residual contamination levels that result in doses that are just below the unrestricted release criterion, it is not justified to exclude a former burial site or sites. Therefore, this screening cannot be used for sites that have surface soil or building contamination outside of what is contained in the burial site and sites where members of the public would be exposed concurrently to both the burial and other residual radioactivity. It is restricted for use at those sites where a former burial is expected to be the only source of residual contamination at time of decommissioning.

The Timeliness Rule, published August 15, 1994, outlines a schedule for licensees to follow in performing decommissioning activities and requires licensees to notify NRC of plans to meet this schedule. It also requires licensees to decommission portions of their site, including "unused outdoor areas," which have not been used for a period of 24 months. These outdoor areas include former 10 CFR 20.304 and 20.302 disposals, and are, therefore, subject to the Timeliness Rule.

There are several issues associated with the assessment of prior burials. Many licensees considered these burials to be permanent disposals at the time of placement. Licensees did not budget the time nor monetary resources to evaluate these sites at the time of decommissioning. There is also a concern about the cost benefit of evaluating these sites for decommissioning. Many universities and hospitals disposed of small quantities of wastes associated with research and medical applications. The cost to characterize and remediate small burials of byproduct materials may outweigh the hazards avoided. However, some burials may pose greater risks to the public, such as those containing significant quantities of source and special nuclear material wastes. At these sites, characterization and/or remediation may be needed and costs of remediation will be considered for sites that are below 100 mrem/yr and have an adequate ALARA analysis. In addition, there are concerns about the quantity and quality of available disposal records. At the time of decommissioning, complete records of 10 CFR 20.304 and 20.302 disposals are necessary for NRC to evaluate the acceptability of the disposals. Former 10 CFR 20.401(c)(3) stated that records of disposals made pursuant to 10 CFR 20.302 and 20.304 should be maintained until NRC authorizes their disposition. However, for many of the older sites, these records are scarce or unavailable. The sites that have no burial records, may be required to evaluate and/or characterize the burials. Then, if NRC determines that the site does not pose a risk to the public, the site could be released for unrestricted use. If, however, it is determined that the site could pose a significant risk, the licensee may be required to remediate the burial. This analysis is based on the radiological risks associated with the burial. If the burial areas require characterization and/or remediation, other applicable local, state, or federal radiological and non-radiological regulations should be considered.

To help alleviate some of these concerns, the staff developed this screening methodology to determine which former burials require additional characterization and assessment and which burials are acceptable for unrestricted use. To perform this screening, the licensee will need a copy of Part 20, Appendix B, and NUREG-1500 "Working Draft Regulatory

Guide on Release Criteria for Decommissioning: NRC Staff's Draft for Comment"[1]. The NRC will defer decisions on releasing former burials based on this methodology until this draft is finalized.

4.0 REGULATORY POSITION

4.1 Scope

The methodology of this BTP applies to prior burials of radioactive material that were buried under 10 CFR 20.304 and 20.302. This methodology is not intended to be applied to burial sites that are currently in use or to evaluate former or proposed burials under 10 CFR 20.2002. The final rule on "Decommissioning Recordkeeping and License Termination: Documentation Additions," was issued on July 26, 1993 (58 FR 39628), and requires a single document listing: (1) all areas outside restricted areas where current and previous wastes have been buried, (as documented under 10 CFR 20.2108); and (2) other information necessary to ensure that decommissioning is carried out in accordance with the NRC's regulations. Therefore, for disposals made pursuant to 10 CFR 20.2002, waste disposal records should be sufficiently accurate and complete to demonstrate acceptability for release in accordance with recordkeeping and decommissioning requirements. In addition, recent approvals of 10 CFR 20.2002 disposal requests have been based on the assumption that the site would be released for unrestricted use. Guidance for evaluating these burials is contained in NUREG-1101, "Onsite Disposal of Radioactive Waste." As stated previously, this screening is intended to be used for sites in which the former burial is expected to be the only source of residual contamination at the time of decommissioning. This screening is based only on the radiological risks associated with the burial. If the burial areas require characterization and/or remediation, or contain hazardous and/or mixed wastes, other applicable local, state, or Federal radiological and non-radiological regulations should be considered.

