ORNL/ER-411

Assessment of Classified Waste Information for CERCLA Decisions at Melton Valley and Bethel Valley Watersheds, Oak Ridge National Laboratory, Oak Ridge, Tennessee

H&R Technical Associates, Inc.

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

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PREFACE

Waste materials which have been classified for security purposes have historically been placed in the burial grounds (solid waste disposal facilities) at Oak Ridge National Laboratory (ORNL). The locations of these burial grounds are now regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). From the viewpoint of environmental remediation, classified waste disposal presents two problems. Because information about the waste material was restricted at the time of disposal, the possibility exists that a classified disposal may contain some unrevealed hazardous material. Secondly, security restrictions may be imposed on remedial activities. This document provides an unclassified summary of what is known and unknown regarding the disposal of classified waste, allowing further research to be performed in specific areas as needed. Additionally, the document lists the conclusions that can logically be made regarding the continuing risk associated with these materials in the ground and indicates the kinds of restraints which will be placed on site remediation operations to protect continuing security classification in specific areas. This work was prepared under Work Breakdown Structure 1.4.12.6.1.02.45.14.20 (CCADS 3325, "Melton Valley Watershed Record of Decision Project").

CONTENTS

ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
ANP	aircraft nuclear propulsion
ARE	aircraft reactor experiment
CARL	Comparative Animal Research Laboratory
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
ERDA	Energy Research and Development Administration
EU	enriched uranium
FY	fiscal year
HEU	highly enriched uranium
HRE	homogeneous reactor experiment
KAPL	Knolls Atomic Power Laboratory
NEPA	Nuclear Energy Propulsion for Aircraft
NERVA	nuclear energy for rocket vehicle application
NSR	nuclear safety review
ORAU	Oak Ridge Associated Universities
ORINS	Oak Ridge Institute of Nuclear Science
ORNL	Oak Ridge National Laboratory
RCRA	Resource Conservation and Recovery Act
SF	source and fissile material
SNM	special nuclear material
SS	source and special material
SWIMS	Solid Waste Information Management System
SWSA	Solid Waste Storage Area
UCN	Union Carbide Nuclear
UTAES	University of Tennessee Agricultural Experiment Station

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers as well as its successors the Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA), and Department of Energy (DOE) routinely buried radioactive waste materials at the Oak Ridge National Laboratory reservation. Some of these disposals contained materials that were classified for security considerations. In some cases, there has been a significant lack of recorded information about these waste disposals, making it difficult to evaluate the continuing "risk" (involving such concerns as physical loss, environmental impact, safety problems, and noncompliance with modern waste management regulations) associated with the presence of these materials in the ground. Further, this lack of information has resulted in misconceptions about the nature of these waste materials, giving the erroneous impression that these waste materials are significantly different from unclassified waste materials, or that the waste material contents have not been previously reported in generic summaries. This document provides an unclassified summary of what is known and unknown regarding these disposals, allowing further research to be performed in specific areas as needed. Additionally the document lists the conclusions that can logically be made regarding the continuing risk associated with these materials in the ground and indicates the kinds of restraints which will be placed on site remediation operations to protect continuing security classification in specific areas.

1. INTRODUCTION

For 50 years the Oak Ridge National Laboratory (ORNL) site has been used for the disposal and storage of radioactive waste. Such waste has been generated by on-site laboratory programs, programs at other sites on the Oak Ridge Reservation, and off-site programs at various commercial and non-commercial sites. Some of the waste materials that were generated would be regulated today under the Resource Conservation and Recovery Act (RCRA). Extensive environmental management programs have been established to detect, monitor, and if necessary, prevent further dispersion of these materials in the environment. Formerly used disposal sites for these materials are regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

An often overlooked aspect of ORNL operations is the laboratory role in U.S. defense programs to which access has been restricted for national security purposes. From its beginnings as a completely secret U.S. Army facility to its present operations, many laboratory research and development activities have been conducted as part of these "classified" programs. Virtually all of the laboratory research and development activities were classified at the inception of the laboratory. The percentage of classified laboratory research and development activities dropped gradually until the early 1960s, then abruptly to less than ten percent. Present day classified laboratory research and development activities are incidental to the main missions of the laboratory. (The terms "classified" and "classification" in a security context refer to restricting information access on a need-to-know basis and establishing specific criteria for the identification, protection, and dissemination of the information.)

In some cases, the waste materials generated by these classified research activities have also been classified because of their information content, and this classification has made detailed reporting of information regarding RCRA-regulated material for CERCLA sites to regulatory agencies difficult. Usually, to avoid revealing classified information when reporting waste stream contents, the waste materials have been described generically or included in the descriptions of broader waste streams in unrestricted reports so that they cannot be associated with specific classified programs. This classification of waste material information has two associated problems. The first problem is that the required information transfer between the laboratory and the regulatory agencies becomes confused; over time, it becomes difficult to determine which information has been transmitted and in what form. This problem is exacerbated by the relationship of the laboratory and the regulatory agencies in that classification of information may be misinterpreted as deliberate concealment of improper disposal activities. Further, classified information is expensive to maintain and properly declassify. As budgets are reduced, classified information is often destroyed to eliminate this cost, again making information transfer more difficult and the destruction subject to misinterpretation.

The second problem is that of the management of physically solid waste materials which have been previously buried, but are still classified. Often remedial activities are needed at a disposal site; however, the presence of buried classified waste materials can add significant administrative requirements and restrictions to the remedial activities.

1.1 PURPOSE AND SCOPE

This report summarizes in an unclassified format what is known and not known about the disposal of classified solid waste materials at specific CERCLA sites at ORNL. The summary has been prepared to remove as much confusion as possible about disposals of classified solid waste materials and to indicate if there still exists a significant environmental protection vulnerability which has resulted from the disposal of classified solid waste materials. As a secondary issue, the summary will indicate where details of classified solid waste material disposals have been archived. Finally, the report will indicate where administrative requirements and restrictions to any proposed remedial activities will be necessary.

The scope of this report includes only the physically solid classified radioactive waste materials which were buried or abandoned at a series of designated landfill locations at ORNL. It does not include classified radioactive waste materials which were managed as liquids or gases since recovery of classified information from such waste streams is generally not an issue. To clarify this distinction, some additional background is necessary. ORNL waste is segregated by physical form for processing and disposition; until recently, separate ORNL organizations and processes were used to manage these different physical forms. Historically, physically solid materials were generally given landfill disposal, physically liquid waste materials were released to water courses or to seepage basins, and physically gaseous or airborne particle wastes were usually released to the air. This segregation was based more upon waste transport economics, rather than upon actual form of the waste materials. In general, therefore, containerized liquids such as drummed sludges, bottled chemicals, or containers of waste oil were usually managed as solid waste and given landfill disposition. Bulk liquid waste that could be piped or transported in large tanks was managed as liquid waste and given disposition in seepage basins. This report is concerned with those materials managed as solid waste and given landfill disposition.

1.2 REPORT ORGANIZATION

The process used to identify all information related to disposal of classified materials at ORNL solid waste disposal sites was a comprehensive literature search in all ORNL waste management archives and the classified and formerly classified ORNL Laboratory Records files. The sole criterion for selection was whether or not the document contained any information relevant to solid waste management operations. Since individual documents are rarely helpful, a separate archive of relevant classified and unclassified information was created at the classified file point at Laboratory Records so that documents from the same time period or subject area could be examined and correlated, regardless of classification. A summary of the types of documents examined and their relevance to CERCLA activities is presented below. In general, as will become clear in the remainder of this report, few classified documents exist which explicitly contain information regarding solid waste operations. The reason for this is that most of the 150,000 classified documents at Laboratory Records and other locations have been recently declassified. Since no alternate location for their storage exists, however, access to these documents is restricted. In addition to restricted access, it is only in the last year that a searchable computerized data base of document subjects has been created, allowing data searching without reading each document.

In general, solid radioactive waste landfill locations were operated in sequence. This report is therefore organized sequentially by landfill location so that readers can obtain a balanced and comprehensive view of the continuum of ORNL classified solid waste management operations over 50 years. For each solid waste disposal location, a document list was prepared. The list contains both

the unclassified and classified documents/materials related to the disposal location. These lists will be found at the end of Sects. 2-7.

At the beginning of the discussion of a landfill location, a broad background view of the classified laboratory waste management operations of that time is presented. This discussion is necessary for an understanding of the issues associated with remedial activities in former solid waste disposal areas. Following the background discussion, a summary is presented of the existing documentary evidence maintained by the ORNL Laboratory Records or ORNL Waste Management organizations. This archived documentation can be grouped in twelve general classes as follows.

- Disposal Operations Documents. As solid waste disposal operations became complex, line supervisors typically kept notebooks or logs to assist in scheduling or record keeping. Since this type of documentation was not required by the government, these materials reflect data that was chiefly of interest to the supervisors. In some cases, waste materials which would be currently regulated under RCRA can be identified. These were used as early as the 1940s.

- Special On-site Disposal Documents. Current solid waste disposal practice requires written requests for special on-site disposal actions. That is, if an ORNL waste generator has solid waste for disposal that is not part of an approved generic waste stream, a specific request for disposal must be submitted. This practice was not started at ORNL until the 1960s. In some cases, waste materials which would be currently regulated under RCRA can be identified.

- Disposal Management Documents. Correspondence at the department or laboratory management level regarding the disposition of solid waste is frequently useful in the understanding of the issues associated with remedial activities in former solid waste management disposal areas. This type of correspondence is available from the 1940s. Rarely will these documents allow identification of waste materials which would be currently regulated under RCRA.

- Health Physics Documents. Health Physics concerns associated with worker radiation protection and contamination control had a strong impact on the requirements and operations for solid waste disposals. This type of correspondence is available from the 1940s to the 1950s. Rarely will these documents allow identification of waste materials which would be currently regulated under RCRA.

- Nuclear Criticality Safety Documents. Criticality safety was only a peripheral issue until significant amounts of fissile materials began to be placed in single disposal locations. In general, criticality safety review of solid waste disposals was not started at ORNL until the 1960s. Rarely will these documents allow identification of waste materials which would be currently regulated under RCRA.

- Nuclear Materials Accountability Documents. The accountability of strategic nuclear materials (a broader category than fissile materials) was an important issue from the earliest operations. This type of correspondence is available from the 1940s. Because the chemical form of the strategic nuclear material was important for accountability, these documents often provide the best description of waste materials which would be currently regulated under RCRA. Unfortunately, this system of classified documents used a specific record destruction schedule; only when the schedule was not followed or when old records were microfilmed can information be obtained.

- Engineering Records. This type of correspondence is available from the 1940s. Rarely will these documents allow identification of waste materials which would be currently regulated under RCRA, but they will often provide the location of specific landfill disposals.

- Commercial Sales Documents. ORNL conducted commercial sales of both isotopes and burial ground services. This type of correspondence is available from the 1940s. Because the documents often provide detailed descriptions of an off-site waste stream, they often provide the best description of waste materials which would be currently regulated under RCRA. Unfortunately, these records were simply discarded when the sale of burial ground services ceased; only a representative sample still exists from which information can be obtained.

- Financial Accounting Documents. Financial accounting documents concerning disposal operations often provide insight into disposal operations activities. This type of correspondence is available from the 1940s. Rarely will these documents allow identification of waste materials which would be currently regulated under RCRA.

- On-site Generator Documents. Documentation is sometimes available in on-site generator files that can give details of specific waste disposals. No comprehensive archive of these files exists.

- Off-site Generator Documents. Documentation is sometimes available from off-site generator files that can give details of specific waste disposals. No comprehensive archive of these files exists.

- Other Evidence. Photographs and special studies at former burial grounds can provide both general and specific information regarding disposals.

The nature of archival research is the continuous building of a body of knowledge. A comprehensive review and study of all of these documents has only been recently completed, providing additional information or correlation not available in earlier reports. Where necessary, some explanatory discussion has been provided in this report when the archived documentary evidence indicates that previous ORNL reports regarding solid waste disposition have included misinterpretations or conclusions for which other alternatives are more likely.

For each solid radioactive waste landfill location, summary discussions are provided regarding the disposal of classified material, the disposal of special nuclear material, and the conclusions that can be reached regarding the relevance of the information to CERCLA activities associated with classified solid waste disposals at the location. Again, document lists of the archived documentation which may be reviewed and examined for further interest are provided.

1.3 CLASSIFIED INFORMATION ASSOCIATED WITH WASTE MATERIALS

According to U.S. government regulation, objects which can reveal classified information are managed much like classified documents, kept in security protection areas, and given special markings. Access to such objects is controlled and limited to those personnel holding security clearances with a need to know the specific information. Unauthorized revelation of the objects, and thus classified information, is punishable under federal statute. Specific procedures are usually prepared for declassifying and downgrading the level of security classification assigned to an object. In general, since 1954, classified information has been grouped into three categories with differing declassification schemes. The first category is that of "restricted data;" this is information directly related to (1) the design, manufacture, or utilization of nuclear weapons, (2) the production of special nuclear material, or (3) the use of special nuclear material in the production of energy. Declassification of this category of information is very specific and performed on a case by case basis since revelation of even the oldest information can benefit unauthorized entities intent upon acquiring this technology. The second category is that of "formerly restricted data;" this is information that has been removed

from the "restricted data" category and is protected in a manner similar to "national security information" with special restrictions on its distribution. The third category is that of "national security information"; this is information which requires protection against unauthorized disclosure in the interest of national defense or foreign relations, essentially offering the U.S. a temporary advantage over potential adversaries. Declassification of this category of information is often set to a specific time scale or performed on a "blanket" basis. Regardless of category, a classified object is declassified only by written directive of the appropriate security manager.

Waste materials may be given a security classification by security managers in order to prevent or delay the unauthorized revelation of classified information from either category. In general information about waste will be classified for one or more of the following reasons.

- Protection of the physical concept, shape or dimensions. The waste contains one or more objects from which classified information can be obtained visually. Examples of this would be scrap weapon components or reactor parts.

- Protection of the chemical composition or form. The waste contains one or more objects from which classified information can be obtained by chemical analysis or examination. Examples of this would be reactor fuel samples.

- Association of the material with a protected process. The waste itself contains no classified information, but the association of the waste material with a particular classified process reveals classified information about the process. Most of the early ORNL reactor fuel processes were classified.

- Association of the material with a protected program. The waste itself contains no classified information, but the association of the waste material with a particular classified program reveals classified information about the program. Most of the materials associated with weapons development programs are classified, although they often have other unclassified uses.

- Physical security of an amount of special nuclear material that exceeds a specific level. Special nuclear material (SNM) denotes one of several specific unique materials such as uranium-235 or plutonium-239 which is required directly for the fabrication of nuclear weapons. Such materials are closely controlled. The material itself is not classified; however, the specific location where quantities above a certain level of the material is buried may be classified.

Usually the amount of inherently classified information in a solid waste disposal would be limited. Logic would dictate that large quantities of classified objects would not be fabricated to be buried, nor would large concentrations of SNM be placed in uncontrolled burials. It is much more likely that a waste disposal would be classified because of its association with a classified process or program. However, in one case, an entire waste stream remains classified simply because it has a high probability of containing a classified object.

1.4 CLASSIFIED WASTE CONTAINING HAZARDOUS MATERIALS

From a regulatory decision making viewpoint, it would be beneficial to know which components of classified waste materials are regulated by RCRA and in what quantities they are present at an ORNL CERCLA site. The answer to this question can never be determined with any certainty since the Resource Conservation and Recovery Act was passed in 1976, the Comprehensive Environmental

Response, Compensation and Liability Act was passed in 1980, the first DOE orders requiring hazardous waste characterization appeared in the early 1980s, and full compliance with waste management documentation regulations did not occur at any DOE site until some time after that. As will be shown in Sects. 2-7, only a few classified waste disposals were made at ORNL after 1976. This means that, just as for unclassified waste materials at ORNL CERCLA sites, classified waste materials buried before about 1980 were uncharacterized by modern standards. Only in rare cases will pre-1976 waste documentation, classified or unclassified, contain any information regarding a hazardous waste component in a specific disposal action.

This undocumented aspect of hazardous waste disposal in the ORNL burial grounds has been previously reported (DOE/OR/01-1326 1994). A good approximation can be made, however, of the type of hazardous materials sent to the ORNL burial grounds for disposal when the mission and size of the laboratory is considered in perspective. ORNL represents a large physical plant at which several hundred buildings have generated waste of all types characteristic of small industrial and large experimental laboratory activities. Reviewing the "Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste," (40 CFR 261.10), it is clear that these activities generated waste streams that contained characteristically "ignitable," "corrosive," "reactive," and "toxic" waste materials. While it is doubtful that the characteristically "ignitable," "corrosive," and "reactive" waste materials still have these hazardous characteristics after 25 to 50 years of exposure to the other waste materials and native soil in a burial trench, it is possible that a small amount of these waste materials may have been buried in high integrity packaging such as stainless steel as will be shown in Sect. 6. Of those materials considered characteristically "toxic" (i.e., regulated materials on the RCRA D List), typical industrial solvents and laboratory chemicals in use in the U.S. (i.e., benzene, carbon tetrachloride, methyl ethyl ketone, tetrachloroethylene, and trichloroethylene) would have been buried as contaminants in the plant solid waste. Most of the metals on the RCRA D List would certainly have been buried, the most prominent being lead which had a wide range of physical forms at ORNL. It is unlikely that these toxic materials, if they were going to mobilize in ground water, still present a hazard after 25 to 50 years of burial ground leaching.

Of those waste materials considered "hazardous" (i.e., regulated materials on the RCRA F List), spent industrial solvents widely used in the U.S. industrial processes (i.e., methyl isobutyl ketone [hexone], tetrachloroethylene [perchloroethylene], and trichloroethylene) would have been buried as contaminants in the plant solid waste. Considering the nature of the ORNL research and experimental laboratory activities, it would certainly be likely that chemicals from the RCRA P and U Lists would have been buried, the most prominent being beryllium. Again, it is unlikely that these toxic materials, if they were going to mobilize in ground water, still present a hazard after 25 to 50 years of burial ground leaching.

Classified solid waste materials may or may not have contained a hazardous material component when buried. In some cases, classified waste materials derived their security classification from the association of a site or process with a particular chemical. In general, however, the chemical would not be regulated today by RCRA; that is, the chemical component making the waste classified would be immaterial to hazardous waste regulation decision making. Instead the classified chemical would have usually been a radionuclide, such as tritium. In contrast, a classified waste stream might have contained lead, beryllium, or simply have been characteristically hazardous at the time of disposal. An example would be drummed process sludges with a caustic pH regularly shipped as waste from a process building. Such a waste would either contain or have been mixed with items which contained classified information, making the waste stream classified.