This screening is intended to be used by both the licensee and NRC to determine the ultimate disposition of the burial ground. Licensees will perform the screening calculations, NRC staff will review the calculations and make a final determination if the site passes the screening. If the NRC's review indicates the site passes the screening, no further evaluation or characterization of the site will generally be required. The site can be removed from the license, if that is the wish of the licensee, and the site will not need to be revisited during license termination. Those sites that do not pass this screening will require more detailed analysis to assess potential radiological risks. The amount of analysis required beyond this screening depends on the complexity of the site, the amount of available site characterization information and site characteristics, and will be determined on a case-by-case basis.

---

[1] NUREGs can be ordered by calling (202) 512-1800.

4.2 Screening Methodology

4.2.1 General Approach

This methodology consists of three steps. The first step involves collecting information on the materials which were buried at the site. The other two involve conservative dose assessments using this historical information to determine the possible consequences from human exposure to the buried material. The Step 2 calculations are performed first because they require a minimal amount of information about the site, and are easy to perform. If a site passes Step 2, there is no need to collect additional information required to perform Step 3 calculations because Step 2 is more conservative. If the site does not pass Step 2, then Step 3 calculations should be performed. If a site fails both Steps 2 and 3, this site requires more detailed analysis to determine whether it poses an unacceptable risk to the public.

4.2.2 Step 1 - Records Review

The first step for the licensee should be a review of the burial records. These records should indicate the activity and types of isotopes that were disposed of at the site and the time period for those disposals. All available and relevant records should be used to develop a complete inventory for the burial area. The total activity of each isotope in the entire burial site should be determined and converted into microcuries (μCi). This total inventory should be adjusted to account for radioactive decay which has occurred since the time of burial.

It may be difficult to find records for some of the older burials. Many of these sites may have had several changes in management or location of record storage, and the records may have been misplaced or lost. If no records are available, this methodology can be performed using the original possession limits contained in the license for the site for the actual or reasonable estimate of time in which the trench was in operation and estimating the throughput resulting from the licensed activity during that time. This approach would most likely overestimate the quantities in the burial site because the activity disposed of in a burial is typically only a fraction of the activity allowed to be possessed under the license based on NRC staff experience. This will only be allowed for estimating the total inventory for use in Step 2. If there are no records, the trench size could not be determined, and, therefore, Step 3 could not be implemented. If using the original possession limits results in not passing this screening criteria, the licensee should consult with NRC for case-by-case guidance for evaluating the site. The maximum quantity that was allowed to be buried in the trenches under rescinded 10 CFR 20.304, Appendix C cannot be used as an estimate for the quantity of isotopes in the trenches because NRC has identified instances in decommissioning burial sites where disposal limits were exceeded. Without some evidence (i.e., disposal records) that these guidelines were followed, the licensee and NRC can have little confidence in the trench inventory.

If no records are available and the use of license limits result in a failure at Step 2, the licensee can take some intrusive samples of the burial ground to determine the general type and concentration of isotopes at the site and then perform this screening. The level of characterization necessary (i.e., number of samples) will be determined on a case-by-case

basis in consultation with NRC staff. NRC draft "Branch Technical Position on Site Characterization for Decommissioning Sites," dated November 1994, contains a description of the type of site characterization information that could be required. After Step 1 is complete and the total activity for each isotope in the burial site is estimated, the licensee should continue with Step 2.

4.2.3 Step 2 - Groundwater Pathway

Following the general screening model approach described in NCRPM Report No. 123, this step assumes that the total activity for each isotope is leached into the minimum quantity of water needed to meet an family of four's average use in one-year (91 m^3). Therefore, the activity of each isotope (after decay) should be divided by 9.1E7 milliliters (ml) to obtain a concentration (C) for each isotope as follows:

$$C\ \mu Ci/ml = \frac{total\ inventory\ (\mu Ci)}{9.1E7\ ml} \qquad (1)$$

The concentration of each isotope can be compared to the effluent release criteria contained in Part 20, Appendix B, Table 2, Column 2 for water. The concentrations contained in this table are estimated to produce a dose of approximately 50 mrem/yr assuming an individual consumes 2 liters/day. Because Appendix B lists concentrations in μCi/ml for isotopes which result in a dose of 50 mrem, this concentration/dose ratio can be used to estimate the dose produced from a different concentration of that isotope. The potential dose from the estimated concentration for the isotopes in the burial can be estimated as follows:

$$D\ mrem/yr = \frac{(C\ \mu Ci/ml)(50\ mrem/yr)}{(B\ \mu Ci/ml)} \qquad (2)$$

where: C = the concentration of a burial site isotope in groundwater μCi/ml;
B = the Appendix B, Table 2, Col. 2 concentration for the same isotope; and
D = the dose from exposure to this isotope.

This calculation should be performed for all isotopes in the burial site. After the doses are estimated for each isotope, the doses should be totaled. If the total dose is less than the 100 mrem/yr screening level, the site passes Step 2 and, in general, the site will require no additional evaluations. If the dose is greater than the 100 mrem/yr screening level, then the analyses of Step 3 should be performed.

Note: Step 3 CANNOT be used for isotopes with atomic numbers of 88 or higher. Step 3 uses draft NUREG-1500, which is currently undergoing revisions for these isotopes. If a

site contains these isotopes, licensees should consult with NRC staff for case-by-case guidance for evaluating these sites. If a site passes Step 2, then it passes the screening. If a site contains isotopes with atomic weight greater than 88, and it fails Step 2, then the site fails the screening and must be evaluated on a case-by-case basis.

4.2.4 Step 3 - Exhumation Concentration

In this step, it is assumed that the total inventory of the site is evenly distributed throughout the burial trenches. Most burial sites consist of several burial trenches located at the same site. The activity of each isotope should be divided by the total grams of material in the trenches. This will produce a trench concentration (μCi/gram of waste) for each isotope. This calculation should only consider the specific burial area containing the waste and contaminated soils. It should not include the soil cap, if one is present, or the 6 feet of clean soil which was required to be placed between burials conducted under the provisions of 10 CFR 20.304. For example, if a 100 m^3 site contained 6 burial trenches with each one having a volume of 10 m^3, the total inventory would be assumed to be evenly distributed over the volume of the trenches (60 m^3), not the volume of the site (100 m^3). For sites where the volume of the trenches cannot be reasonably determined, licensees should consult with NRC staff for case-by-case guidance for evaluating these sites.

This step of the methodology assumes that a member of the public builds a house directly on the burial site. The Draft Environmental Impact Statement developed for 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," dated September 1981 (NUREG-0782), contains information concerning the dilution of waste caused by exhumation of a building foundation. Appendix G of NUREG-0782 contains the inadvertent intruder scenario and states that the waste concentration should be reduced by a factor of 4 to account for dilution during excavation (the contaminated material would be mixed with the clean cover material as well as the clean soil surrounding the burial). This concentration should be converted into picocuries per gram (pCi/g) for comparison with NUREG-1500 values. NUREG-1500, Appendix A, Table A-1, "Total Dose" column contains the total dose calculated using a residential scenario, with default assumptions, and is based on 1 Pci/g of an isotope. To calculate a screening dose for the burial site, the above calculated exhumed concentration can be multiplied by the Appendix A values.

$$D\ mrem/yr = C\ pCi/g \frac{A\ mrem/yr}{pCi/g} \qquad (3)$$

where C = the concentration of a single isotope in the burial ground;
A = the NUREG-1500 Appendix A, Table A-1 dose for the same isotope; and
D = the dose from exposure to this isotope.

This calculation should be performed for all isotopes in the burial site. After the doses are estimated for each isotope, the doses should be totaled. If the total estimated dose is less than the 100 mrem/yr screening level, the site passes the screening and no further analysis

is generally necessary for the site; however, extenuating circumstances may warrant further review. If the estimated dose is greater than 100 mrem/yr screening level, the site fails this screening analysis and the licensee will be required to perform additional site-specific analyses (Section 4.3.5). Example calculations are provided in Appendix C.

4.2.5 Results

If the site passes one of the steps above, the site would generally not require any further characterization or remediation. The licensee should submit the results of this screening, including a description of the site, as known, and copies of the calculations performed for this screening. This should be submitted to NRC, along with a statement concerning the licensee's intention to take no further actions at the site. In accordance with recordkeeping requirements, the licensee will be required to maintain these records until the NRC authorizes their disposal. Assuming that the licensee submitted the notification and analysis in a timely manner (as described in IN 96-47), NRC would then issue a letter stating that the licensee has complied with the Timeliness Rule and that the former burial is suitable for unrestricted release. It will then be determined by NRC and the licensee when the burial site would be released. This BTP is intended to be a final evaluation for former burials. Decisions made based on this BTP are not expected to change because of the issuance of future rules such as NRC's radiological criteria for license termination.

There may be instances where the licensee's calculations indicate the site passes the screening, but NRC determines the site requires more evaluation to consider additional hazards that may be associated with the waste. This would include sites which contain both radioactive and hazardous wastes. This methodology may determine the site is suitable for release based on the radioactive materials alone. However, the presence of hazardous chemical wastes may warrant additional evaluation to ensure protection of the public and environment. This could also include sites where it is known the burial will be excavated in the future (i.e., the burial is in the path for a future road), sites with very limited burial records, and sites where there is other residual contamination outside of the burial area.

If the site fails Step 3 above, the licensee will be required to perform more specific characterization of the site. The details of the characterization process and the level of detail required will be determined on a case-by-case basis. NRC draft "Branch Technical Position on Site Characterization for Decommissioning Sites," dated November 1994, contains a description of the type of site characterization information that could be required. In some cases, if the characterization information indicates that total activity in the burial site is less than the activity originally used in the screening method, this more realistic total activity can be used in the screening methodology. If the site then passes the screening using this new activity, the site would not require further evaluation. If the site fails again, then the licensee will have to work with NRC staff to develop a plan for additional actions to be taken at the site. Evaluations beyond this methodology may require site characterization information and a dose assessment. More detailed assessment of the environmental transport and potential doses should be conducted in accordance with Policy and Guidance Directive PG-8-08, "Scenarios for Assessing Potential Doses Associated with Residual Radioactivity." In such cases, sites will be acceptable for unrestricted release, if projected doses are a small fraction of 100 mrem/yr and ALARA,

considering corrective actions. The staff will consider the magnitude of the projected dose, and existing radiological criteria for decommissioning, in conjunction with the objectives of keeping residual contamination levels ALARA, to determine if the waste may pose a significant risk to the public and the burial requires remediation.

It should be noted that the results of this screening are most affected by the quantity and quality of the records available to determine total inventory, and the assumptions used in determining the trench concentration. Slight variations in the trench size could be the difference between a site failing or passing the methodology.

4.3 Dose Screening Level and Basis

This methodology uses the public dose limit of 100 mrem/yr in Part 20 as a screening level for determining if a site poses a significant risk to the public. Although this is higher than the dose levels previously imposed for on-site burials (i.e., a few mrem/yr), the staff believes this is appropriate for screening these sites because of the high degree of conservatism built into the methodology and limitations of existing information.

Following the general screening model approach described in the National Council on Radiation Protection and Measurements (NCRPM) Report No. 123, dated January 22, 1996, Step 2 of this methodology assumes the total inventory in the burial ground is leached into the minimum quantity of water needed to meet the average water use of a family of four for 1 year (91 m^3). The dose is then calculated assuming an individual member of the family drank 2 liters/day of the 91 m^3 for 1 year. The use of 91 m^3 is also the screening default value used in NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning," (Table 6.22).

NRC staff analysis in NUREG-1500, Table A-1 contains estimated annual total effective dose equivalent factors. These dose factors indicate that there are cases, in which the inhalation of an isotope in a residential scenario would produce a larger dose than the ingestion of an equal amount of activity. It also indicates that the direct exposure pathway for some isotopes may be more limiting than either the ingestion or inhalation pathway. However, Appendix A, of this BTP, contains an analysis which demonstrates that the ingestion scenario, as used in this methodology, is so restrictive that inhalation and direct exposure calculations are not necessary.