While it cannot be stated absolutely, the hazardous chemicals from classified waste streams expected to be present in the ORNL burial grounds in any quantity have in general been previously reported. An excellent description of the chemistry associated with the formerly classified nuclear processes at ORNL in the context of the laboratory operations is found in *The ORNL Chemical Technology Division 1950-1994*, prepared by R.L. Jolley, R.K. Genung, L.E. McNeese, and J.E. Mrochek (Jolley et al. 1994). These ORNL processes would have produced the bulk of the chemically contaminated solid waste at ORNL. The second largest classified waste stream sent to the ORNL solid waste burial grounds was the Mound Site process waste stream; a detailed description of the chemistry associated with the formerly classified processes is found in the environmental restoration scoping report for the site (Mound 1992). Some of classified Y-12 Plant processes sent waste materials to the ORNL solid waste burial grounds; the best overall perspective of this waste is found in a report prepared for environmental remedial activity (Y/DS-196 1984). Lists of chemicals from these unclassified documents will not be reproduced in this report. Instead this report will summarize in an unclassified format what is known and not known about the disposal of classified solid waste materials at specific CERCLA sites at ORNL. This report will address the specific relevance of the classified information to CERCLA decision making, indicate where details of classified solid waste material disposals have been archived, and indicate where administrative requirements and restrictions to any proposed remedial activities will be necessary.

1.5 GENERAL BACKGROUND INFORMATION

Rather than repeat in this report a body of general knowledge which has been previously compiled, several of the excellent general summaries and histories which have been prepared at ORNL have been referenced. These provide good background information relative to solid waste disposals at the ORNL burial grounds. Readers are advised in particular to review Leland Johnson and Daniel Schaffer's *Oak Ridge National Laboratory: The First Fifty Years* (Johnson and Schaffer 1992). In his early history of ORNL, W.E. Thompson discusses the specific plant processes and research projects in some detail, particularly those associated with reactor development technology (Thompson 1963). D.A. Webster of the U.S. Department of the Interior Geological Survey prepared *A Review of Hydrologic and Geologic Conditions Related to the Radioactive Solid-waste Burial Grounds At Oak Ridge National Laboratory, Tennessee* (Webster 1976). This report provided an important base to several documents, including J.H. Coobs and J.R. Gissel's *History of Disposal of Radioactive Wastes into the Ground at Oak Ridge National Laboratory*, ORNL/TM-10269 (Coobs and Gissel 1986). Finally, to assist readers in understanding the locations of the specific burial grounds discussed in Sects. 2-7, Figure 1 shows the burial ground locations, as solid waste storage areas (SWSAs), in relation to the Melton Valley and Bethel Valley watersheds.

1.6 REFERENCES FOR SECTION 1 AND ADDITIONAL READING OF INTEREST

Coobs and Gissel 1986. J.H. Coobs and J.R. Gissel, *History of Disposal of Radioactive Wastes into the Ground at Oak Ridge National Laboratory*, ORNL/TM-10269, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1986.

DOE/OR/01-1326 1994. *Remedial Investigation Report on Waste Area Grouping 5 at Oak Ridge National Laboratory, Oak Ridge, Tennessee; Appendix B: Technical Findings and Conclusions*, DOE/OR/01-1326&D0/V3, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1994.

Johnson and Schaffer 1992. Leland Johnson and Daniel Schaffer, *Oak Ridge National Laboratory: The First Fifty Years*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 1992.

Mound 1992. *Environmental Restoration Program, Mound Plant, RI/FS, OU 9 Site Scoping Report: Vol. 7 - Waste Management*, Mound Site, Miamisburg, Ohio, July 1992.

Thompson 1963. W.E. Thompson, *History of the Oak Ridge National Laboratory 1943 - 1963*, CF 63-8-75, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August 23, 1963.

Webster 1976. D.A. Webster, *A Review of Hydrologic and Geologic Conditions Related to the Radioactive Solid-waste Burial Grounds At Oak Ridge National Laboratory, Tennessee*, U.S. Department of the Interior Geological Survey, 1976.

Y/DS-196 1984. *Inventory of Disposals Conducted at ORNL Burial Sites from the Y-12 Plant (U), February 1957 through August 1983*, Product Optimization Department, Y-12 Plant, Oak Ridge, Tennessee, June 29, 1984. Declassified.

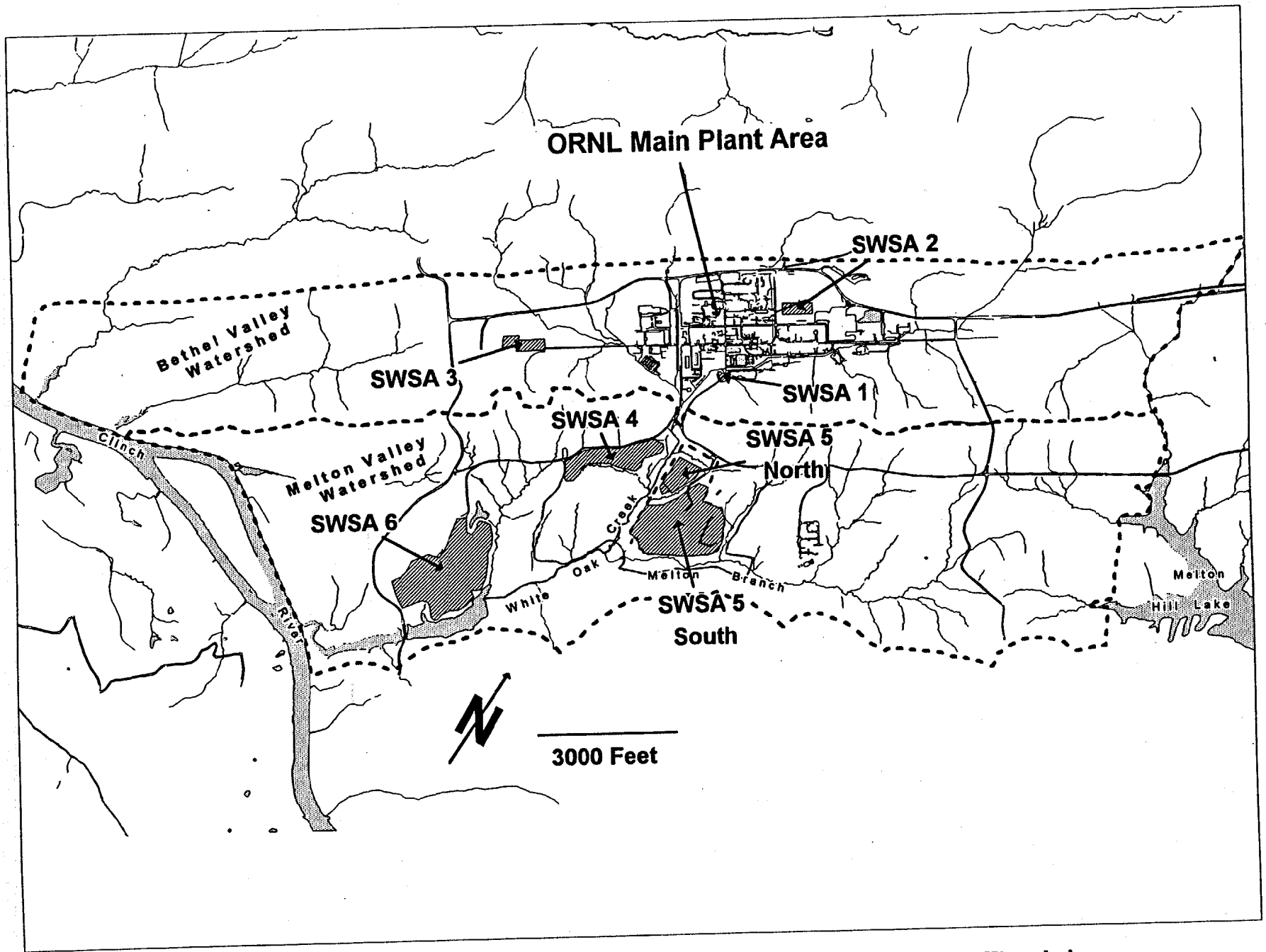

Figure 1. Locations of Solid Waste Storage Areas in relation to the Melton Valley and Bethel Valley Watershed areas.

2. BURIAL GROUND 1 (1944-5/1945)

2.1 KNOWN HISTORICAL OVERVIEW

From November, 1943 to early 1945, the X-site of the U.S. Army's Manhattan Project was a secret pilot plant for graphite reactor operation and plutonium extraction technology while Hanford Engineering Works was under construction. In addition, the site provided development research into the physical and chemical characteristics of radionuclides and materials needed for atomic weapons production. Designated as Clinton Laboratories, the X-site was constructed and operated by Du Pont under scientific and technical supervision of University of Chicago personnel.

Very little detailed information is known about the first disposal area for solid radioactively contaminated waste materials, Burial Ground 1. The location was immediately adjacent to the site incinerator which was used for burning both contaminated and uncontaminated combustible material. Non-combustible solid waste materials were stacked above ground or placed in covered trenches. The term burial ground is a misnomer, since the purpose of earth coverage seems to have been temporary shielding, rather than permanent disposal. The creek bottom location next to the incinerator was unsatisfactory for subsurface disposal, and the solid waste storage operation was soon moved to Burial Ground 2 on high sloping ground eighteen hundred feet to the northeast. The best synopsis of information about Burial Ground 1 was prepared in 1976 by the U.S. Geological Survey (Webster 1976) and is subsequently quoted nearly verbatim in later documents (ERC 1982, Coobs and Gissel 1986). From this synopsis and indirect evidence in surviving memoranda, the following facts are given:

- the burial ground was in use for about a year and a half (1944 to May 1945),
- it was not established as part of the site operations planning,
- only the general area dimensions (about 1.5 acres) are known, and
- the area is believed to have been cleared of buried solid radioactive waste packages as part of later incinerator removal and road construction.

2.2 DOCUMENTARY EVIDENCE

The documentary evidence relating to solid waste disposal operations at ORNL was examined for detailed information regarding Burial Ground 1. Little detailed documentation about the burial ground was located. It does not appear that such records once existed, and were later destroyed, since a surprisingly large and detailed record collection at ORNL Laboratory Records exists from this time, covering a variety of now mundane subjects. Instead, it appears that solid waste operations at the small U.S. Army plant in Tennessee were simply not of sufficient importance in one of the most difficult years of both World War II and the Manhattan Project to generate a need for detailed data about them. This can be contrasted with the large amount of detailed data and correspondence still in existence for the contemporary liquid waste disposal operations of the X-site, which were considered essential to the startup of Hanford.

As far as can be determined at this time (1997), no detailed information regarding permanent disposal of solid waste at Burial Ground 1 was documented in 1944 because burial of non-combustible

lab trash in a segregated area to reduce exposure was simply a routine operation. That is, it was little different from burial of uncontaminated lab trash and required no detailed documentation. As will be shown in the sections describing later burial grounds, special (non-routine) on-site disposals would not be systematically documented until the 1960s. Disposal management documents concerning solid waste such as routine disposal quantity reports, budget requests, etc. were also to come later. Health Physics documents such as surveys of disposals and procedures do not appear till the Burial Ground 2 time frame. Nuclear criticality safety memoranda exist during the 1944 period for liquid waste operations, but criticality was probably never a concern for solid waste operations since only negligible fissile material would have been in solid waste in 1944. For similar reasons, nuclear materials accountability in solid waste was probably not an issue. The burial ground was not an engineered facility and only appears on later engineering documents. Commercial sales documents, often used for solid waste transactions at a later time, were not in existence in 1944. Financial accounting documents containing information about waste disposal operations do not appear till the Burial Ground 3 time frame. Finally, there is no indication that on-site generators of lab trash bothered to document solid waste material transfers in 1944, and there is no indication of off-site waste shipments to the X-site during the operation of Burial Ground 1.

The best contemporary (late 1940s) photographic view of the location of Burial Ground 1 is ORNL 518-74 as marked in Duguid 1977, Figure 27. The best modern detailed photographic views were prepared as part of a final soil surface radiological survey (Williams et al 1988). This survey indicates that surface gamma radiation readings at the burial ground location were measured in tens of microroentgens per hour, roughly two to three times the measured background rate for the area, forty years after the burials of waste had ceased.

2.3 DISPOSAL OF CLASSIFIED MATERIAL

Given the nature of the Manhattan Project, any discussions and memoranda dealing with waste or even the X-site itself were originally classified. As an example, in 1944 the "Atomic Chart of Radioactive Nuclei" was a secret document. At the time of disposal, since there was no attempt to segregate solid waste streams, all solid waste in Burial Ground 1 would have been considered by security managers to contain classified information, in that an examination of such waste would have revealed details about classified processes and experiments. This means that the buried waste materials were classified (1) by reason of simple association with the program (Manhattan Project), (2) by reason of the chemical makeup of the waste materials, or (3) by reason of association with the process chemistry or throughput. There is no indication that the waste would have been classified by reason of shape or dimension, or by reason of SNM protection.

The pilot plant buildings in the inner fenced high security area of the site would have generated the classified radioactive solid waste items. The Department of Energy (DOE) has not attempted to make a blanket declassification of all possible waste items from Manhattan Project processes of the era; however, the processes in use at the X-site at that time (e.g., graphite reactor operations, bismuth phosphate precipitation process for plutonium recovery, analytical chemistry procedures for isotope separation) have been declassified as have the documents describing their materials and throughput values.

Less than ten buildings at the X-site would have contributed to this waste stream as equipment failed and was replaced, became too contaminated to reuse in a particular application, or was cleaned.

In general, solid waste placed in Burial Ground 1 would have been unpackaged and would have consisted of the following:

- slag residue from the burning of combustible materials in the site incinerator,
- noncombustible laboratory detritus such as glassware and small chemical apparatus,
- spent chemicals and sludges not suitable for disposal in the liquid waste system,
- noncombustible equipment components too radioactive or uneconomical to repair, and
- carcasses from small animal experiments.

The waste was collected in segregated garbage cans, which were taken to the burial ground and emptied. Larger items of equipment were moved by truck. Descriptions and the estimated amounts of these waste materials have been previously provided in unclassified environmental restoration documents.

This classified waste load would have been relatively small since (1) the burial ground was not in use for very long, and (2) Burial Ground 1 was not included in the original site process planning. That is, a solid waste landfill had been provided for the disposal of site construction materials or debris and the unclassified solid waste generated by a typical small military installation of the period (garbage, motor pool waste, coal ash, etc.). The site planning, however, had made no provision for solid radioactive waste streams; every effort was made to keep radioactive materials in solution for disposition in the liquid waste system, an important part of the pilot plant research, so none was expected.

2.4 DISPOSAL OF SPECIAL NUCLEAR MATERIAL

There is no indication that strategically accountable materials in quantities other than negligible contamination were present in the solid waste at Burial Ground 1. The general correspondence still available shows that every effort was made to maintain these materials as product or as liquid waste components. In addition, throughput at the X-site was relatively small. As an example, the total amount of plutonium separated during WWII at the site is given as less than 400 g (Johnson and Schaffer 1992).

2.5 CONCLUSIONS

Attempts to locate detailed information regarding permanent disposals of any solid waste at Burial Ground 1 have not been successful. The most important reason for this is that it is not likely that any documentation was ever prepared or maintained in the first place. In 1944 the X-site was a small operation of about 1500 people, most of whom worked in close proximity in a few buildings on several closely related projects. Radioactive solid waste management was probably handled by less than 10 personnel who handled all the other custodial solid waste management needs of the site. Communication would have been verbal unless there was an administrative need to document information. During that year, most personnel worked long shifts on campaigns to develop process data for nuclear weapons development; solid waste management documentation was an issue of only

peripheral importance. What information is available indicates that the burial ground was an unsuccessful effort to deal with an unforeseen problem.

From an environmental protection viewpoint, further investigation of the Burial Ground 1 location and the classified waste disposals associated with it are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified ORNL environmental restoration documents,
- no waste management documentation exists which could provide better information regarding the environmental hazards of waste disposal at that location, and
- since the waste was unpackaged at the time of disposal, the effects of the materials on the environment would have been manifest by this point, if they were to occur.

Logically, therefore, any waste materials placed in Burial Ground 1 which would today be regulated under RCRA have already been identified if they are going to be identified. Further, if the location ground water sample wells are not now detecting regulated materials, it is highly unlikely that the classified material disposals of 1944 will be a new source of regulated materials. Finally, given the burial ground location, limited depth of burial, time since disposals were made, and climate characteristics of the area, leach rates of detected regulated materials placed in Burial Ground 1 should have reached steady state conditions after 50 years.

From a security classification viewpoint, the following logic process concerning the classified waste disposition at Burial Ground 1 can be made:

- all the waste buried was classified at the time, but the X-site processes that would have generated the waste have since been declassified,
- in general, the X-site did not prepare or handle classified weapon components,
- no evidence exists to indicate accountable amounts of SNM were buried at the X-site,
- no evidence exists to indicate that classified off-site waste was buried at the X-site, and
- anecdotal evidence indicates that buried materials have been removed.

It can be concluded, therefore, that environmental restoration activities are not likely to present a security vulnerability, although a specific vulnerability analysis has not been performed for the Burial Ground 1 location.

2.6 REFERENCES FOR SECTION 2 AND ADDITIONAL READING OF INTEREST

2.6.1 Waste Management File References

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Duguid et al 1977. J.O. Duguid, D.E. Edgar, J.R. Gissel, R.A. Robinson, *A Study of Low-Level Radioactive Solid Waste Disposal and Storage Areas at the Oak Ridge National Laboratory*, ORNL/CF-77/376, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October, 1977, fig. 27.

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2.6.2 ORNL Laboratory Records File Documents

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CF-43-4-156. J.N. Wilson to F.B. Vaughan, intra-laboratory correspondence, subject: Waste Disposal at Site X, Clinton Laboratories, Knoxville, Tennessee, April 16, 1943.

CF 44-2-141. H.F. Stringfield to I. Perlman, correspondence, subject: Notice of Shipment to Chicago, Clinton Laboratories, Knoxville, Tennessee, February 5, 1944.

CF 44-2-303. H.F. Stringfield to L.B. Borst, intra-laboratory correspondence, subject: Notice of Shipment to Dayton, Clinton Laboratories, Knoxville, Tennessee, February 21, 1944.

CF 44-5-360. M.D. Whitaker, to J.G. Hamilton, correspondence, subject: Waste Disposal from Site X, Clinton Laboratories, Knoxville, Tennessee, May 23, 1944.

CF 44-5-402. S.T. Cantril to A.J. Schwertfeger, intra-laboratory correspondence, subject: Pickup and Storage of Actively Contaminated Materials, Clinton Laboratories, Knoxville, Tennessee, May 25, 1944.

CF 44-7-111. J.G. Stangby to H.F. Stringfield, intra-laboratory correspondence, subject: "X" Metal Transactions, Chemistry Section, Clinton Laboratories, Knoxville, Tennessee, July, 1944.

CF 44-7-175. W.H. Ray to H.M. Parker, intra-laboratory correspondence, subject: Surveys in the 200 Area, June 25 - July 1, 1944, Clinton Laboratories, Knoxville, Tennessee, July 8, 1944.

CF 44-10-57. M.D. Peterson to H.F. Stringfield, intra-laboratory correspondence, subject: X-Metal Inventory - Technical Division, Section I, Clinton Laboratories, Knoxville, Tennessee, September, 1944.

CF 46-8-78. W.H. Ray and D.M. Davis, intra-laboratory correspondence, subject: Survey of the Old Burial Ground, Clinton Laboratories, Knoxville, Tennessee, August 6, 1946.

2.6.3 ORNL Engineering Records Drawing Files

D- 535. Clinton Laboratories, X-10 Area, Clinton Engineer Works, Manhattan District, Knoxville, Tennessee, [1943].

E-529. Organization Chart, Monsanto Chemical Co., Clinton Laboratories, Knoxville, Tennessee, November 11, 1945.

E-542. Buildings and Roads, Monsanto Chemical Co., Clinton Laboratories, Knoxville, Tennessee, September 1, 1945.

3. BURIAL GROUND 2 (6/1945-5/1946)

3.1 KNOWN HISTORICAL OVERVIEW

During 1945 and 1946, the X-site of the Manhattan Project made the transition from its wartime mission to that of a classified military research station, Clinton Laboratories, organized around reactor design, fuel reprocessing research, basic radionuclide and associated materials research, and training of technical personnel. Monsanto Chemical Company replaced Du Pont as the plant operating contractor (July, 1945).

More detailed information is known about the second disposal area for solid radioactively contaminated waste materials, Burial Ground 2, than Burial Ground 1. The location of Burial Ground 2 was immediately adjacent to the collateral east security gate of the central high-security exclusion area and the built-up area of the site, on a hillside between an abandoned farm house and its spring house. An unpaved loop road for waste disposal truck traffic was placed within the fenced four-acre site. Again, solid waste materials were stacked above ground or placed in covered trenches. The materials stored above ground were usually activated or contaminated components and equipment that could possibly be recycled for other projects. As used for this purpose, the location was in essence a "hot" storage yard. The term burial ground was now appropriate, since solid and semi-liquid wastes of little value were permanently buried under earth or concrete fill. With the advent of the disposal of a significant off-site waste stream requiring a landfill surface of about 0.33 acre/yr (from the Monsanto facilities at Dayton, Ohio), the sloped location with long narrow trenches quickly became too cramped. In addition, the location was not satisfactory for scheduled vehicle unloading and decontamination in inclement weather, nor was it suitable for the contemporary powered excavation equipment because of the grade. As a result, it was in use only about one year. In October, 1945, four months after opening, Clinton Laboratories formally requested permission from the U.S. Army to close Burial Ground 2 and open Burial Ground 3. The solid waste storage operation was moved to Burial Ground 3 on relatively flat ground about 1-1/2 miles to the west by the end of May, 1946, although it is likely that some burials occurred in Burial Ground 3 in February and March, 1946. Again, the best synopsis of information about this burial ground was prepared in 1976 by the U.S. Geological Survey (Webster 1976) and is subsequently quoted nearly verbatim in later documents (ERC 1982, Coobs and Gissel 1986).

3.2 DOCUMENTARY EVIDENCE

The documentary evidence relating to solid waste disposal operations was examined for detailed information regarding Burial Ground 2. Some detailed documentation about the burial ground was located. Again, it does not appear that many records referring to the burial ground once existed. Instead, it appears that solid waste operations were becoming more formalized, but had not crystallized into operations of the size and scope requiring a need for detailed data about them.

As far as can be determined at this time (1997), little detailed information regarding permanent disposal of solid waste at Burial Ground 2 was documented in 1945/46 because burial of lab trash in a segregated area to reduce exposure was still simply a routine operation, little different from burial of uncontaminated lab trash and requiring no detailed documentation. Memoranda from 1945 and 1946 indicate that management of solid waste generated at the X-site was still only a minor problem compared to that of liquid waste management. The surviving correspondence related to waste disposal management still deals almost exclusively with liquid and gaseous waste processing development;

although the director of the health physics organization indicated to the laboratory management that the study of geologic waste disposal would be a major area of postwar research for the site (CL 45-6-105). As will be shown in the sections describing later burial grounds, special (non-routine) on-site disposals would not be systematically documented by waste disposal personnel until the 1960s. Disposal management documents concerning solid waste such as routine disposal quantity reports, budget requests, etc. were also to come later. Health Physics documents covering such items as surveys of disposals and procedures begin at this burial ground. Nuclear criticality safety was probably never a concern for solid waste operations at this time since only negligible fissile material would have been in solid waste in 1945/46. For similar reasons, nuclear materials accountability in solid waste was probably not an issue. The burial ground was not an engineered facility and only appears on later engineering documents. Commercial sales documents, often used for solid waste transactions at a later time, were not in existence in 1945/46. Financial accounting documents containing information about waste disposal operations do not appear till the Burial Ground 3 time frame. Finally, there is no indication that on-site generators of lab trash bothered to document solid waste material transfers, although documentation of off-site waste shipments to the X-site begin during this period.

The best photographic view of the location of Burial Ground 2 is an enlarged section of one of the contemporary site overview photographs. The farm house and spring house are clearly visible, as are the gates and roads. The burial ground is clearly shown in the early 1950s photograph on page 93 of Johnson and Schaffer. The soil patterns visible more than five years after the burial ground closure may have resulted from exhumation of some of the waste for subsequent transfer to Burial Ground 3 or 4; three distinct longitudinal patterns are seen. It is likely that one of the longitudinal patterns is a formerly used access lane for vehicles, since both a site drawing (E-542A) and an engineering drawing shown in a site plan for a proposed research center indicate such a lane in the center of the burial ground location (CF 47-4-461). Entries in the burial ground logbook for Burial Ground 3 as well as interviews with former site personnel quoted by the U.S. Geological Survey (Webster 1976) clearly indicate that Burial Ground 2 retains a significant fraction of the originally buried waste. In particular, the waste which was covered with concrete backfill (the waste from Dayton) was left in place.

3.3 DISPOSAL OF CLASSIFIED MATERIAL

Given the nature of the Manhattan District operations, discussions and memoranda dealing with Clinton Laboratories waste were classified. Much of the memoranda has only been declassified in 1995. At the time of disposal, since there was no attempt to segregate solid waste streams, all solid waste in Burial Ground 2 would have been considered by security managers to contain classified information, in that an examination of such waste would have revealed details about classified processes and experiments. This means that the buried waste materials generated from on-site operations were classified (1) by reason of simple association with the program (Manhattan District), (2) by reason of the chemical makeup of the waste materials, or (3) by reason of association with the process chemistry or throughput. There is no indication that the waste would have been classified by reason of shape or dimension, or by reason of SNM protection.

The pilot plant buildings in the inner fenced high security area of the site would have generated the classified radioactive solid waste items. DOE has not attempted to make a blanket declassification of all possible waste items from Manhattan District processes of the era; however, the processes in use at Clinton Laboratories at that time (e.g., graphite reactor operations, bismuth phosphate precipitation process for plutonium recovery, analytical chemistry procedures for isotope separation) have been declassified as have the documents describing their materials and throughput values.

Less than ten buildings at Clinton Laboratories would have contributed to this waste stream as equipment failed and was replaced, became too contaminated to reuse in a particular application, or was cleaned. In 1946 modifications were begun to replace the pilot plant bismuth phosphate recovery process (the principal fuel reprocessing system) with a pilot plant REDOX (solvent extraction) process. In general, solid waste from on-site operations placed in Burial Ground 2 would have been unpackaged and would have consisted of the types of materials found in Burial Ground 1 along with a few discarded items from the replacement of the fuel reprocessing system. The waste was still collected in segregated garbage cans, which were taken to the burial ground and emptied. Larger items of equipment were moved by truck. Descriptions and the estimated amounts of these waste materials have been previously provided in unclassified environmental restoration documents.

This classified waste load from on-site operations would have been relatively small since (1) the burial ground was not in use for very long, and (2) Clinton Laboratories was a reduced version of the previous X-site operations during the period of Burial Ground 2 operations. Again, a solid waste landfill provided for the disposal of site construction materials or debris and the unclassified solid waste generated by the site. As before, every effort was made to keep radioactive materials in solution for disposition in the liquid waste system, an important part of the pilot plant research.

The U.S. Army directed Clinton Laboratories to begin acceptance of classified radioactive waste shipments from Monsanto research facilities in Dayton (Site M) in August 1945 (CF 45-8-34). Dayton originated weekly waste material shipments from Units III and IV to the X-site for land disposal that same month. This liquid waste was bismuth oxychloride solution and sludge contaminated with naturally occurring polonium-210 (Mound 1992, pp. 1 - 4, 2 - 3). This Mound reference describes the waste containers as "strong, leakproof containers;" in fact, the containers were apparently wooden barrels initially and were severely contaminated on their exterior. A detailed description of the first two Burial Ground 2 disposal operations involving off-site waste is found in surviving health physics reports (CF 45-8-271, CF 45-9-107). In addition, Dayton shipped contaminated solid classified scrap materials from their facilities along with the barrels. Dayton planned to ship about 10 barrels of waste per week, a significant work requirement increment for what had been previously a low level of effort at the Clinton Laboratories Burial Ground 2. Monthly health physics operations summaries indicate at least 10 more truckloads of Dayton waste went to this burial ground (CF 46-3-2). The short half-life alpha-emitting polonium in the Dayton waste led the Clinton Laboratories health physics organization to require segregation of this material from the other open trench disposal operations at Burial Ground 2 and placement of a layer of concrete over the "alpha waste" disposal. This resulted in the practice of using different disposal procedures for "alpha" and "beta-gamma" contaminated waste materials.

No Dayton waste disposal documents of this time are known to exist. It appears that for security reasons, no description of the waste contents was provided to the Burial Ground 2 personnel at the time of disposal, and that only two or three persons in the Clinton Laboratories health physics organization knew the radioactive and hazardous characteristics of the materials. Attempts to locate waste disposal documents at Mound and ORNL have not been successful. An attempt to declassify the Dayton waste has been unsuccessful. While the polonium recovery process is no longer classified, the solid scrap waste materials would have come from Dayton facilities which fabricated nuclear weapon components. This means that the buried waste materials generated from the Dayton operations were originally classified (1) by reason of shape or dimension, (2) by reason of simple association with the program (Manhattan District), (3) by reason of the chemical makeup of the waste materials, or (4) by reason of association with the process chemistry or throughput. There is no indication that the waste would have been classified by reason of SNM protection. Since there is no longer any means to determine whether or not classified weapon components are still present in the burial ground, nor

can it be determined exactly where such disposals were located, it is not likely that security managers will remove the classification of the waste.

Clinton Laboratories was also directed to receive occasional small classified shipments of liquid waste from the University of Chicago Metallurgical Laboratory facilities (Site C) during the time of Burial Ground 2 operations (CF 45-10-213). This waste was fuel reprocessing liquid containing recoverable uranium and milligram quantities of plutonium. These shipments required the use of a lead shielded container carrier. The shipments were much less frequent than those from Dayton and, unlike the Dayton shipments, were intended to be added to the Clinton Laboratories liquid waste processing operations at the tank farm rather than buried. Health physics documentation indicates that these liquid waste shipments from Chicago were emptied at the liquid waste tank farm, not at Burial Ground 2.

3.4 DISPOSAL OF SPECIAL NUCLEAR MATERIAL

There is no indication that strategic materials in quantities other than negligible contamination were present in the solid waste at Burial Ground 2. The general correspondence still available shows that every effort was made to maintain these materials as product or as liquid waste components. As noted previously, plutonium throughput at the X-site during the year previous to the operation of this burial ground was relatively small, less than 400 g.

The U.S. Geological Survey (Webster 1976) reports (and is subsequently repeated by other authors) that plutonium-contaminated liquid was buried in Burial Ground 2. Some clarification is required for this statement. Routine burial ground disposal of any quantity of plutonium requiring accountability at that time is highly improbable, given the value placed on that material and the type of liquid waste operations in place at Clinton Laboratories. It is much more likely that this assertion is a mis-description of the off-site waste shipments from Chicago described above, or a description of small quantities of residual sludge left in the fuel reprocessing development equipment at the site being converted from the bismuth phosphate recovery process to the REDOX recovery process. There is no indication that any significant quantities (greater than 1 g) of special nuclear material was part of a solid waste disposal operation at this time.

3.5 CONCLUSIONS

Attempts to locate detailed information regarding permanent disposals of solid waste at Burial Ground 2 have only been partially successful. The most important reason for this is that it is not likely that much documentation was ever prepared or maintained in the first place. During 1945 - 1946, Clinton Laboratories was still a small operation of about 1500 people, most of whom worked in close proximity in a few buildings on several closely related projects. Radioactive solid waste management was still probably handled by less than 10 personnel who handled all the other custodial waste management needs of the site. Communication would have been verbal unless there was an administrative need to document information. In the year immediately after WWII, it was clearly the U.S. Army's intent to terminate research operations at Clinton Laboratories and consolidate its nuclear ammunition development elsewhere. Contemporary memoranda show that turnover of critical personnel was high during this period, and modern accounts indicate that all levels of management were focused on organizational change issues. Solid waste management documentation was an issue of only peripheral importance. What information is available indicates that the burial ground operations were expanding in scope because of off-site waste stream shipments. As early as late 1945,

it was recognized that the need for rapid contamination control of off-site waste required a location more suitable for earthmoving and truck traffic.

From an environmental protection viewpoint, further investigation of the Burial Ground 2 location and the classified waste disposals associated with on-site (Clinton Laboratories) processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified ORNL environmental restoration documents,
- no waste management documentation exists which could provide better information regarding the environmental hazards of waste disposal at that location, and
- since the waste was unpackaged at the time of disposal, the effects of the materials on the environment would have been manifest by this point, if they were to occur.

Further investigation of the classified waste disposals associated with Dayton processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified Mound environmental restoration documents, and
- no waste management documentation exists which could provide better information regarding the environmental hazards of this waste disposal (bismuth oxychloride liquid and sludge with a high basic pH).

While the Dayton waste was packaged at the time of disposal, it is inconceivable that packages did not deteriorate to failure very shortly after burial. The effects of the materials on the environment would have been manifest by this point, if they were to occur. Logically, therefore, any waste materials placed in Burial Ground 2 which would today be regulated under RCRA have already been identified if they are going to be identified. Further, if the location ground water sample wells are not now detecting regulated materials, it is highly unlikely that the classified material disposals of 1945 will be a new source of regulated materials. Finally, given the burial ground location, limited depth of burial, time since disposals were made, and climate characteristics of the area, leach rates of detected regulated materials placed in Burial Ground 2 should have reached steady state conditions after 50 years.

From a security classification viewpoint, the following logic process concerning the classified waste disposition at Burial Ground 2 can be made for waste from on-site (Clinton Laboratories) operations:

- all the waste buried was classified at the time, but the on-site processes that would have generated the waste have since been declassified,
- in general, on-site operations did not prepare or handle classified weapon components, and
- no evidence exists to indicate that accountable amounts of SNM were buried at Clinton Laboratories.

The following logic process concerning the classified waste disposition at Burial Ground 2 can be made for waste from Dayton operations:

- all the waste buried was classified at the time, but the Dayton processes that would have generated the liquid and sludge waste have since been declassified,
- no evidence exists to indicate that accountable amounts of SNM were present as waste at Dayton operations,
- some Dayton operations prepared or handled classified weapon components,
- waste from these Dayton operations is likely to have been sent to Burial Ground 2, and
- these weapon component designs have not been declassified.

It can be concluded, therefore, that environmental restoration activities may present a security vulnerability, although a specific vulnerability analysis has not been performed for the Burial Ground 2 location.

3.6 REFERENCES FOR SECTION 3 AND ADDITIONAL READING OF INTEREST

3.6.1 Waste Management File References

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3.6.2 ORNL Laboratory Records File Documents

CF 45-6-2. K.Z. Morgan to distribution, intra-laboratory correspondence, subject: Health Physics Section of Health Division, Clinton Laboratories, Knoxville, Tennessee, June 18, 1945.

CF 45-6-105. K.Z. Morgan to R.S. Stone, intra-laboratory correspondence, subject: Some of the Problems Confronting Health Physics if Fission Research and Development Continues, Clinton Laboratories, Knoxville, Tennessee, June, 1945.

CF 45-6-563. H.F. Stringfield to CPT J.A. Hay, shipping manifest, subject: Transfer of X-metal and Compounds, Clinton Laboratories, Knoxville, Tennessee, June 30, 1945.

CF 45-7-73. J.R. Whitlock to H.F. Stringfield, intra-laboratory correspondence, subject: X-Metal Inventory - Technical Division, Section I, Clinton Laboratories, Knoxville, Tennessee, July, 1945.

CF 45-7-115. H.F. Stringfield to C.J. Koenig, intra-laboratory correspondence, subject: Test Check of Shipping Memorandum Covering the Transfer of X-metal, Used X-metal, and Metal Compounds, Clinton Laboratories, Knoxville, Tennessee, July, 1945.

CF 45-7-518. J.G. Stangby to H.F. Stringfield, intra-laboratory correspondence, subject: Monthly Inventory of Compounds, Chemistry Division, Clinton Laboratories, Knoxville, Tennessee, July, 1945.

CF 45- 8-34. CPT J.A. Hay to M.D. Whitaker, correspondence, subject: Disposal of Soda Pulp Oxychloride, U.S. Army Manhattan Engineering District, Oak Ridge, Tennessee, August 2, 1945.

CF 45- 8-227. G.F. Putnam to K.Z. Morgan, intra-laboratory correspondence, subject: Survey of No.2 Guard Tower and Surrounding Area, Clinton Laboratories, Knoxville, Tennessee, August 24, 1945.

CF 45-8-271. R.R. Coveyou to K.Z. Morgan, intra-laboratory correspondence, subject: Transfer and Disposal of Wastes from Site M, Clinton Laboratories, Knoxville, Tennessee, August 31, 1945.

CF 45-8-308. R.L. Doan to A.H. Snell, intra-laboratory correspondence, subject: Intra-plant Transfer of K-25 Waste, Clinton Laboratories, Knoxville, Tennessee, August 16, 1945.

CF 45-9-107. R.A. Simons to K.Z. Morgan, intra-laboratory correspondence, subject: Second Transfer of Wastes from Site M, Clinton Laboratories, Knoxville, Tennessee, September 10, 1945.

CF 45-10-213. CPT J.A. Bergantz to M.D. Whitaker, correspondence, subject: Waste Tuballoy, U.S. Army Manhattan Engineering District, Oak Ridge, Tennessee, October 26, 1945.

CF 46-3-2. R.E. Hayden and W.H. Ray to K.Z. Morgan, intra-laboratory correspondence, subject: Radiation Surveys - February 1946, Clinton Laboratories, Knoxville, Tennessee, March 6, 1946.

CF 47-4-461. W.E. Cleneay et al, *Report on the Site Plan and Preliminary Layout of the Proposed Research Center*, Monsanto Chemical Co., St. Louis, Missouri, April 15, 1947, p. 37.

3.6.3 ORNL Engineering Records Drawing Files

C-3405. Topography - East Burial Ground, Monsanto Chemical Co., Clinton Laboratories, Knoxville, Tennessee, November 8, 1947.

CL-603. New Burial Grounds, Clinton Laboratories, February 27, 1945.

E-529. Organization Chart, Monsanto Chemical Co., Clinton Laboratories, Knoxville, Tennessee, November 11, 1945.

E-542. Buildings and Roads, Monsanto Chemical Co., Clinton Laboratories, Knoxville, Tennessee, September 1, 1945.

3.6.4 ORNL Waste Management Files

Un-numbered engineering sketch. East Burial Ground, October 30, 1947.