The staff considers the assumptions used in this ingestion scenario to overestimate likely doses to potential members of the public, such as: (1) there has been no migration from the burial so that the total inventory originally placed in the burial remains; (2) the entire inventory leaches into the groundwater in a one-year period; (3) someone moves onto the site, and places a well near the burial ground that would capture all of the contaminated water; (4) there is no sorption of the radionuclide during transport and only limited dilution and dispersion; (5) a single individual drinks only well water from the site for that year. As shown in the example given later in this section, more likely doses to a hypothetical individual would be a small fraction of the doses estimated in this methodology and would likely be in the range of a few millirem per year if the dose using this methodology is less than 100 mrem/yr.

Step 3 of this methodology assumes that a farmer lives on top of the burial ground at some point in the future. This scenario also contains several conservative assumptions such as: (1) there has been no migration from the burial so that the total inventory originally placed in the burial remains; (2) that an intruder inadvertently digs into the waste and brings the entire inventory to the surface; and (3) the intruder fails to recognize the waste. These are assumptions used in developing the exhumed concentrations. There are also several conservative assumptions contained the dose conversion factors developed for soils in NUREG-1500, which are used in this step to estimate screening doses.

NUREG-1500 uses a family farm scenario, in which an individual lives on the site, drinks water from an on-site well, and ingests 25 percent of his/her food from a garden, on-site. The resident's house and garden are assumed to be in the contaminated area, and the garden alone is assumed to be 2500 m^2 (NUREG/CR-5512, Table 6.23). Therefore, to contain the house and garden, the contaminated area has to be larger than 2500 m^2. Many of the on-site disposals that have been reviewed by NRC in the past have had areas less than 2500 m^2. These sites are generally too small to contain a house and a garden, and, since they are smaller than those used in NUREG-1500, would likely produce a smaller dose than predicted using NUREG-1500 values. Therefore, based on the conservative assumptions used in both estimating the soil concentration, and estimating the doses, the actual doses produced from a site are expected to be a small fraction of the screening doses predicted using this methodology.

The following example of a Cs-134 burial is used to illustrate the level of conservatism in these scenarios. Assuming a burial contains 270 μCi[2] of Cs-134, the resulting dose for the ingestion scenario in Step 2 equals approximately 160 mrem/yr. If this same inventory is evenly distributed in a trench which is 5m x 2m x 1m, the exhumation concentration is calculated to be 4.2 pCi/g Cs-134 based on Step 3. Using NUREG-1500, this results in a dose of approximately 13 mrem/yr. As an independent check, a RESRAD analysis was also performed using a concentration of 4.2 Pci/g Cs-134 and a contaminated zone area of 5m x 2m, but no other site specific information. This analysis produced a dose of 7 mrem/yr (assuming no soil cover and that the groundwater was within 2 meters of the bottom of the burial). Therefore, although the scenarios in this methodology can predict elevated doses, they are only for screening purposes and do not necessarily reflect actual doses which could be produced from the site. The projected doses calculated using a more rigorous approach are a small fraction of 100 mrem/yr screening level.

---

[2] NRC's standard metrification policy is to place metric units first, followed by non-metric units in parentheses. However, the supporting tables for this BTP (i.e., 10 CFR Part 20, Appendix B) are presented in non-metric units, therefore, for comparison purposes non-metric units are used in this BTP. A conversion table is contained in Appendix B.

APPENDIX A
ANALYSIS OF OTHER PATHWAYS

There are only a limited number of isotopes for which the inhalation pathway is more limiting than the ingestion pathway for the residential scenario in NUREG-1500, Appendix A, Table A-1. For all of these, however, the direct exposure pathway is even more limiting than either the inhalation or ingestion pathways. The staff created the ingestion pathway scenario used in this methodology to be so restrictive, that even for isotopes which are primarily an external hazard (e.g., Co-60), the dose produced, based on ingestion, is higher than one produced using an external scenario, as in NUREG-1500.