Un-numbered engineering sketch. East Burial Ground, November 21, 1947.

4. BURIAL GROUND 3 (6/1946-2/1951)

4.1 KNOWN HISTORICAL OVERVIEW

From 1946 to 1951, Clinton Laboratories expanded its classified military mission to that of an applied nuclear research laboratory, again organized around reactor design, fuel reprocessing research, and training of technical personnel. Much of the work remained classified and was funded by Department of Defense programs. The U.S. Atomic Energy Commission (AEC) replaced the U.S. Army as the government organization responsible for the laboratory in January of 1947. At the end of 1947, Carbide and Carbon Chemicals Division of Union Carbide and Carbon Corporation was named to replace Monsanto as the contractor for site operations (effective March 1948) and the site was renamed Oak Ridge National Laboratory (Johnson and Schaffer 1992).

More detailed information is known about this third disposal area for solid radioactively contaminated waste. Burial Ground 3 was located 1800 ft to the west of the then-existing Clinton Laboratories administration building flagpole (CF 45-10-448). A gravel road for waste disposal truck traffic was placed within the fenced location. Again, solid waste materials were stacked above ground in two "hot" storage yards, or placed in excavated holes and trenches and permanently buried under earth or concrete fill. Records describing Burial Ground 3 operations indicate that the practice of separating the waste containers into "alpha" and "beta-gamma" lots was in use at this location. By mid-1949 the expanding waste disposal operations at ORNL filled the available disposal area, and after the burial ground was expanded, the solid waste storage operation was moved to Burial Ground 4 in late February, 1951. After termination of disposal operations, the location was used as an above-ground contaminated scrap yard. Again, the best synopsis of information about this burial ground was prepared in 1976 by the U.S. Geological Survey (Webster 1976) and is subsequently quoted nearly verbatim in later documents (ERC 1982, Coobs and Gissel 1986).

4.2 DOCUMENTARY EVIDENCE

As far as can be determined at this time (1997), little detailed information regarding permanent disposal of solid waste at Burial Ground 3 was documented in 1946/51 because burial of lab trash in a segregated area to reduce exposure was still simply a routine operation, little different from burial of uncontaminated lab trash. There is no indication that ORNL laboratory activities generated or used any special forms or records to indicate characteristics of solid radioactive waste materials. The reason for this is that there was simply no demand for this type of record keeping at that time. In the original direction to construct Burial Ground 3, the U.S. Army only required that a log be maintained of the disposal locations (CF 45-10-448). At that time, the reason for knowing a disposal location was that Clinton Laboratories frequently recovered contaminated equipment from trenches as well as above-ground storage points for reuse. There was, therefore, no external U.S. government requirement for detailed information from waste generators. Further, the solid waste management organization was uninterested in detailed waste characterization, since the burial ground log indicates that immediate radiation safety and other transportation information were the primary items of interest to the burial ground supervisor. In perspective, the compactness of ORNL operations and the secret nature of detailed solid waste information was such that only a few personnel had a complete knowledge of the ORNL solid waste streams. Since these personnel knew the information already (they were the generators), they had no need to record it, nor was it disseminated.

As the solid waste disposal operations at the laboratory expanded to include extensive contaminated equipment storage and disposal of solid waste from other sites, however, burial ground logs were initiated at Burial Ground 3 as a means of recording work control, property management, radiation safety checks, and billing information. Two burial ground logs for Burial Ground 3 are known to exist. The first covers the period from January 1947 to July 1950 and was a work log used by transportation supervisors who provided the solid radioactive waste pickup and disposal service (A-2388). In general, for each major operation during a work shift, a generic description of the material being buried is given, together with its generation source, approximate total weight, radiation measurement, disposal location, and any special remarks. The second (A-2389) covers the period July 1950 to the end of 1952 and was a streamlined version of the first log type, showing primarily only disposals made at Burial Grounds 3 and 4 for organizations located external to the main ORNL area (Bethel Valley) during this period. These logs provide a good perspective on the types of solid waste materials and can often be correlated to generators and waste streams known to exist at that time.

As will be shown in the sections describing later burial grounds, special (non-routine) disposals would not be systematically documented until the 1960s. Disposal management documents concerning solid waste such as routine disposal quantity reports, budget requests, etc. also begin to appear at this time, but the bulk of waste management documentation during this period concerns liquid and gaseous waste disposals which were severe problem areas for the laboratory. Health Physics documents such as surveys of disposals and procedures appear first in the Burial Ground 3 time frame, but later these activities became so routine that descriptions of them were rarely made. Nuclear criticality safety was probably never a concern for solid waste operations since only negligible fissile material would have been in solid waste in 1946/51. For similar reasons, nuclear materials accountability in solid waste was probably not an issue. Again, the burial ground was not an engineered facility and only appears on later engineering documents. A program for commercial sales of disposal work, often used for solid waste transactions at a later time, was initiated on a limited scale in the last months of Burial Ground 3 operations. Financial accounting documents containing information about waste disposal operations appear first in the Burial Ground 3 time frame as does the disposal charge-back system developed to recover costs of the disposal of solid waste materials from off-site generators. Finally, there is no indication that on-site generators of lab trash bothered to document solid waste material transfers during Burial Ground 3 operations, unless the material was to be held for future use. Off-site solid waste shipments provided about half of the waste disposal activity at Burial Ground 3, although description of this waste is limited.

The best photographic views of the location of Burial Ground 3 are shown in ERC 1982; these are environmental restoration "before and after" photographs taken in the 1970s. A sketch of the burial ground is given on page 32 of Webster 1976. The trench patterns seen in the sketch are based on an interview. Matching the coordinates given in the first burial ground log (A-2388) with the civil engineering surveying sketch, it is clear that the disposal coordinates given in the burial ground log originate from the northeast corner of the burial ground fence. Using this coordinate system, the trench boundaries can be identified to within about 10 ft, and the specific locations of waste can be identified to within about 50 ft, until July 1950 when a different disposal location methodology was initiated. Finally, it can be discerned from a comparison of the burial ground logbook information with the health physics surveys that large contaminated equipment was once stored just outside the burial ground in a fenced area to the northeast of the burial ground gate.

4.3 DISPOSAL OF CLASSIFIED MATERIAL

Given the nature of the U.S. AEC operations conducted at ORNL, most discussions and memoranda dealing with radioactive solid waste in the 1946-51 time frame were classified. Much of the memoranda has only been declassified in 1995. At the time of disposal, since there was no attempt to segregate solid waste streams, all solid waste in Burial Ground 3 would have been considered by security managers to contain classified information, in that an examination of such waste would have revealed details about classified ORNL processes and experiments. This means that the buried waste materials generated from ORNL operations were classified (1) by reason of simple association with the AEC program, (2) by reason of the chemical makeup of the waste materials, or (3) by reason of association with the process chemistry or throughput. There is no indication that the waste from ORNL would have been classified by reason of shape or dimension, or by reason of SNM protection.

The classified radioactive solid waste items from ORNL would still have been generated in the original pilot plant buildings in the inner fenced high security area of the site; although by 1951, additional facilities were being built and former wartime facilities were being converted to other uses. Some of the Y-12 Plant facilities were being decommissioned and reassigned to ORNL, generating classified process scrap as the original processes were demolished. A classified Y-12 Plant isotope separation process line was reassigned to ORNL. DOE has not attempted to make a blanket declassification of all possible waste items from AEC processes of the era; however, the processes in use for ORNL operations at that time (e.g., reactor operations, the bismuth phosphate, REDOX, and Purex processes for plutonium recovery, the RaLa process, analytical chemistry procedures for isotope separation, uranium feed materials processing, and the electromagnetic separation process) have been declassified as have the documents describing their materials and throughput values.

Contamination control became a major factor as the radioactivity in solid waste materials became more and more concentrated. In general, solid waste from ORNL operations placed in Burial Ground 3 would have been packaged in drums, boxes, cans, and bottles for contamination control (since disposal trenches were often left open and uncovered). The waste was still collected in segregated garbage cans, which were taken to the burial ground and emptied. Larger items of equipment were moved by truck. Descriptions and the estimated amounts of these waste materials have been previously provided in unclassified environmental restoration documents.

This classified waste load from ORNL operations would have been about twice that sent to Burial Ground 2. The increase came from the additional operations in the Bethel Valley facilities and the added waste from the ORNL divisions at Y-12. Again, a solid waste landfill was provided for the disposal of site construction materials or debris and the unclassified solid waste generated by the site. As before, every effort was made to keep radioactive materials in solution for disposition in the liquid waste system, an important part of the pilot plant research for Hanford and the new Idaho facilities. The majority (a little more than half) of the waste sent to Burial Ground 3, however, was generated from non-ORNL operations, particularly classified operations.

The history of Mound waste disposal operations (Mound 1992) indicates that the solid waste materials from Dayton facilities (Units III and IV) continued to be shipped to ORNL for disposal from 1946 to 1948. No date is given for the beginning of production scale operations at Dayton, but indirect evidence in ORNL health physics documentation indicates that by 1946 artificially induced polonium-210 was an ORNL graphite reactor product. Bismuth bricks were irradiated at ORNL, shipped to Dayton and processed there to recover the polonium (CF 46-7-240). The Dayton process generated the polonium-contaminated bismuth oxychloride sludges and trash, first shipped as a waste stream to Burial Ground 2. In addition to this process waste, a significant amount of building

structural component material was shipped to ORNL for disposal in 1948 as both Units III and IV at Dayton were demolished and the Dayton site decontaminated. At some point before 1950, according to the Mound history, the bismuth brick feed from the ORNL graphite reactor was terminated in favor of aluminum-clad irradiated bismuth slugs from Hanford. The bismuth oxychloride waste sludge from the new process feed was held at Mound for potential recovery and reuse of the bismuth, until the 1953 time frame. The dissolved aluminum cladding waste stream, however, was shipped to ORNL. The log for Burial Ground 3 (A-2388) shows that surveys of the Dayton waste shipments for alpha-emitting contamination stopped in April, 1948. The log shows an average of two, increasing to an average of three, semi-trailer shipments (30-40 drums) of waste per month were shipped to ORNL from Mound for disposal during the 1949-1950 period. (In February of 1949, polonium processing operations were begun at the new Mound site, south of Dayton.) In addition to the polonium processing, Monsanto also conducted experiments in the recovery of radium from uranium ores and the separation of actinium from radium during the operating period of Burial Ground 3. Although this was done with relatively small quantities of material, it is possible that solid waste contaminated with these isotopes was shipped to ORNL for disposal in this burial ground. No Monsanto disposal operations documents of this time are known to exist. Attempts to locate such documents at Mound and ORNL have not been successful.

The logs show that truckloads of waste were routinely accepted for disposal at the burial ground from the Dayton (and later Mound) operations during this 1947-1951 period, usually on a weekly basis. Initially a convoy of three to four small trucks was used; eventually a single semi-trailer was used for the shipment. As a general rule, a Dayton waste shipment was initially packed in a few large boxes and 10 to 30 35-gal drums, although other contaminated scrap and small packages were sometimes received. If the estimated weights given in the first log are reasonable, the Dayton shipments constituted more than half the burial ground disposals by weight. No description of the waste container contents was made initially, nor were the contents characterized in a manner similar to that of modern radioactive waste practices. The external contamination levels of the waste containers are initially recorded in the log as often being greater than 60,000 dpm. The waste containers were simply placed without being opened in a previously excavated "alpha" trench and covered with concrete as soon as it was practical to do so. For its eventual closure, an "alpha" trench would be backfilled with earth over the concrete. Initially an occasional waste item contaminated with an alpha-emitting nuclide from an Oak Ridge facility would also be placed in the "alpha" trench with the Dayton waste containers before they were covered with concrete, as were the occasional solid waste shipments from Argonne National Laboratory. In a year's time, an area about 150 ft square would be filled with alpha-emitting contaminated waste materials from Dayton. In July of 1950, the disposal of these wastes changed slightly; an excavation described as a "hole" was used for "alpha" waste, rather than a trench. It is not clear if this is a powered auger hole or a larger excavation. As before, concrete was used to fix the waste in place prior to backfill with earth. Also at this time, the disposal log indicated a distinction in the waste drums between drums of solid waste and drums of sludge.

Waste from the Y-12 area was generally characterized in the log as "concrete chips" or "scrap." Such waste arrived by the truckload on a campaign basis without an ORNL radiation survey reading at the burial ground. For example, four truckloads arrived in July of 1947, nine truckloads in December of 1948, and five truckloads in mid-1949. About 1100 drums of waste uranium solution from Y-12 averaging 0.005 % uranium were buried in a trench and covered with earth during a month-long campaign in February, 1949. In September of that year, another 850 drums of undescribed Y-12 material with "alpha contamination" were buried and covered with concrete. It is likely that these shipments were part of the dismantling of the Y-12 electromagnetic isotope separation process and represent decontamination solutions as well as building and process scrap. A few other drum-size

shipments of waste chemicals from Y-12 are recorded during this time. The "red can" pickup service was extended for the ORNL Biology Division after it was relocated to the Y-12 site in 1948. In mid-1950, three research divisions of the Y-12 Plant were organizationally transferred to ORNL and the "red can" pickup service was extended to them. After this date in the second log, a weekly solid radioactive waste truck run from the ORNL divisions located at the Y-12 site is shown, hauling five to eight cans and other trash. Other Y-12 site waste shipments in 1950 and early 1951 include monthly shipments of both solid and liquid beryllium shop waste and occasional waste from a health physics section.

Waste from the K-25 site was generally uncharacterized but handled as "alpha" waste. One box was shipped in 1947 and about 30 cans were shipped in 1948. Throughout most of 1949, about three shipments of 5-10 fiberboard drums per month of dry material was sent to Burial Ground 3 and usually deposited with the Dayton waste. Nine shipments were made in 1950; most of these went to "beta-gamma" trenches. It is not clear from the logs exactly what might have been the source at the K-25 site for this material, but evidence in health physics memoranda indicates that the waste probably came from the laboratory area at the K-25 site.

Waste from the Chicago Metallurgical Laboratory (becoming Argonne National Laboratory in 1947) was slightly better defined and also generally handled as "alpha" waste. Seven shipments arrived in 1947, five in 1948, and one in 1950. The waste materials are described as rags, pipe, lumber, a drum of radium-contaminated waste, clothing, drums of hexone, and drums of oil, and usually had radiation measurements recorded. They were usually deposited with the Dayton waste. It should be noted that liquid wastes containing any recoverable quantity of special nuclear material were emptied at the tank farm rather than buried. The burial ground log (A-2388) records that a Chicago shipment of solution containing 85.8 mg of plutonium was transported from the burial ground and poured into tank W-3 at the liquid waste tank farm on March 15, 1949.

The Knolls Atomic Power Laboratory (KAPL) site sent two small undefined shipments to Burial Ground 3 in 1948.

The burial ground logs recorded a shipment of waste material from "Fairchild" in April, 1949 and four shipments from either Fairchild or the U.S. Air Force Nuclear Energy Propulsion for Aircraft (NEPA) program in 1950. Fairchild Engine and Aircraft Corporation was the subcontractor to ORNL for development of a nuclear powered bomber power plant, operating a small facility in the abandoned S-50 plant near K-25 before the program was moved to General Electric at Evandale, OH.

4.4 DISPOSAL OF SPECIAL NUCLEAR MATERIAL

There is no indication that strategic materials in quantities other than negligible contamination were present in the solid waste at Burial Ground 3. The general correspondence still available shows that every effort was made to maintain these materials as product or as liquid waste components. Shortly after Burial Ground 3 was opened, the general correspondence between Clinton Laboratories and the U.S. Army regarding the accountability of strategic materials indicated that a much more formal structure was needed to account for these materials. By late 1946, the program that later developed into the present-day material control and accountability system was initiated. The first of several acronyms denoting strategic materials, SF (source and fissile) materials, was utilized in December of 1946. In that month, a rollup of SF inventories was prepared for the transition of the laboratory from military administration (CF 46-12-412, no longer existing). All through 1947, the routine SF inventory and reporting system was developed, using ledgers and spreadsheets to prepare

monthly summaries for the AEC. Inventories were made of heavy water, thorium, depleted uranium, normal uranium, enriched uranium, uranium-233, and plutonium. Enriched uranium inventories were further subcategorized by enrichment level. The inventory of December, 1947 is interesting in that it shows that (1) there were only 146 g of plutonium on the ORNL site in 1947, and (2) there was no specific provision on the report format for disposals of SF material to a solid waste disposal operation (CF 48-1-273).

General correspondence of the time shows that every effort was made to return scrap enriched uranium to Y-12 Plant for recycle. In the 1947-1949 period, the AEC was starting to produce the first production model nuclear weapons (Hansen 1988), as well as develop more efficient designs; this required all available enriched uranium. The Y-12 Plant, no longer used for uranium enrichment, was established as the center for uranium recycling and production technology. As a consequence, there is no evidence that scrap enriched uranium of any quantity was sent to Burial Ground 3.

The burial ground log records a 250-drum shipment of waste material from Iowa State University in Ames, Iowa in September, 1949. The Ames site was used during the Manhattan Project for production of high purity uranium feed stocks and later for production of thorium (Rhodes 1986). It is doubtful that the waste contained any fissile material.

4.5 CONCLUSIONS

Attempts to locate detailed information regarding permanent disposals of solid waste at Burial Ground 3 have been moderately successful. The most important reason for this is that burial ground operations became complex enough to require documentation. During 1946-1951, the laboratory expanded as it was assigned its classified cold-war missions. Radioactive solid waste management was handled by a small organization with less than 10 personnel. This group handled both the solid waste management needs of the site and a growing number of off-site organizations. By 1951, a regular collection service hauled waste from the main laboratory (Bethel Valley) area, the ORNL organizations at Y-12 and K-25 sites, and other sites in Oak Ridge to the burial ground. Communication would still have been verbal, but there was an increasing administrative need to document information, particularly that associated with off-site shipments.

By the time Burial Ground 3 closed, waste disposal management at ORNL had evolved into an important element of the AEC federal defense programs. From just occasional correspondence between Clinton Laboratories and the U.S. Army in 1946, memoranda and reports related to solid waste disposal management increased to a steady communication between site AEC representatives and ORNL management, particularly involving acceptance of off-site shipments at ORNL. By 1951 the AEC looked upon ORNL as the site of choice east of the Mississippi for disposal of radioactive waste materials from its widely scattered research and development operations, particularly those without disposal capability.

From an environmental protection viewpoint, further investigation of the Burial Ground 3 location and the classified waste disposals associated with ORNL processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified ORNL environmental restoration documents,

- no waste management documentation exists which could provide better information regarding the environmental hazards of waste disposal at that location, and

- even though the waste was packaged at the time of disposal, the effects of the materials on the environment would have been manifest by this point, if they were to occur.

Further investigation of the classified waste disposals associated with Dayton (and later Mound) processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified Mound environmental restoration documents, and

- no waste management documentation exists which could provide better information regarding the environmental hazards of this waste disposal (bismuth oxychloride liquid and sludge with a high basic pH).

While the Dayton waste was packaged at the time of disposal, it is inconceivable that packages did not deteriorate to failure very shortly after burial. The effects of the materials on the environment would have been manifest by this point, if they were to occur.

These conclusions are also valid for the waste accepted from other non-ORNL operations. Logically, therefore, any waste materials placed in Burial Ground 3 which would today be regulated under RCRA have already been identified if they are going to be identified. Further, if the location ground water sample wells are not now detecting regulated materials, it is highly unlikely that the classified material disposals of 1946-51 will be a new source of regulated materials. Finally, given the burial ground location, limited depth of burial, time since disposals were made, and climate characteristics of the area, leach rates of detected regulated materials placed in Burial Ground 3 should have reached steady state conditions after 50 years.

From a security classification viewpoint, the following logic process concerning the classified waste disposition at Burial Ground 3 can be made for waste from ORNL operations:

- most of the waste buried was classified at the time, but the ORNL processes that would have generated the waste have since been declassified,

- in general, ORNL operations did not prepare or handle classified weapon components, and

- no evidence exists to indicate that accountable amounts of SNM were buried at ORNL.

The following logic process concerning the classified waste disposition at Burial Ground 3 can be made for waste from Dayton (and later Mound) operations:

- all the waste buried was classified at the time, but the Dayton processes that would have generated the liquid and sludge waste have since been declassified,

- no evidence exists to indicate that accountable amounts of SNM were present as waste at Dayton operations,

- some Dayton operations prepared or handled classified weapon components,

- waste from these Dayton operations is likely to have been sent to Burial Ground 3, and
- these weapon component designs have not been declassified.

It can be concluded, therefore, that environmental restoration activities may present a security vulnerability, although a specific vulnerability analysis has not been performed for the Burial Ground 3 location.

It is difficult to discuss substantively the possibility of waste from the other non-ORNL sites still containing classified information. It appears logical that Y-12 Plant may have sent scrap process equipment used in early weapons component manufacture for disposal to Burial Ground 3; the plant did not have its own classified waste disposal area at that time. It also appears logical that the K-25 site sent scrap from its barrier production facilities, although this cannot be verified. The weapon component designs have not been declassified, nor has the barrier technology. It can be concluded, therefore, that the potential for the presence of these wastes may require that a specific security vulnerability analysis be performed for the Burial Ground 3 location prior to any environmental restoration activities. From the description given in the waste disposal docmentation, the Fairchild waste, Argonne waste, and KAPL waste probably no longer contain classified information.

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5. BURIAL GROUND 4 (3/1951- 7/1959)

5.1 KNOWN HISTORICAL OVERVIEW

From 1951 to 1959, Oak Ridge National Laboratory was in a period of expansion that transformed the site from its WWII configuration to a site with an organization and physical appearance close to its present day status. Initially the laboratory retained and expanded its classified military mission. It remained an applied nuclear research laboratory, organized around reactor design, fuel reprocessing research, and training of technical personnel, adding studies of the effects of nuclear weapons. Much of the work remained classified and was funded by Department of Defense Korean Conflict and Cold War era programs, including most of the work with reactors built in this period. In addition to this defense program work, however, the AEC began research programs aimed at developing a nuclear energy economy as well as compiling basic atomic and nuclear research. Chapters 3 and 4 of Johnson and Schaffer provide an excellent description of ongoing laboratory programs in this era. During the period in which waste management operations were conducted routinely at Burial Ground 4, the percentage of laboratory programs which were classified decreased from nearly 100 % to about 38 % (CF 57-7-97). The organizational element of Carbide and Carbon Chemicals Division (of Union Carbide and Carbon Corporation) which operated the three major AEC sites on the Oak Ridge Reservation was renamed the Union Carbide Nuclear Company of Union Carbide and Carbon Corporation in 1955.

Little detailed information is known about waste management operations in this fourth disposal area for solid radioactively contaminated waste. Originally, this burial ground was supposed to be located roughly where SWSA-6 is now located, with access from White Wing Ferry Road, now State Highway 95 (Larson 1950). Instead, Burial Ground 4 was located on the south side of Haw Ridge, just west of the gap through which White Oak Creek drains the main laboratory area. It has been speculated that the only reason for locating a burial ground once again in the drainage basin of the creek was the operational cost savings associated with its immediate proximity to the main laboratory area (Webster 1976). Correspondence concerning the burial ground, however, indicates that the AEC was both adamantly suggesting an optimum geological disposal location, and amenable to the costs of the SWSA-6 location (Holland 1949, Roberson 1950). A more likely explanation is that the changing security boundaries of the Oak Ridge Reservation (allowing more public access), the changing international situation (advent of the Korean Conflict), and the high concern regarding Soviet espionage in that era made the SWSA-6 location problematic from a physical security viewpoint when nearly all the materials entering the burial ground came from classified process work. The finally chosen 23-acre location was essentially inaccessible to the public and easily secured without elaborate fencing or additional guard force personnel and equipment. An existing dirt road was improved for waste disposal truck traffic. Solid waste materials were either burned in a ravine ("burning pit"), or placed in excavated holes and trenches and permanently buried under earth or concrete fill. Records describing Burial Ground 4 operations indicate that the practice of separating the waste containers into "alpha" and "beta-gamma" lots was initially continued at this location. By mid-1958, the waste disposal operations had nearly filled the available disposal area, and the solid waste storage operation was moved to Burial Ground 5 in July, 1959. After termination of disposal operations, the location was used as an above-ground contractor landfill for construction site debris. In the 1960s at least one additional trench was excavated and used for the disposal of classified waste. Again, the best synopsis of information about this burial ground was prepared in 1976 by the U.S. Geological Survey (Webster 1976) and is subsequently quoted nearly verbatim in later documents (ERC 1982, Coobs and Gissel 1986).

5.2 DOCUMENTARY EVIDENCE

Four burial ground logs for Burial Ground 4 are known to exist, showing primarily only disposals made at Burial Grounds 3 and 4 for organizations located external to the ORNL Bethel Valley facilities during this period. In general, for each major operation during a work shift, a generic description of the material being buried is given, together with its generation source, disposal location, and any special remarks. The reason for the preparation of this type of a separate "off-area" disposal log was that ORNL had developed a charge-back system by this time (the beginning of FY 1951), and a log to back up disposal charges to external organizations was required. This log does not record radiation survey measurements or the approximate weights of the waste. It seems logical to assume that separate logs (daybooks) for routine and requested ORNL disposals were also used, because it was the practice to record this information at Burial Ground 3 and Burial Ground 5. Anecdotes of an office fire at Bldg. 7803 at Burial Ground 5 in August 1961 indicate that the Burial Ground 4 documentation kept in the burial ground office was destroyed, including the only copy of the Burial Ground 4 layout map showing the disposal locations. Presumably the four remaining burial ground logs were located elsewhere at the time of the fire because they contained billing information.

In the back of each of the four logs are recorded the number of color coded contaminated trash cans (the "red cans" were changed to "yellow cans" during this period) replaced at each laboratory facility pickup point during the period of the log. This information was recorded in order to bill the facilities for the cost of the cans; however, the listing indicates which ORNL and other facilities generated contaminated trash for burial ground disposal. In addition to the pickup service for the color coded contaminated trash cans, the burial ground initiated a pickup service for color coded Dempster Dumpster™ steel containers used for contaminated trash ("dumpsters" or "yellow pans") starting in 1952. The bulk of ORNL waste would have been picked up in the steel containers; typically none of the waste placed in these containers was characterized or described in any documentation.

As far as can be determined at this time (1997), no detailed information regarding permanent disposal of solid waste at Burial Ground 4 was documented in 1951/59 because burial of lab trash in a segregated area to reduce exposure was still simply a routine operation, little different from burial of uncontaminated lab trash. Burial ground logs were continued at Burial Ground 4 as a means of recording work control, property management, radiation safety checks, and billing information. These logs provide a good perspective on the types of solid waste materials and can often be correlated to generators and waste streams known to exist at that time. As will be shown in the section describing Burial Ground 5, special (non-routine) disposals would not be systematically documented until the 1960s. There is no indication that ORNL laboratory activities generated or used any special forms or records to indicate characteristics of solid radioactive waste materials. Again, the reason for this is that there was simply no demand for this type of record keeping at that time. Neither was there any external U.S. government requirement for detailed information from waste generators. Further, the solid waste management organization was uninterested in detailed waste characterization, since immediate radiation safety and other transportation information were the primary items of interest to the burial ground supervisor.

In perspective, the compactness of ORNL operations and the secret nature of detailed solid waste information was such that only a few personnel had a complete knowledge of the ORNL solid waste streams. Since these personnel knew the information already (they were the generators), they had no need to record it, nor was it disseminated. Some disposal management documents concerning solid waste such as routine disposal quantity reports, budget requests, etc. survive from this time, but the bulk of waste management documentation during this period concerns liquid and gaseous waste disposals which were severe problem areas for the laboratory. Health Physics documents such as

surveys of disposals and procedures became so routine that descriptions of them were rarely made (Note 1, Sect. 5.6). Nuclear criticality safety was likely to have never been a concern for solid waste operations since only negligible concentrations of fissile material would have been in solid waste in 1951-59. At this time, nuclear materials accountability for the small quantities of strategic nuclear materials left in solid waste probably became an issue, but surviving documentation is not complete (Note 2, Sect. 5.6). Again, the burial ground was not an engineered facility and only appears on later engineering documents. A program for commercial sales of disposal work, often used for solid waste transactions, was initiated but appears to have no surviving documentation. Financial accounting documents containing information about waste disposal operations as well as the disposal charge-back system developed to recover costs of the disposal of solid waste materials from off-site generators has almost no surviving documentation. Finally, there is no indication that on-site generators of lab trash bothered to document solid waste material transfers during Burial Ground 4 operations. Off-site solid waste shipments provided about half of the waste disposal activity at Burial Ground 4, although description of the waste is limited.

The best photographic views of the location of Burial Ground 4 are shown in ORNL/RAP/LTR-88/13 (Williams et al 1989); these include contemporary operations photographs from the 1950s as well as environmental restoration photographs taken in the 1980s. Detailed sketches of the burial ground are also presented. The best description of the Burial Ground 4 trench layout is found in ORNL/ER-329/V1. The trench patterns seen in the report are based on extensive remote sensing operations and area sampling. While it is clear that the disposal trenches begin from the northeast corner of the burial ground fence and that the trench boundaries can be identified to within about 10 ft, the specific locations of waste cannot be identified because of lack of documentation.

5.3 DISPOSAL OF CLASSIFIED MATERIAL

As the U.S. AEC operations conducted at ORNL became more openly conducted and reported in the 1951-59 time frame, fewer ORNL waste streams contained materials that were classified. Most discussions and memoranda dealing with radioactive solid waste were unclassified or were declassified by the 1960s as the AEC began its Atoms for Peace initiative. Nevertheless, at the time of disposal, since there was no attempt to segregate solid waste streams, all solid waste in Burial Ground 4 would have been considered by security managers to contain classified information. Not only did Burial Ground 4 contain classified waste, it was specifically considered by the AEC as a disposal site for any classified materials, even those which were uncontaminated. Evidence in the logs indicates that the AEC operations office sent classified documents to the burial ground for either burial or burning.

5.3.1 Classified Waste from ORNL

The classified radioactive solid waste items from ORNL would have been generated in both the Bethel Valley facilities and those ORNL facilities at the Y-12 site and the K-25 site. The processes in use for ORNL operations at that time (e.g., reactor operations, the processes used for isotopes and plutonium recovery, analytical chemistry procedures for isotope separation, and the electromagnetic separation process) have been declassified as have the documents describing their materials and throughput values. The principal waste which would still today contain classified materials would be waste from ORNL activities in support of naval fuel development.

In general, solid waste from ORNL operations placed in Burial Ground 4 would have been packaged in drums, boxes, cans, and bottles for contamination control (since disposal trenches were

often left open and uncovered). The bulk ORNL waste was collected in segregated steel containers ("yellow dumpsters"), which were taken to the burial ground and emptied. Larger items of equipment were moved by truck. As before, every effort was made to keep radioactive materials in solution for disposition in the liquid waste system, an important part of the pilot plant research for Hanford and Idaho. Descriptions and the estimated amounts of these waste materials have been previously provided in unclassified environmental restoration documents.

5.3.2 Classified Waste from Y-12 Plant

The early Burial Ground 4 documentation shows a regular collection of waste from the Y-12 site. Waste transported from Y-12 site was generally characterized in the first log as "alpha waste" or "dead animals." However, most of this waste did not come from Y-12 Plant operations. ORNL Biology Division rather than Y-12 Plant has always conducted the government animal experimentation program. About the time Burial Ground 4 disposals began, the animal experimentation program had just reached an expanded scale of operations. Small animal carcass disposal from the ORNL Biology Division at Y-12 site went to Burial Ground 4 as did small animal carcass disposal for Oak Ridge Institute of Nuclear Studies (later Oak Ridge Associated Universities) and large animal carcass disposal for University of Tennessee Experiment Station (later Comparative Animal Research Laboratory). These wastes were unclassified and were a large component of wastes denoted in the initial burial ground log as "Y-12" waste, since they were collected simultaneously with some of the other waste from the Y-12 site and the Oak Ridge city area on a regular collection schedule. None of these facilities, however, were part of the Y-12 Plant operations. Such waste was picked up by the truckload on a near daily basis by ORNL personnel.

For the waste that is clearly not animal experimentation waste, it is difficult to differentiate in the initial logs between the waste from Y-12 Plant operations and other ORNL operations at the Y-12 site. (In the early 1950s, the Y-12 Plant operations were relatively small scale; the plant was being converted from an abandoned isotope separation process to its later missions of enriched uranium processing and weapons component fabrication.) Occasionally the log waste description was "dry waste," "alpha carbon," or "fluoride residue." Such waste would have been collected from classified processes in nearly every case; in general ORNL personnel collected ORNL division waste, and Y-12 Plant personnel would have transported waste from Y-12 Plant operations as well as the bulk contaminated debris from the renovation of the plant buildings. In September 1955, billing to specific accounts located at the Y-12 site began and the "Y-12" notation was dropped in favor of the account numbers. In February 1957, the building location at Y-12 began to be listed and the "X-10" notation used to indicate that the account was an ORNL division located at Y-12. Non-ORNL accounts at Y-12 were listed by building and account number after this date. From the opening of the ORNL burial ground, Y-12 Plant (as distinguished from ORNL divisions located at Y-12) waste shipments to the ORNL burial ground increased and held steady until the Bear Creek Burial Ground opened (1955) and then diminished. For example, in June 1952, the burial ground operators picked up 55 containers of dead animals, 40 containers of "waste" or "dry waste," 54 containers of "alpha waste," 5 drums of "uranium waste," 600 gallons of beryllium-contaminated liquid, and over 4000 lbs of spent clothing at Y-12 for disposal at ORNL. (This included waste picked up from ORNL divisions located at Y-12.) In June 1955, the burial ground operators picked up 4 containers of dead animals, 675 containers of "alpha waste," 7 loads of "alpha-contaminated ductwork," 12 loads of carbon dust, and one shipment of "SF" material at Y-12 for disposal at ORNL. (This also included waste picked up from ORNL divisions located at Y-12.) In June 1959, the burial ground operators picked up 4 dumpsters of metal scrap, 25 containers from Bldg. 9212, 103 containers of beryllium shop waste, and 6 tanks of beryllium-contaminated liquid at Y-12 for disposal at ORNL. (This did not include waste picked up

from ORNL divisions located at Y-12.) All waste steams from the Y-12 Plant operations would have been considered classified by security managers at that time.

It should be noted that these collection operations included tanks of liquid waste for disposal at the "lagoon" area behind Burial Ground 4; it is very difficult to distinguish with exactness which containers of liquid waste from the area went to a solid waste disposal trench and which went to a liquid disposal pit. It does appear likely that most of the liquid contaminated with beryllium went to the liquid disposal pit area.

The statistical review of Y-12 Plant operations waste shipments sent to ORNL for disposal (Y/DS-196, now declassified) has little detailed information regarding shipments made during the operations period of Burial Ground 4. (A Y-12 Plant Maintenance Department memo quoted in the review notes that chargeable account numbers were necessary for Y-12 Plant disposals to the ORNL disposal sites starting in April 1957.) The review notes that 500 tons per year is the best estimate of the total amount of waste shipped to ORNL from Y-12 Plant (not including the ORNL divisions located at Y-12 Site) during the period of the 1950s. Some care must be taken using this figure to describe solid waste sent to Burial Ground 4, however. The waste material noted in the report was hauled to ORNL by the Y-12 Plant Salvage Operations Group, which did not distinguish the individual ORNL waste management operations well in its memoranda. Many of these salvage shipments were tank trucks of liquid waste such as beryllium-contaminated water; these liquid shipments went to the open liquid disposal pits in Melton Valley, behind Burial Ground 4. In addition, these quoted memoranda show a 1959 campaign of special drum disposals in specially designated disposal trenches established at the "X-10 burial ground." As will be shown in Sect. 6, these trenches are most probably located in Burial Ground 5; not Burial Ground 4.

5.3.3 Classified Waste from K-25 Site

Waste from K-25 was generally characterized as "floor sweepings," "electrolyte waste," and was disposed of in "beta-gamma" trenches. Unlike the waste from Y-12, disposal at Burial Ground 4 was billed to specific K-25 Site accounts and the building location at K-25 was often given. Waste shipments from K-25 to Burial Ground 4 averaged one to two shipments per month. For example, in June 1952 there were three loads of "electrolyte waste" from K-1301, one dumpster of "floor sweepings" from K-1037, and one box of beryllium scrap from the NEPA facility. In June 1955 there was one load of scrap from K-1401. There were no shipments from K-25 in June 1959.

5.3.4 Classified Waste from Other Sites

After about six years of operation, space in Burial Ground 4 began to become limited, and ORNL indicated to the local AEC area office that additional burial ground space would be needed by 1959 (Swartout 1957). This correspondence indicated that local disposals from the Oak Ridge Reservation to Burial Ground 4 averaged about 5000 tons per year, while the disposals from generators outside the reservation varied between 600 and 7000 tons per year. Thus, often the majority (a little more than half) of the waste sent to Burial Ground 4 was usually generated from non-reservation operations, particularly classified operations.

The logs show that truckloads of waste were routinely accepted for disposal at the burial ground from the Mound Site operations during this 1951-1959 period, usually on a weekly basis by a single semi-trailer. As a general rule, a Mound waste shipment was packed in a few large boxes and 40 to 80 drums. No description of the waste container contents was made, nor were the contents characterized in a manner similar to that of modern radioactive waste practices. The disposal log

indicated a distinction in the waste drums between drums of solid waste and drums of sludge. The history of Mound waste disposal operations (Mound 1992) agrees with the entries in the four Burial Ground 4 log books that the solid waste materials from Mound facilities continued to be shipped to ORNL for disposal from 1951 to 1959. The original Mound process generated the polonium-contaminated bismuth oxychloride sludges and trash, first shipped as a waste stream to Burial Ground 2. The bismuth oxychloride waste sludge from the process feed was held at Mound for potential recovery and reuse of the bismuth until the 1953 time frame, then shipped to ORNL for disposal. The dissolved aluminum cladding waste stream, however, was continuously shipped to ORNL. At some point in the mid-1950s, the Mound Site added the classified missions of nuclear weapon component experiments and space research with tritium and plutonium-238, respectively. The information on this period is minimal, but it is apparent that by the end of the operations period of Burial Ground 4, portions of the Mound waste stream arriving frequently by truck would have been contaminated with both these isotopes. In the 1950s Mound also conducted a series of pilot scale radiochemistry experiments aimed at separating high specific activity materials from natural and reactor target waste streams. The radioactive isotopes included radium-226, actinium-227, thorium-228, 229, 230, and 232, protactinium-231, uranium-233 and 234. These experiments generally involved solvent extraction of the isotopes with a variety of inorganic and organic chemicals. The residue of these classified experiments including chemicals and equipment would have eventually been shipped to ORNL for disposal as solid waste. While the process knowledge associated with Mound waste streams has been identified through anecdote and memoranda in the history of Mound waste disposal operations, no Monsanto disposal operations documents of this time are known to exist. Attempts to locate such documents at Mound and ORNL have not been successful.