Based on calculations performed using Step 3 of this BTP and the RESRAD, version 5.1, the dose modeling code, Step 2 of this methodology produces a higher screening dose, and, therefore, is more restrictive than the other two methods. Since both Step 3 and RESRAD consider all pathways, including direct exposure, in the dose calculations, if Step 2 doses are high then the other pathways do not need to be considered independently. To demonstrate this, it was assumed that there was a burial trench which contained a total activity of 270 μCi of Co-60. Co-60 was chosen because NUREG-1500 indicates it produces the largest external dose per pCi/g. It was assumed that the entire inventory of the burial was contained in a relatively small trench, with an area of 10 m^2 and depth of 1 meter. This area was used to be consistent with the contaminated zone area used in the Step 3 screening of this BTP. It was assumed that the groundwater was within 1 meter of the bottom of the burial, and that there was no cover on the material. If the total activity is used in Step 2, a screening dose of 48 mrem/yr is estimated. Step 3 of the screening estimates a dose of approximately 40 mrem/yr, and a RESRAD analysis predicts 18 mrem/yr. A RESRAD analysis using more site specific parameters (i.e., cover thickness, depth to groundwater) would likely reduce this dose even further.

APPENDIX B
METRIC CONVERSION TABLE

QUANTITY	FROM	TO METRIC	MULTIPLY BY
activity	Ci (curie)	MBq (becquerel)	37,000.0
dose equivalent	rem	Sv (sievert)	0.01
length	ft (feet)	m (meter)	0.304 8
volume	ft^3	m^3	0.028 316 85
volume	gal (gallon)	L (liter)	3.785 412

APPENDIX C
SAMPLE CALCULATIONS

1.0 EXAMPLE SITE No.1

This site contains 1-3 animal carcasses that were tagged with 41 millicuries (mCi) Cs-134, 10.5 Mci Fe-55, 60 Mci Zn-65, 2.7 Mci Co-60 and 25 Mci I-125. These animals were placed in a 5m x 2m x 1m burial pit in 1980.

1.1 STEP 1 - RECORDS REVIEW

No burial records were available to determine how many of the tagged animals were placed in the pits. There were records on the number of animals tagged, and the maximum activity that was used to tag these animals. Therefore, the maximum activity of each isotope was used to estimate the total inventory. The burial has been in place for 15 years, which is sufficient time for Zn-65 and I-125 to decay to insignificant activities. Therefore, they can be excluded from consideration. The calculated activities for the remaining isotopes are adjusted for decay.

Isotope	μCi
Cs-134	270
Fe-55	233
Co-60	376

1.2 Step 2 - Groundwater Pathway

The total inventory for each isotope was divided by 9.1E7 ml (91 m^3) of groundwater. This represents the concentration in μCi/ml of that isotope which could be ingested by a person in 1 year.

Isotope	μCi	μCi/ml(water)
Cs-134	270	2.9E-6
Fe-55	233	2.5E-6
Co-60	376	4.1E-6

This concentration was then compared to Part 20, Appendix B, Column 2, limits. These limits represent concentrations in effluent releases which could cause doses of approximately 50 mrem/yr assuming ingestion of 2 liters per day. The Appendix B ratio of concentration to dose was used to determine roughly the dose that could be produced from the waste concentrations in groundwater. For example,

$$D \text{ mrem/yr} = \frac{(2.9E\text{-}6\ \mu Ci/ml\ Cs\text{-}134)(50\ mrem/yr)}{(9E\text{-}7\ \mu Ci/ml\ Cs\text{-}134)}$$

161 mrem/yr from Cs-134

This calculation was preformed for the remaining two isotopes and the results are included in the following table.

Appendix B

Isotope	μCi	μCi/ml	μCi/ml/50 mrem/yr	mrem/yr
Cs-134	270	2.9E-6	9E-7	161
Fe-55	233	2.5E-6	1E-4	1.25
Co-60	376	4.1E-6	3E-6	68

The doses were summed and the result was a dose of over 230 mrem/yr. This dose exceeds the 100 mrem/yr screening level, and, therefore, this site fails Step 2 of the screening methodology. Since this burial did not contain any isotopes greater than atomic number 88, Step 3 was performed.