Beginning in 1951, the AEC offered the Burial Ground 4 radioactive waste disposal service to any other government agency, university, or commercial entity on a charge-back basis. Over the next ten years, more than 120 non-ORNL accounts were opened for disposals at ORNL. Most of these accounts can be seen in the four logs for Burial Ground 4. Some were opened for one-time disposals. Others were opened for routine periodic disposals. Waste would arrive by the single box or by the box car. No description of the waste container contents was made, nor were the contents characterized in a manner similar to that of modern radioactive waste practices. Based on site identification, most of these non-ORNL accounts were universities and medical research sites returning isotopes to ORNL for disposal, or commercial firms which manufactured well drilling, radiography, and radionuclide devices. Most of these waste generators would have not been involved in classified programs; however, the bulk of the materials (in terms of volume) would have come from the commercial firms (or universities) performing defense contracts. Examples of these commercial defense contractors include Monsanto (operating the Mound site), Westinghouse (at several AEC and DOD locations) and Battelle Memorial Institute.

By 1951, the AEC looked upon ORNL as the site of choice east of the Mississippi for disposal of solid radioactive waste materials from its widely scattered research and development operations, particularly those without disposal capability. Specific campaigns to dispose of accumulated solid wastes from other AEC operations were conducted; correspondence regarding these disposals took place at the Laboratory Director - AEC level. These campaigns included four from Argonne National Laboratory (McKinley 1953a, Larson 1953, McKinley 1953b, Kasschau 1953, McKinley 1953c, McKinley 1954, Larson 1954, McKinley 1957, Ramsey 1957), two from Knolls Atomic Power Laboratory (Roth 1955, Larsen 1955, Roth 1958), and two from Feed Materials Production Center (Center 1956, Center 1957).

In addition to the classified waste shipments sent to Burial Ground 4 when the burial ground was open for disposal (1951-1959), burial ground supervisor files (Note 3, Sect. 5.6) indicate that 23 truck

loads of classified waste were sent to a single trench at Burial Ground 4 during the period of October 1968 to February 1969. (Twenty-two were from the Mound site waste stream; one was from a Westinghouse site closing down the nuclear energy for rocket vehicle application [NERVA] rocket engine program. These were the last disposals of the Mound waste stream at ORNL and the disposals still have the potential to contain classified information.) It does not appear that any other waste shipments of this time when Burial Ground 5 operations were ongoing were buried in Burial Ground 4.

5.4 DISPOSAL OF SPECIAL NUCLEAR MATERIAL

In general, there is no indication that strategic materials in quantities other than negligible contamination were present in the solid waste at Burial Ground 4. The general correspondence still available shows that every effort was made to maintain these materials as product or as liquid waste components. For the few known disposals in which more than a few grams of material were present, the disposals involved the scrapping of highly radioactive reactor experiment internals (reactor core components) such as piping and tanks containing fuel residues.

A study was made in the ORNL central records files of all documents attributed to the ORNL nuclear materials control accountability group during the period of Burial Ground 4 operations. Approximately 815 documents were reviewed (Note 4, Sect. 5.6). While the documents are not comprehensive, they indicate that most transfers of accountable, but not economically recoverable, SNM materials for disposal occurred as liquids rather than as solids. These liquid transfers would have been made at the ORNL liquid waste treatment system or at a liquid waste disposal pit. A good estimate of the amounts of plutonium and uranium transferred for disposal in Burial Ground 4 would be less than 10 kg during 1951-1959. These include 223 g of U-233 contained in 25.5 tons of thorium nitrate, 4,207 g of U-235 in scrapped aircraft reactor experiment (ARE) components, 236 g of U-235 in uranyl sulfate waste from the homogeneous reactor experiment (HRE), and 1536 g of U-235 from the scrapped aircraft nuclear propulsion (ANP) in-pile loop experiment.

This estimate reflects a new nuclear materials control and accountability procedure begun during the period of Burial Ground 4 operations. A standard practice was developed by the AEC in which solid and liquid waste items containing unirradiated uranium in significant quantities were shipped to Y-12 Plant for recovery, and waste solutions containing irradiated uranium and plutonium were shipped from other sites to the ORNL tank farm for recovery. Excess SNM materials at ORNL were recycled to other programs or eventually shipped to other AEC sites for reuse or recovery. By the mid-1950s, however, the AEC facilities had accumulated such a surplus of solid and liquid wastes contaminated with accountable quantities of strategic nuclear materials that an economic recovery valuation procedure was applied to the standard practice. At each AEC location, a holder of the waste items could petition for disposal of the surplus SNM material as waste by showing that it was not economically recoverable. After review and approval, the holder of the waste items could transfer the items to the waste disposal operations and remove the accountability for the items from the holder's SNM material account. (Until this procedure was developed, a complicated scheme of classifying waste materials as "operations losses" had apparently been in use.) In theory, the accountability for the SNM materials passed to the waste disposal operations; however, after permanent disposal, inventory of the material was physically impossible and the amount of the SNM material transferred was simply rolled up into a "book value" established for the disposal operations. Further, unlike standard SNM material transfers, no measurements were made by the disposal operations group to verify that the amounts of SNM materials in a waste disposal manifest were correct. In some cases a notation was made on waste transfer documents that the SNM material content of the waste was

unverified; in most cases, the amounts were simply assumed to be valid. No comprehensive documentation remains from the 1950s of the SNM transferred to Burial Ground 4 as not economically recoverable.

In contrast to this, the fissile material content of the 1969 NERVA waste shipment is relatively well documented. By the late 1960s, more stringent ORNL criticality safety requirements were being implemented, requiring waste disposals to meet specific fissile material concentration criteria. Shipment documentation included waste generator certification that the waste packages met the criteria.

5.5 CONCLUSIONS

Attempts to locate detailed information regarding permanent disposals of solid waste at Burial Ground 4 have only been moderately successful. The most important reason for this is that while burial ground operations became complex enough to require some documentation, the operations became so routine that there was no need to retain the documentation for any length of time. Radioactive solid waste management needs of the site and a growing number of off-site organizations were still handled by a small organization. Communication would still have been verbal, but there was an increasing administrative need to document information, particularly that associated with off-site shipments. It is likely, as has been claimed, that an archive of supervisor daybooks, memoranda, and disposal location records pertaining to the Burial Ground 4 were destroyed in a building fire in 1961. Based on other records of the time, however, it is extremely doubtful that these destroyed records would have included detailed descriptions of waste characteristics. The principal advantage which these records would provide today would be detailed disposal site locations which could be correlated with waste stream process knowledge.

From an environmental protection viewpoint, further investigation of the Burial Ground 4 classified waste disposals associated with ORNL processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified ORNL environmental restoration documents,
- no waste management documentation exists which could provide better information regarding the environmental hazards of waste disposal at that location, and
- even though the waste was packaged at the time of disposal, the effects of the materials on the environment would have been manifest by this point, if they were to occur.

Further investigation of the early 1950s-era classified waste disposals associated with Mound processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified Mound environmental restoration documents, and
- no waste management documentation exists which could provide better information regarding the environmental hazards of this waste disposal (bismuth oxychloride liquid and sludge with a high basic pH).

While this waste was packaged at the time of disposal, it is inconceivable that packages did not deteriorate to failure very shortly after burial. The effects of the materials on the environment would have been manifest by this point, if they were to occur.

These conclusions are also valid for the waste accepted from other non-ORNL operations in the 1950s. Logically, therefore, any waste materials placed in Burial Ground 4 which would today be regulated under RCRA have already been identified if they are going to be identified. Further, if the location ground water sample wells are not now detecting regulated materials, it is highly unlikely that the classified material disposals of 1951-59 will be a new source of regulated materials. Finally, given the burial ground location, limited depth of burial, time since disposals were made, and climate characteristics of the area, leach rates of detected regulated materials placed in Burial Ground 4 should have reached steady state conditions after 40 years.

The Mound waste stream is the most likely source of tritium appearing in Burial Ground 4 ground water sample wells. While it is not credible that significant quantities of the isotope are present in the waste (it is an accountable strategic defense material), the chemical form of the material as a contaminant (in which the tritium atom replaces a hydrogen atom in water or oil molecules) is very difficult to contain, requiring several layers of confinement to prevent the spread of contamination. Even though the outer waste package containment (steel drums) may have failed with time, it may take longer for the other confinements to fail in a disposal site. It cannot be determined with any certainty which confinement materials would have been used in the 1950s and 60s and how the lab trash would have been packed. (Since the association of specific radioisotopes with Mound operations was classified at the time, the classification of this waste stream was such that no shipping documents or waste management information contain any descriptions of waste.) From knowledge of the tritium handling processes, however, internally contaminated scrap stainless steel tubing and equipment with plugged openings would be expected to be present as waste; this type of confinement would be relatively impervious to the effects of landfill disposal. As a consequence, it is possible that low levels of tritium will be measured in Burial Ground 4 ground water sample wells until several half-lives of the isotope have expired.

From a security classification viewpoint, the following logic process concerning the classified waste disposition at Burial Ground 4 can be made for waste from ORNL operations:

- most of the waste buried was classified at the time, but the ORNL processes that would have generated the waste have since been declassified,
- in general, ORNL operations did not prepare or handle classified weapon components, and
- the specific location of accountable amounts of SNM can no longer be determined.

However, during 1951-1959, the laboratory continued its classified cold-war missions, one of which was the disposal of solid waste materials from classified defense programs in an area where physical security could be maintained. The following logic process concerning the classified waste disposition at Burial Ground 4 can be made for waste from Mound operations:

- all the waste buried was classified at the time, but the Mound processes that would have generated the liquid and sludge waste have since been declassified,
- no evidence exists to indicate that accountable amounts of SNM were present as waste at Dayton operations,

- some Mound operations prepared or handled classified weapon components,
- waste from these Mound operations is likely to have been sent to Burial Ground 4, and
- these weapon component designs have not been declassified.

It can be concluded, therefore, that environmental remediation activities may present a security vulnerability. Special procedures for conducting remedial activities have been required on previous occasions for the Burial Ground 4 location.

It is difficult to discuss substantively the possibility of waste from the other non-ORNL sites still containing classified information. Y-12 Plant sent scrap process equipment used in weapons component manufacture for disposal to Burial Ground 4; the plant did not have its own classified waste disposal area until 1955. K-25 site sent scrap from its barrier production facilities. The weapon component designs have not been declassified, nor has the barrier technology. It can be concluded, therefore, that the potential for the presence of these wastes alone requires that specific security procedures be performed for the Burial Ground 4 location prior to remediation activities. The NERVA project waste no longer contains classified information, but waste from other sites involved with naval fuel development may still contain classified information.

5.6 REFERENCES FOR SECTION 5 AND ADDITIONAL READING OF INTEREST

5.6.1 Waste Management File References

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5.6.4 Special Notes

Note 1. Individual survey logbooks assigned to the radiation protection technicians assigned to the area which included Burial Ground 4 still exist, are nearly complete for the period 1951/1959, and are located at Laboratory Records under the names of the individual technicians. It is clear that burial ground contamination control surveys were routine and of comparatively little concern.

Note 2. Declassified bound volumes of AEC 101 forms showing transfers of SNM from Y-12 Plant to ORNL are located at Y-12 Plant Records. Duplicate copies are located with the ORNL Waste Management Files at ORNL Laboratory Records.

Note 3. The files are located with the ORNL Waste Management Files at ORNL Laboratory Records.

Note 4. The ORNL Laboratory Records CF files were sorted for any record associated with H.F. Stringfield, the ORNL accountability representative for nearly twenty years. Each available record was examined for waste disposal references.

6. BURIAL GROUND 5 (7/1959- 7/1973)

6.1 KNOWN HISTORICAL OVERVIEW

From 1959 to 1980, Oak Ridge National Laboratory was in a period of physical improvement and mission change that resulted in its present day appearance. Initially the laboratory retained its classified military mission, but by 1960 two factors served to truncate severely the laboratory's classified activities. First, the defense program sponsorship of reactor design, fuel reprocessing research, training of technical personnel, and studies of the effects of nuclear weapons was rapidly reduced to very low levels at ORNL by the AEC as it concentrated on the engineering and production aspects of these defense programs at other sites. Second, the laboratory management made a concerted effort to realign the laboratory organization and facilities to support broad unclassified research programs aimed at developing a nuclear energy economy, as well as compiling basic atomic and nuclear research data. So strong was this emphasis on the shift to unclassified programs, that by 1980 few outward vestiges of the Manhattan Project remained visible, and few personnel were aware of the small but continuing classified defense program activities.

During the first few years of the period in which waste management operations were conducted routinely at Burial Ground 5, the percentage of laboratory programs which were classified decreased radically. This can be seen from the register of the accountable classified research program notebooks assigned to ORNL research personnel that is required to be maintained by the Laboratory Records organization. It is interesting to note that from 1944 until 1960, the register of classified research notebooks had 172 pages of notebook assignment entries. From 1960 to 1970, however, only six pages of the register were used for classified notebook assignment. This dropped to two register pages for entries between 1970 and 1980. Chapters 5 and 6 of Johnson and Schaffer provide an excellent description of the shift in laboratory programs during the 1960s.

Considerable detailed information is known about waste management operations in this fifth disposal area for solid radioactively contaminated waste. There are two important reasons for this. First, within the first few years of the period in which waste management operations were conducted routinely at Burial Ground 5, the AEC developed a new policy for solid radioactive waste data acquisition. Originally, a radioactive waste burial ground was simply a landfill operation (dump), little different from any non-radioactive landfill operation, government-operated or otherwise, of the time. The purpose of the burial ground was to place waste under soil cover so that human exposure to radiation and radioactive contamination would be minimized (isolation from the human biosphere). The extensive studies performed on ground and surface water effluents from the ORNL site in the late 1950s, however, indicated that the placement of Burial Ground 4 in the drainage basin of the White Oak Creek had resulted in some migration of the waste contamination to a river system used for human consumption. The need to measure improvements in the success of the landfill operation resulted in the change of the ORNL "dump"-type operation to an operation in which significant radioisotope content of a burial was recorded together with its disposal location. The recording of this information served two theoretical purposes: it was expected to help prevent migration because the awareness of the isotopic content might result in some preventative packaging and disposal action; and it was expected to help mitigate migration by identifying a source and pathway for any identified migration which could then be isolated. As a result, therefore, a data acquisition system was established in 1961 for waste disposal packages. The second important reason that considerable detailed information is known about waste management operations in this fifth disposal area is that much of the recorded information has survived and been archived by ORNL Waste Management.

In 1959, the AEC intended to formally make Burial Ground 5 an eastern regional burial ground for radioactive waste from both government and commercial nuclear operations. The size and placement of the burial ground reflects this planning, as does the requirement for extensive waste package data acquisition. Laboratory management also intended to use the burial ground as a research resource, in which a significant amount of research on subsurface nuclide migration would be conducted, and modern procedures for isolation of waste from the human biosphere would be demonstrated. The implementation of much of this planning was eliminated in 1962 when the AEC decided to authorize the establishment of commercial radioactive waste disposal operations.

By 1968 the ORNL waste disposal operations had become administratively complicated, reflecting the advent of modern waste disposal regulations and the differences in type and suitability of ORNL solid waste matrices for landfill disposal. Waste was segregated for storage or disposal as determined from its isotope content, fissile material content, security classification of the waste matrix, and other considerations. The burial ground was segmented to account for this segregation. The southern area reserved for "low-level" waste had nearly been filled by 1970, and the bulk of the solid waste disposal operation was moved to Burial Ground 6 (later Solid Waste Storage Area 6 [SWSA-6]) in early 1973. The southern sector of Burial Ground 5 (later Solid Waste Storage Area 5 South [SWSA-5S]) continued to be used occasionally for burial of non-transuranic waste materials until July 1973. To avoid confusion, Sect. 6 will be limited to discussions of disposals in this southern sector of Burial Ground 5.

The northern sector of Burial Ground 5 (later Solid Waste Storage Area 5 North [SWSA-5N]) continued to be used for burial of transuranic waste materials until April 1982. After termination of permanent disposal operations, the location has been used for above- and below-ground storage of waste packages until the present. In 1972 a small area of Solid Waste Storage Area 5 North was fenced and set aside for disposal of classified waste packages from off-site locations, but this area was rarely used for the disposal of classified waste. Since disposal operations in Solid Waste Storage Area 5 North were conducted in the same time frame as Solid Waste Storage Area 6, the discussion of disposals in this part of Burial Ground 5 will be in Sect. 7. A good summary of information about Burial Ground 5 was prepared by Coobs and Gissel in 1986.

6.2 DOCUMENTARY EVIDENCE

Considerable detailed information regarding permanent disposal of solid waste at Burial Ground 5 is still available and has been archived for research and review. Burial ground logs (Sect. 6.2.1) provided a means of recording work control, property management, radiation safety checks, and billing information. While the waste characteristics were not recorded, these logs provide a good perspective on the generic types of solid waste materials and can often be correlated to generators and waste streams known to exist at that time. The log data were used as a basis for a computerized disposal record keeping system (Sect. 6.2.2). Systematic documentation of special (non-routine) disposals (i.e., waste not thrown in color coded contaminated trash cans and Dempster Dumpster™ steel containers) was begun (Sect. 6.2.3). Disposal management documents concerning solid waste such as routine disposal quantity reports, budget requests, etc. survive from this time. Health Physics documents such as surveys of disposals and procedures were so routine that descriptions of them were rarely made, although some unusual occurrence reports are available (Note 1, Sect. 6.6). As the economic importance of fissile materials declined, waste contaminated by these materials began increasingly to be sent to the burial ground. As a consequence, nuclear criticality safety began to be a concern and procedures were initiated for the control of these materials in solid waste operations. In addition, nuclear materials accountability for the small quantities of strategic

nuclear materials left in solid waste increasingly became an issue, but surviving documentation is not complete because these records had a formal records destruction schedule. Shortly after its initial opening, Burial Ground 5 became an engineered facility and engineering records of disposal locations are available. A previously initiated program for commercial sales of disposal work has surviving documentation from the late 1960s. The financial accounting documents containing information about waste disposal operations as well as the disposal charge-back system developed to recover costs of the disposal of solid waste materials from off-site generators has almost no surviving documentation because these records also had a formal records destruction schedule. Finally, on-site generators of lab trash often have surviving logs or generator copies of waste management documentation for solid waste material transfers during Burial Ground 5 operations. While these generator records have not been comprehensively evaluated throughout the laboratory, they are often useful in correlation of waste stream information. Off-site solid waste shipments to Burial Ground 5 gradually decreased to a relatively small percentage, and description of the waste is limited.

6.2.1. Burial Ground Operations Documents

Seven hard copy burial ground logs for Burial Ground 5 are known to exist. The first (SWSA-5 Logbook 1-6-60 to 6-29-62) was begun during a time period overlapping that (January 2, 1958 to October 7, 1960) of the last existing log for disposals at Burial Ground 4 (A-2395). In general, for each charge-back disposal operation, the organization generating the material being buried is given, together with the estimated weight of the waste, the number and type of packages, the estimated volume, the purchase order number, and the amount to be charged to the generator for the disposal. This log clearly was used to back up disposal charges to the external organizations. This log does not record radiation survey measurements, but does begin to record the disposal locations, starting in October 1960 when the last log that included Burial Ground 4 ended. A separate log (SWSA-5 Logbook 1-5-61 to 8-7-62) was used to record disposals made for the K-25 site, the Y-12 site, ORNL divisions at the Y-12 site, the University of Tennessee Agricultural Experiment Station (UTAES often logged as UTAEC) site, and the Oak Ridge Institute of Nuclear Science (ORINS). In addition to the organization, the building number generating the material being buried is given, together with the estimated weight of the material, the number and type of packages, the estimated volume, a generic description ("waste," "yellow pan," "pipe," "duct," etc.) of the disposal, and the disposal trench number. A third separate log (SWSA-5 Logbook 1-3-61 to 3-20-62) was used to record disposals made for ORNL divisions at the main ORNL (Bethel Valley) area. In addition to the building number generating the material, the estimated volume of the material is given, together with a generic description, the disposal trench number, and the vehicle driver.

In addition to the three early hard copy burial ground logs discussed above, four others still exist (SWSA-5 Logbooks 3-21-62 to 6-15-62, 10-11-66 to 1-31-69, 2-3-69 to 12-30-70, 1-4-71 to 12-23-75). By 1966, the burial ground logbook had assumed its final role and format. At this time, the burial ground logbook had become the first record of all disposals made on a particular day, including non-ORNL main area disposals. In addition to the organization or the building number generating the material, a generic description ("plywood," "yellow pan," "filters," "mixed FP," etc.) of the disposal (sometimes including the number and type of packages) was given, as well as the estimated volume, the disposal trench number, the distance of the disposal from the trench starting point, and the distance from the trench bottom. From the burial ground logbook, information was transferred to keypunch forms for input to a computer data base (Sect. 6.2.2).

In addition to the burial ground logbooks, separate daybooks for work assignment and other special notes were kept by the burial ground supervisors. Seven of these still exist as well as a notebook listing trench opening and closing dates (SWSA-5 Daybooks 5-18-64 to 9-24-64, 7-24-64

to 7-2-65, 1-13-71 to 3-31-71, 4-1-71 to 6-30-71, 7-1-71 to 10-18-71, 10-18-71 to 2-16-72, 3-15-72 to 6-8-72, and Trench Record 1-15-64 to 4-7-81).

6.2.2 Computer Data Base

Beginning in January 1962, specific information about each disposal was recorded in a computer data base. The computer appears to have been a large mainframe unit located at the K-25 site, using punched card input. Information was punched into card decks which were periodically input to the computer; data storage was on magnetic tape. In addition to the complete data base printout, periodic reports were generated including a monthly "burial ground log" and "off-area disposal" report. The data base, later known as the Solid Waste Information Management System (SWIMS) exists in three "volumes," Mod I, Mod II, and Mod III. SWIMS Mod I records the data for the waste burial operations performed at Burial Ground 5. The data base management software was converted from mainframe to desktop computer operation in 1988, and the data base storage converted from magnetic tape storage to magnetic disk storage. Two versions of the SWIMS Mod I data base exist; one containing all the entries is located in the Waste Management files at Lab Records; one with all the known disposals of classified waste deleted is located at Waste Management Records (Bldg. 3001) for routine access. The routine access version uses the Knowledge Man software to access the data and produce reports on demand. The complete SWIMS Mod I data base at Lab Records is accessed by FoxPro or Access software[1]. The SWIMS Mod II and Mod III data base volumes were not separated into two versions because by the time SWIMS Mod II data entry began (1975), the disposal data for the few landfill disposals of classified waste after this time were generally not recorded in SWIMS.

Some detailed discussion regarding data entry practices is necessary in order for researchers to understand the limitations of the SWIMS data. During the operation of Burial Ground 5, the data base was not established and maintained in a manner typical of a modern data base. As a result, considerable error has been incorporated into the data. An earlier study (Grizzard, 1986) indicated that disposal data was input to the data base from a burial ground authorization form. This was later the case (probably after 1975), but initially during the period of Burial Ground 5 disposals, the information for the data base came from the burial ground disposal logs, as can be seen by matching the log information with that of the data base. It appears that the logs or copies of them were used directly to punch in the data, since copies of eighty-column coding sheets with disposal information have not been found. When the circumstances of the Burial Ground 5 records fire are considered, it seems entirely likely that the data base was initially configured to be an away-from-site backup of the burial ground logbook data.

As might be expected, punching data into cards from the log entries would have been somewhat problematic. Aside from the lack of data, the punch card operator selected the words and meanings for input. This means that accuracy and completeness of the data submitted to the computer varied greatly and depended upon the education and experience of the punch card operator. There is no evidence to indicate that a modern data base activity, such as data validation was used. There is every indication that the data was punched and never checked against generator or other burial ground records. In addition, researchers should be cautioned that modern computer printouts of the data base are an artifact of the data management software. That is, the data fields reflect a much later era of information management and interest in waste content; the original data fields were few. A review of

[1]Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof.

a typical SWIMS printout today shows data fields for information which was not even recorded in the 1960s. Usually the data management software fills these empty data fields with a default value such as "0," but in some cases the input for fields from later times used numerical codes for which there are no "0" values. This results in data fields such as "transuranic contents" with "0" values, as well as waste contents and packaging data columns reflecting default value type codes. In general, before 1971, the only information input to the data base was the date of the disposal, the site and building number from which the waste was generated, the badge number of the authorizing burial ground foreman, the charge account number, the type of transport, the badge number of the disposal operator, the burial ground, the trench or well number, the distance from the start of the trench, the distance from the bottom of the trench, and the volume of the waste.

In addition to the cognitive error associated with this type of data entry, the known physical error rate associated with punch card operations introduced two additional distortions. First, numerical values often become transposed or shifted; and second, when a card failed to compile because of a field error, the data for the card was not recorded. Comparison of the data base to burial ground logbook data shows a significant loss of data; i.e., entries appear in the logbooks which do not appear in the computer data base. It is unlikely that this data loss would be noticed since the software numbered the entries. That is, unlike later era data entries from forms with preprinted document numbers, the early data entries were numbered in the order in which they were compiled by the computer; this means that SWIMS Mod 1 "document numbers" are not authentic document numbers traceable to a particular disposal transaction. Again, accuracy and completeness of the data submitted to the computer varied greatly and depended upon the skill and experience of the punch card operator.

Finally, there appears to be a significant loss of data in SWIMS Mod 1 at the time of the opening of Burial Ground 6. Two new programs had just been initiated at Burial Ground 5, the segregation of uranium-bearing materials into so-called "fissile wells," and the segregation of materials containing "transuranic" contaminants into a new set of trenches in the northern sector of Burial Ground 5. Both the fissile wells and transuranic trenches were numbered starting with 1. Shortly afterward, Burial Ground 6 was opened, also using trenches and fissile wells that were numbered starting with 1. It appears that for some time, the data entries for Burial Ground 6 overwrote the entries for Burial Ground 5, since there are more logbook entries than SWIMS Mod 1 entries and the logbook descriptions of the buried materials are significantly different from the SWIMS data entries. This error was stopped, but it does not appear that any action was taken to correct the SWIMS data base. As a result, the logbook entries, rather than SWIMS data, should be used to review disposals in the first two transuranic trenches in the northern sector of Burial Ground 5. Due to cognitive errors in both the logbook entry and the computer data entry process, the SWIMS waste description data for "fissile wells" is misleading; the hard copy records from the waste generators should be used to review these disposals.

6.2.3 Special On-site Disposal Documents

Beginning in 1961, ORNL laboratory activities started using a special form that roughly indicated characteristics of solid radioactive waste materials. The primary reason for this appears to be a strong demand for this type of information transfer from the ORNL Radiation Safety and Control organization at that time. The exact rationale for documenting the transfer of contaminated materials to the burial ground cannot be discerned, although the need for more formalized accountability and billing of generators might have been included. Another possible consideration is that contaminated objects of some value were now being buried; greater traceability of their final disposition may have been a concern. From a waste analysis viewpoint, this form initially had little use; and it should be noted that there was no external U.S. government requirement for detailed information regarding

waste contents from waste generators. Further, the solid waste management organization was uninterested in detailed waste characterization, since immediate radiation safety and other transportation information were the primary items of interest to the burial ground supervisor. There was no requirement to keep these documents as records; however, they were filed and about half of the Burial Ground 5 copies of the form are still in existence.

This form, later used to input SWIMS data, was initiated at roughly the same time as the waste disposal data base, but was used for several purposes other than data entry. Form UCN [for Union Carbide Nuclear]-2822, originally "Request for Transfer of Contaminated Materials to Burial Ground," was used in sixteen versions before it was canceled in 1993. The pencil draft of the form is dated 4/60 and according to the Forms Control Section records, it was to replace forms X [for X-site]-762 and TX [for temporary X-site]-2760. Neither of these two forms appear to ever have been used. The first version of UCN-2822 is dated 4/61 and three more versions, 5/62, 3/64, and 2/72 were used during landfill disposal operations at Burial Ground 5. These versions were used interchangeably; that is, a generator ordered the forms from Laboratory Stores and used them until this supply was exhausted. Older version forms thus appear for disposals as late as 1968.

The form was filled out by a waste generator without an instruction sheet. This means that accuracy and completeness of the data submitted to the burial ground supervisor varied greatly and depended upon the education and experience of the both the generator and the burial ground supervisor. The first block on the form offered the generator the choice of having the waste hauled or of delivering the waste to the burial ground. A second two-line block was labeled "materials," allowing the generator to insert a description of the waste. Virtually anything appears in this block in completed forms. Over time, for routinely generated waste of the same type, this description got more and more terse as the generator and burial ground supervisor both already knew the description of the waste from a particular area. Other small blocks were placed in the top section of the form for the building originating the waste and type of outer container. A one-line block was placed for the generator to list "principal radioactive isotopes present." This is a source of great error for later researchers because the generators tended to list only the isotopes of interest to them. In no case is a comprehensive isotope list made or a concentration given. In the case of depleted uranium, this block tended to have U-235 listed rather than U-238, giving the impression to later researchers that vast quantities of fissile material have been buried at the site. "MFP" is often used to denote "mixed fission products." The rest of the 8 ½ in. by 11 in. form was used to insert radiation safety precautions, billing information, and the disposal location. Thus, the main purpose of the form was to request waste collection and transportation from the burial ground operations group in a manner that allowed the service to be billed to the generator. The waste description by the generator was only sufficient to indicate the logistical requirements necessary for the operation. The isotope and radiation data were of interest primarily for radiation protection purposes. In the 1970s, as the waste management operations became more complex and regulations more stringent, later versions of the UCN-2822 form were revised to incorporate recording of detailed information about the waste content for regulatory compliance.

One other note of caution regarding this form should be added. Unlike modern waste disposal practices, a waste generator at ORNL had two options. For routine waste, the generator simply bagged or canned the waste and placed it in the nearest "yellow pan." There was no documentation required. Fully two-thirds to three-quarters of a building's radioactive solid waste was prepared for disposal in this manner during most of the Burial Ground 5 operations period. Only for waste with some unusual characteristic requiring special handling by the burial ground personnel (usually high specific activity) would a UCN-2822 form be prepared. In summary, it is important to note that researchers should not

view Burial Ground 5 operations as if they were conducted using later disposal information management practices.

6.2.4 Burial Ground Disposal Locations

An incomplete set of detailed engineering records concerning Burial Ground 5 exists (Survey Books 1962-1995, compiled in Petree 1995a-c). As noted previously, a major AEC policy change occurred in 1961 regarding the methodology by which waste disposal records would be organized and maintained. As part of this change, the detailed coordinates of each disposal trench and auger hole would be surveyed and recorded by Engineering Design Department personnel (Walker 1964). The survey approach used was a semi-exact chain survey rather than an exact transit survey of each disposal coordinate. That is, to control cost, a series of benchmarks was established throughout the burial ground by transit. From these benchmarks, locations were measured by survey chain and recorded in civil engineering logs. The cumulative error introduced by this semi-exact method is only a few feet per coordinate, because of the limited size of the burial ground area. Thus, *when these coordinates have been recorded*, the location of a trench coordinate or auger hole can be readily located thirty years later at Burial Ground 5. This practice of surveying and logging the disposal locations began the first week of 1962 with trench number 31 and auger hole number 1, although the locations of trenches 28 through 30 could be ascertained and were also recorded. That is, the exact locations of the first twenty-seven trenches and an unknown number of auger holes in Burial Ground 5 are no longer available since they were not surveyed and recorded by the Civil Engineering group and the location documentation was probably destroyed in the Bldg. 7803 fire. While it seems clear that prior to 1962, some means (similar to the grid layout system used at Burial Ground 4) was used to indicate the location of the trenches and holes at Burial Ground 5, the only evidence for such activity is the burial ground logbook notation. As far as can be determined, the exact locations of trenches and holes covered prior to January, 1962 at Burial Ground 5 can no longer be ascertained.

In addition to the survey books containing surveyed locations of the trenches and auger holes at Burial Ground 5, the Engineering Department prepared engineering drawings and location lists from the recorded information (E-52834, D-52860), as well as occasional special project drawings. In 1963, the plan and section for the 48-in. concrete disposal holes for Yankee Atomic control rods were prepared (S-10806-B-001-D). As part of a drainage improvement project begun in 1972 (engineering job number 20923), the location of trenches, auger holes, and general disposal areas in the burial ground were noted (C-20923- EA-001- E and 002-E) on a site layout. The location of the burial ground and its building number (7802) are clearly shown in the site planning (for contaminated areas) drawing for fiscal year 1983 (A-90015-0-63-F).

6.2.5 Other Sources of Information

On-site generator documents for the period of Burial Ground 5 disposal operations are known to exist at various locations throughout the ORNL operating divisions. As a general rule, these documents are the generator copies of the form UCN-2822, "Request for Transfer of Contaminated Materials to Burial Ground" or operations logs. No coordinated attempt to locate and acquire on-site generator documents of this period has been made by the Waste Management and Remedial Action Division, although some activities of this type were initiated by the Environmental Restoration organization. This remains an area in which documents may still be retrieved and archived for study.

6.3 DISPOSAL OF CLASSIFIED MATERIAL

About 35,000 waste "disposal transactions" were made in SWSA-5S from 1962 to 1973. (A "disposal transaction" may be a trailer load of 148 55-gal drums or a single 5-gal paint can.) By 1962, most of the ORNL programs generating waste were unclassified. Also by 1962, the Y-12 Plant had opened its own burial grounds, so waste buried at ORNL from Y-12 after this date generally (but not always) was collected from unclassified ORNL division activities located at the Y-12 site. Of the 35,000 transactions made at SWSA-5S after 1962, about 2000 involved classified materials when the disposals took place.

6.3.1 Classified Waste from ORNL

As the U.S. AEC operations conducted at ORNL became more openly conducted and reported after 1959, fewer ORNL waste streams contained materials that were classified. Most discussions and memoranda dealing with radioactive solid waste were unclassified or were declassified by about 1963 as the AEC conducted its Atoms for Peace initiative. The classified radioactive solid waste items from ORNL would have been generated in both the Bethel Valley facilities and those ORNL facilities at the Y-12 site and the K-25 site. The processes in use for ORNL operations at that time (e.g., reactor operations, the processes used for isotopes and plutonium recovery, analytical chemistry procedures for isotope separation, and the electromagnetic separation process) have been declassified as have the documents describing their materials and throughput values.

The principal waste disposals located in Burial Ground 5 which would still contain classified materials today would be the relatively small amount of waste from ORNL activities which could be identified as being in support of naval fuel development. This waste from naval fuel development would have been mixed with other scrap and waste from the other reactor fuel examination and development programs. Burial ground log descriptions of ORNL waste were always terse (e.g., "waste"). No documentation has been found that could specifically match a disposal of waste from ORNL to an item of naval fuel development program waste.

6.3.2 Classified Waste from Y-12 Plant

6.3.2.1 SWIMS Data

The SWIMS Mod 1 data base (1962 and later disposal dates) was queried to report all disposal transactions having an origin from a non-ORNL generator in which waste was moved to an ORNL waste management facility (storage/disposal). The query reported 4980 transactions between 1962 and 1974 out of the 35,000 total. Of the 4980 non-ORNL transactions, about 1509 (30%) were from buildings located at the Y-12 site.

1. Of these Y-12 site shipments, approximately 91% of the transactions were from facilities located at the Y-12 site but operated by ORNL Biology, Isotopes Separations, Fusion Energy, or Engineering Technology Divisions. By programmatic definition, waste from these facilities would now be unclassified.

2. Of the remaining 143 shipments, 52 originated from buildings which have had multiple program occupants over the lifetime of the Y-12 site. The most likely programmatic origins of these transactions are:

- Bldgs. 9980 (1 transaction), 9981 (2 transactions), 9983 (1 transaction), 9987 (12 transactions), 9204-4 (1 transaction) - the Y-12 Plant Radiography Group [scrap unclassified sealed radiation sources];
- Bldgs. 9711-1 (1 transaction), 9735 (1 transaction) - Y-12 Plant Health Physics laboratories [scrap unclassified calibration sources and program waste];
- Bldg. 9213 (5 transactions) - ORNL unclassified criticality experimentation and training facility;
- Bldg. 9203 (1 transaction), 9203A (4 transactions), 9205 (21 transactions) - ORNL development projects; and
- Bldg. 9995 (2 transactions) - Y-12 Plant Laboratory analyses of ORNL samples.

With the exception of the development project waste, it is very unlikely that waste from these programmatic sources was classified.

3. Of the 143 shipments from the Y-12 site buildings which have had multiple program usage, four transactions originated from Y-12 Plant process areas which might have generated classified waste material. It cannot be determined with any certainty.

4. Of the 143 shipments from the Y-12 site buildings which have had multiple program usage, 87 have insufficient data to definitely identify their programmatic sources. (It cannot be determined from which building the waste originated.) It may be that these are renovation projects associated with ORNL activities at Y-12 Plant, since the charge account numbers, where they exist, tend to appear as engineering project numbers.