1.3 STEP 3 - EXHUMATION CONCENTRATION

In this step, the total inventory was averaged over the volume of the burial ground, which is 5 m x 2 m and 1 meter deep or equivalent to 1.6E7 grams of waste and soil assuming a soil density of 1.6 g/cm^3 to determine an average concentration (activity per cm^3). This concentration is then converted into pCi/g for comparison with NUREG-1500 values in Table A-1 and divided by 4 to represent expected dilution from cover material and clean soil on the sides during exhumation.

$$\text{Trench Concentration} = \frac{(270\ \mu\text{Ci Cs-134})(1\text{E6 pCi}/\mu\text{Ci})}{(1.6\text{E7 g})}$$

$$\text{Trench Concentration} = 17\ \text{pCi/gram}$$

$$\text{Exhumation Concentration} = \frac{17\ \text{pCi/g}}{4}$$

$$\text{Exhumation Concentration} = 4.2\ \text{pCi/g}$$

Isotope	pCi	pCi/gram
Cs-134	2.7E8	4.2
Fe-55	2.3E8	3.5
Co-60	3.8E8	5.7

These concentrations were then compared to NUREG-1500 values in Table A-1, Column 9, for the total dose in mrem/yr, as follows:

D mrem/yr = (4.2 pCi/g Cs-134)(3.06 mrem/yr), where NUREG-1500 relates 3.06 mrem/yr to 1 pCi/g Cs-134

D = 12.8 mrem/yr from Cs-134

This calculation was performed for the remaining two isotopes, and the results are summarized in the following table.

Isotope	pCi	pCi/gram	mrem/yr/pCi/g	mrem/yr
Cs-134	2.7E8	4.2	3.06	12.8
Fe-55	2.3E8	3.5	1.65E-3	0.006
Co-60	3.8E8	5.7	5.06	28.78

Based on the above calculations, the total dose is approximately 40 mrem/yr and is less than 100 mrem/yr. Therefore, this site passes screening Step 3 and does not require any further characterization nor remediation.

2.0 EXAMPLE SITE No. 2

This site contains process waste from the manufacture of uranium fuel. The burial contains approximately 3 curies of uranium in several trenches. The material was placed in trenches throughout the 1960s.

2.1 STEP 1 - RECORDS REVIEW

Burial records were available and reviewed to determine that approximately 3 curies of uranium were disposed of in trenches. For this example, it was assumed that there was 0.5 curies of U-234 and 2.5 curies U-238. Approximately 27 years have passed since the time of the last burial, which is insufficient time for either uranium to have decayed. Therefore, they cannot be excluded from consideration, and the calculations will be performed with the quantities cited above.

Isotope	μCi
U-234	5E5
U-238	2.5E6

2.2 STEP 2 - TOTAL ACTIVITY INGESTED FROM GROUNDWATER

The total inventory for each isotope was divided by 9.1E7 ml (91 m^3) of groundwater. This represents the concentration in μCi/ml of that isotope that could be ingested by a person in 1 year.

Isotope	μCi	μCi/ml
U-234	5E5	0.005
U-238	2.5E6	0.027

This concentration was then compared to Part 20, Appendix B, Column 2, limits. These limits represent concentrations in effluent releases that could cause doses of approximately 50 mrem/yr. The Appendix B ratio of concentration to dose was used to determine, roughly, the dose that could be produced from the waste concentrations in groundwater. For example,

$$D \text{ mrem/yr} = \frac{(0.005\ \mu\text{Ci/ml U-234})(50\ \text{mrem/yr})}{(3\text{E-7}\ \mu\text{Ci/ml U-234})}$$

8E5 mrem/yr from U-234

This calculation was performed for the remaining two isotopes, and the results are included in the following table.

Isotope	μCi	μCi/ml	App B μCi/ml	mrem/yr
U-234	5E5	0.005	3E-7	8E5
U-238	2.5E6	0.027	3E-7	4.5E6

The doses are well over the 100 mrem/yr screening level, and, therefore, this site fails Step 2 of the screening methodology.

2.3 STEP 3 - EXHUMATION CONCENTRATION

This site contains isotopes that have atomic numbers greater than 88, and, therefore, cannot be used in Step 3. Since this site failed Step 2 and cannot be used in Step 3, this site fails this screening methodology.