6.3.2.2 Burial Ground Log Data

Waste from the Y-12 site in early 1961 was generally characterized in the first log (SWSA-5 Logbook 1-5-61 to 8-7-62) by container as "yellow dumpster pan," "wood boxes and metal drums," or "cabinets and buckets." About ten percent of the log entries include a generic waste description such as "dry waste," "dead animals," or "calutron parts." Occasionally the description contains contaminant notations such as "thor[ium], ber[yllium], ura[nium]," "ura[nium] chips," or "Pu[plutonium]." Such waste was picked up by the truckload on a near daily basis in the first few years of Burial Ground 5 operation (pre-SWIMS data). The waste from the old Y-12 Plant beryllium shops is clearly discernible as is scrap from the dismantling of older Y-12 Plant processes. All waste streams from the Y-12 Plant operations would have been considered classified by security managers at that time. By the end of 1961, however, waste from Y-12 Plant facilities had dropped off markedly and continued at a relatively low level. Waste disposals from the Y-12 site area are rarely mentioned in Burial Ground 5 supervisor logs. In February 1965 (SWSA-5 Logbook 7-24-64 to 7-2-65), it was noted in the supervisor log that the burial ground supervisor had been queried for the reason that UCN-2822 forms were not being filled out by the waste generators serviced by the Y-12 site waste collection truck. By 1969 (SWSA-5 Logbook 2-3-69 to 12-30-70), the building locations for the Y-12 site disposals in the burial ground disposal log indicate that the accounts were nearly all from ORNL divisions located at Y-12 and that the collection truck only made weekly runs.

6.3.2.2 Other Data

The statistical review of Y-12 Plant waste shipments sent to ORNL for disposal (Y/DS-196, now declassified) has little detailed information regarding shipments made during the operations period of Burial Ground 5, but does graph the total amounts of waste sent from the Y-12 Plant for disposal to the ORNL disposal facilities (burial ground and liquid disposal pit). The review states, "It would appear from the available records that disposals were made at a high annual rate (500+ tons/year) until early 1961, at which time the Y-12 Plant began making beryllium, thorium, and considerable uranium [-contaminated waste and scrap] disposals in the Bear Creek Burial Ground that had been previously sent to ORNL. It is important to note that many disposals contained classified materials and classified configurations associated with the Y-12 Plant's weapons programs." The review indicates that an average of about 100 tons of contaminated waste and scrap per year is the best estimate of the total amount of waste shipped to ORNL from Y-12 Plant (not including the ORNL divisions located at Y-12 site) during the remaining operations period of Burial Ground 5. Again, some care must be taken using this figure. The waste material noted in the review was hauled to ORNL by the Y-12 Plant Salvage Operations Group, which did not distinguish the individual ORNL waste management operations well in its memoranda. Many of these salvage shipments were tank trucks of liquid waste such as beryllium-contaminated water; these liquid shipments went to the open liquid disposal pits in Melton Valley, behind Burial Ground 4.

In addition, memoranda quoted in Y/DS-196 show a 1959 campaign of special drum disposals from the Y-12 Plant in specially designated disposal trenches established at the "X-10 burial ground." It is not explicitly stated, but it would be highly unlikely for the waste not to be considered classified at the time of disposal. These disposals correspond to the two trench disposals shown in the first trenches located in Burial Ground 5 (Cowser 1961). One trench was carefully dug, drained, and lined with gravel; after the drums of waste were emplaced upright in the trench, the trench was carefully covered. A second trench was filled using the usual burial ground practice of excavating a trench, simply dumping the drums into the trench, and backfilling the trench with whatever was available. The purpose of these two trench disposals was to demonstrate the difference in radionuclide migration expected from the difference in the two methods of disposal. Apparently, no appreciable difference was measured. The engineered trench design never became a common practice in Burial Ground 5.

Of the 4980 non-ORNL SWIMS Mod 1 transactions, about 704 (14%) were from ORINS (later Oak Ridge Associated Universities [ORAU]) and about 713 (14%) were from the UTAES (later Comparative Animal Research Laboratory [CARL]) site. These animal waste shipments would have been picked by the same truck picking up waste from the ORNL Biology Division at the Y-12 site. By programmatic definition, waste from these activities would be unclassified.

6.3.3 Classified Waste from K-25

As noted previously, the SWIMS Mod 1 data base (1962 and later disposal dates) was queried to report all disposal transactions having an origin from a non-ORNL generator in which waste was moved to an ORNL Waste Management facility (storage/disposal). Of the 4980 non-ORNL transactions, about 35 (<1%) were from the K-25 site. There is insufficient data to definitely identify their programmatic sources.

The burial ground logs (SWSA-5 Logbook 1-5-61 to 8-7-62, SWSA-5 Logbook 2-3-69 to 12-30-70) indicate that waste shipments from the K-25 site to Burial Ground 5 were infrequent and averaged only about three shipments per year. There does not appear to be any consistent waste stream from the K-25 site and only occasionally is the building location at the K-25 site given. For example,

in January 1961 there was one load of "cad[m]ium plated cold traps" from K-1420, and in March, one shipment of "carbon" with the generator unspecified. In February 1969, there was one load of "misc. material uranium," and one load of "cont. mech. junk" with the generators unspecified.

6.3.4 Classified Waste from Other Sites

The overview of AEC waste management operations presented to the U.S. Congress in 1960 (AEC 1960) clearly shows that the AEC intended to set up several regional solid radioactive waste disposal sites on government property. This planning was based on the experience at the ORNL burial grounds of accepting waste from off-site generators. As late as November 1960, ORNL was actively lobbying to prevent AEC waste disposition at Idaho rather than at ORNL (Ramsey 1960b). At the time of the initiation of Burial Ground 5 disposal operations, users of commercially distributed isotopes who might wish to return the isotopes as waste or dispose of contaminated materials could do so for a fee. Shipments from other sites to Burial Ground 5 averaged between 40 and 50 per month. The largest shipper of waste (by weight) was the Mound site. Other sites which can clearly be identified as shipping classified waste to Burial Ground 5 during this period were General Electric (the NEPA project at Evandale, OH), Battelle Memorial Institute, U.S. Army Chemical Center, KAPL, Argonne National Laboratory, Westinghouse Electric (the contractor for Bettis Laboratory), National Lead (the contractor for the Feed Materials Production Center at Fernald, OH), Englehard Industries, and a naval shipyard (SWSA-5 Logbook 1-6-60 to 6-29-62). However, within three years it was decided that private companies could operate low-level radioactive waste landfills as efficiently as a government laboratory, and a moratorium on the acceptance of off-site waste was imposed on the ORNL burial grounds once a commercial burial ground had been opened. Hereafter, the AEC approved the disposal of off-site waste at the ORNL burial grounds on a case-by-case basis; shipments to the burial ground from outside the Oak Ridge Reservation were made only by direction of the AEC, usually in the form of a single page memorandum. The AEC memorandum might authorize a single shipment or a continuing series of shipments. Evidence in the logs indicates that the AEC operations office continued to send classified documents to the burial ground for either burial or burning.

The usual reason for AEC acceptance of waste at Burial Ground 5 from off-site generators was that the waste was classified and required disposal at a secure location (Roth 1963). In practice, the general criteria used after 1963 by the AEC to authorize disposals of waste from outside the Oak Ridge Reservation were: (1) the waste was classified for security reasons (e.g., waste from Mound, Bettis, Knolls, Argonne, etc.); (2) the waste was not classified, but shipment to Burial Ground 5 was the least expensive means of disposal (e.g., disposition of the demolished New Brunswick Laboratory); or (3) an immediate response to a public health threat required low-profile ORNL disposal expertise (e.g., cleanup of the abandoned American Nuclear site, disposal of the abandoned Long Island Nuclear Services shipments).

Mound facilities continued to ship waste from classified programs to ORNL for disposal. The Mound disposal entries are clearly shown in the Burial Ground 5 log books until early 1969. The history of Mound waste disposal operations (Mound 1992) shows that the original Mound process generating the polonium-contaminated bismuth oxychloride sludges and dissolved aluminum cladding waste stream continued until 1970. Mound Site continued the classified missions of nuclear weapon component experiments and space research with tritium and plutonium-238, respectively, during the Burial Ground 5 operations period. The first plutonium-238 process building opened in 1961, but generation of solid waste containing plutonium-238 as the major contaminant for off-site burial probably did not begin until after 1962. Eventually an economic discard limit was established during the operations period of Burial Ground 5 and portions of the Mound waste stream arriving frequently by truck would have been contaminated with plutonium-238. Mound also continued the series of pilot

scale radiochemistry experiments aimed at separating high specific activity materials from natural and reactor target waste streams. The radioactive isotopes included radium-226, actinium-227, thorium-228, 229, 230, and 232, protactinium-231, uranium-233 and 234. The residue of these classified experiments including chemicals and equipment would have eventually been shipped to ORNL for disposal as solid waste. No Monsanto disposal operations documents of this time are known to exist. Attempts to locate such documents at Mound and ORNL have not been successful.

The Isotope Sales Department continued to handle the correspondence between ORNL and the off-site waste generators for burial ground services. Isotope Sales documents dealing with solid waste for Burial Ground 5 were turned over to the ORNL Waste Management and Remedial Action Division when the disposals of waste from outside the Oak Ridge Reservation ceased in 1985 (Note 2, Sect. 6.6). These files show approximately 170 AEC authorized disposals to Burial Ground 5, covering the ten year period from 1965 to 1975. The bulk of the shipments came from Mound and the NERVA rocket engine program. A review of Burial Ground 5 logs and SWIMS data indicates that the Isotope Sales files do not represent the complete number of disposals from outside the Oak Ridge Reservation; a good estimate is that the documentation for a similar number (~170) of disposals after 1963 were either not handled by the Isotope Sales Department or have been destroyed. However, these existing files do provide the most comprehensive view of the classified materials still available.

Clearly the bulk of the classified waste shipped to Burial Ground 5 came from Mound and the NERVA program. The shipping documents accompanying the Mound waste did not describe the waste, but did indicate the activity of the included radioisotopic contamination. In one instance, however, a part of the Mound waste shipment was described because special handling was requested for two double confinement containers of NaK (sodium potassium alloy) contaminated with tritium.

The NERVA waste was described as general machine shop waste contaminated with enriched uranium. The last NERVA program waste disposal at Burial Ground 5 occurred in late 1972. Other than these two waste streams, classified waste disposals in Burial Ground 5 were infrequent and relatively small after 1963. Naval fuel development program waste in small quantities (usually one or two packages per disposal) came from about six government and commercial sites. Waste from the exposure of highly classified defense equipment to underground nuclear tests was shipped to Burial Ground 5, usually in one or two packages per disposal. The largest test site disposal was several carloads of pipe casing from an underground test sent for burial.

The only disposal at ORNL of waste from an accident involving a nuclear weapon is located at Burial Ground 5. In general, waste from these accidents went to other AEC sites. In this case the waste was sent to Oak Ridge with the idea of recovering SNM from the waste. Instead, after years of storage, the waste was buried. Aspects of the accident, the waste, and the exact disposal location are still classified (Note 3, Sect. 6.6).

After the NERVA program waste disposals in late 1972, records show that only one drum of classified waste was sent to Burial Ground 5, the south disposal area of what would later be denoted as SWSA-5. By this time, low-level waste disposal operations had shifted to Burial Ground 6, and waste contaminated with transuranic materials was being segregated to the north disposal area of SWSA-5, SWSA-5N. It was also about this time that the AEC recognized that placement of classified waste in ORNL burial grounds no longer met security protection requirements (Affel 1972). Over the previous decade, the security protection of the ORNL site had been reduced and uncontrolled access by personnel without security clearances increased to the point that the burial grounds could no longer be considered protected areas. In response, a separate section of the SWSA-5N area was fenced and

reserved as a disposal location for classified waste, but was probably not used until 1975. Discussions of the disposals in this reserved area will be found in Sect. 7.

6.4 DISPOSAL OF SPECIAL NUCLEAR MATERIAL

Disposals of special nuclear materials are of interest in this report because (1) at the time of burial, information about the disposal was classified, and (2) security protection requirements (including specific classified analyses) are required for known disposals of SNM above certain accountable levels. The information regarding disposals of SNM at ORNL solid waste burial grounds comes from the burial ground logs, SWIMS, nuclear criticality safety records, and nuclear materials accountability records. In order to understand the limitations and accuracy of the existing information, discussion is necessary in the following sections regarding the systems generating the nuclear criticality safety records and nuclear materials accountability records.

6.4.1 Nuclear Criticality Safety Records

Disposal of solid waste containing fissile materials was initially so infrequent and the amount of fissile material contaminants in the waste so small that no formal written procedures for such activities were in place in the first half of the 1960s. The original burial ground operating procedures in the ORNL Health Physics Manual did not address the issue. Instead, the safety-related aspects of the landfill disposal of waste containing fissile materials were addressed by an existing network of cognizant ORNL management and staff personnel, most likely on a quasi-verbal basis. The Radiation Safety and Control Department, created in 1959, had safety-related oversight over all laboratory operations handling radioactive materials; this was conducted through a set of technical operations review committees, one of which was the Criticality Safety Review Committee. This committee was responsible for in-depth knowledge and review of all ORNL operations handling fissile materials. In addition to this review committee, the Radiation Safety and Control Department required each ORNL division to appoint a divisional radiation safety officer who was the point of contact between the divisions and the department. At some point in the first half of the 1960s, the duties of the Criticality Safety Review Committee devolved upon a full-time ORNL nuclear criticality safety staff, and divisions holding fissile material were required to request a nuclear safety review of each operation in which fissile material above a certain level was present. This request was submitted on a descriptive form, and the nuclear criticality safety staff would respond to the request with an analysis of the safety of the operation. The operation would be approved by the Criticality Safety Review Committee for conduct under specific nuclear criticality safety parameters. This means that the initial general ORNL practice was to have generators of waste (the point of generation) file form UCN-5917, Request for Nuclear Safety Review (NSR), in accordance with Standard Practice Procedure 31, prior to requesting disposal, instead of having a nuclear criticality safety committee operations review applied at the burial ground (the point of disposal).

Further, during the early years of disposal operations, it was ORNL policy to routinely bury small amounts of fissile contaminants and only invoke oversight review by the ORNL nuclear criticality safety committee if the disposal of an amount of fissile contaminants approaching a significant fraction of critical mass was contemplated. That is, no NSR was required by the generator if this lower control limit was not exceeded. The Engineering and Mechanical Division radiation safety officer was the approval authority for routinely buried fissile contaminants below this control limit. The surviving documentation from that time indicates that the control limit for these *routine subsurface disposals* was initially established as being less than 50 grams of fissile material per package (usually a 55-gal drum) of waste. Exceptions were approved on a case-by-case basis by the Engineering and Mechanical

Division radiation safety officer, probably after consultation with the ORNL criticality safety committee chairman. In general, however, if a generator had waste containing fissile contaminants which exceeded this control limit, the generator submitted an NSR for a *special subsurface disposal* (burial of waste contaminated with amounts of fissile isotopes greater than the control limit for a routine subsurface disposal) of fissile materials.

In 1969, however, with the advent of the retrievable storage and eventual disposal of fuel research materials as waste, the practice of approving waste disposal NSR requests from generators of the waste (the point of generation) was found to be administratively unsatisfactory, and the first NSR governing *special subsurface disposals* (burials of waste contaminated with amounts of fissile isotopes greater than the control limit for a routine subsurface disposal) of fissile materials at Burial Ground 5 (NSR 421) was established. An area isolated from the main trench waste disposal area in Burial Ground 5 was identified for these fissile waste disposals. A 30-in. powered auger was used to excavate a vertical shaft in the soil. The excavated shaft may have been lined with pipe. A shaft may have been used for retrievable storage of fissile materials as well as disposal. In essence, this Fissile Material Storage Area was a large "isotope storage garden" for ORNL research organizations with the advantage that an auger hole became a permanent disposal site when research was complete. NSR 421 formally established an upper nuclear criticality safety control limit for auger hole storage and disposal as less than 200 g of any fissile material per hole. Exceedance of this limit in a waste disposal required a separate, approved NSR. (Generators were still required to obtain an approved NSR before storage or disposal.)

NSR 421 was used to administratively place the already existing auger hole storage/disposal points in Burial Ground 5, about ten of which contained more than 200 g per hole, under the nuclear criticality safety committee oversight. NSR 421 has since been superseded several times; a direct "paper trail" from NSR 421 to the current NSR 0017-WM220-07B exists.

In summary, by 1970, a three-tiered system of documented review and approval of disposals of solid waste contaminated with small amounts of fissile isotopes was in effect at Burial Ground 5. For *routine subsurface disposals*, no NSR was required, but approval by the burial ground radiation safety officer was necessary. For *special subsurface disposals*, a blanket burial ground NSR supplemented the generator-initiated NSR with specific burial ground restrictions. For waste contaminated with greater amounts of fissile isotopes than the limit for *special subsurface disposals*, a separate burial-specific NSR was required. This latter type of disposal documentation was usually used for disposals of fuel element sections.

In practice, this criticality safety approval system would result in odd disposal operations. For example, a shipment of 1100 drums of machine shop waste contaminated with small quantities of enriched uranium was accepted from the NERVA site. Most of the drums contained less than 36 g of enriched uranium per drum and were considered *routine subsurface disposals* (the lower control limit at that time was 36 g per drum); these drums were buried in a trench. A few of the drums contained more than 36 g of enriched uranium per drum and were considered *special subsurface disposals*; they were buried in auger holes. Even though nuclear materials control and accountability forms that accompanied the shipment showed that most drums contained only 1 or 2 g of enriched uranium, the 36 g control limit value was input to the SWIMS computer data base for the drums in the trench. The data base now indicates erroneously that the trench contains about 40,000 g of enriched uranium in drums. Similarly, an ORNL disposal of 7,000 g of depleted uranium was listed on the disposal documentation as having more than 36 g of enriched uranium in the drum. Notwithstanding the fact that the material was depleted uranium, the drum was considered a *special subsurface disposal* and buried in an auger hole. Since uranium-235 was listed by the generator as the principal isotope on the

disposal documentation, the SWIMS computer data base now indicates erroneously that the drum contains about 7,000 g of enriched uranium.

Routine subsurface disposals (routine burial of waste contaminated with small amounts of fissile isotopes) requested by the burial ground operations personnel (the point of disposal) were not formally brought under nuclear criticality safety committee approval until NSR 761 was approved in February 1975. In effect, NSR 761 formalized the practice of *routine subsurface disposal* of fissile materials at SWSA-5 and SWSA-6. NSR 761 has since been superseded several times; a direct "paper trail" from NSR 761 to the current NSR 0017-WM220-07B exists.

NSRs exist for the disposal of waste items which exceeded the control limit for *special subsurface disposals*. Usually these were fuel element sections no longer needed for research. In one case in 1965, the AEC requested ORNL burial ground disposal of residue from an off-site accident involving a nuclear weapon. A complete set of the NSRs for Burial Ground 5 operations is located at the Waste Management file point at ORNL Laboratory Records.

6.4.2 Material Control and Accountability Records

The present-day material control and accountability system was in place during Burial Ground 5 operations. The system had a fixed records retention and disposal period that was usually followed. Most of the system records from the period prior to 1985 have been routinely destroyed on schedule. In some cases partial records remain in existence; but attempts to locate complete sets of ORNL materials accountability documents have not been successful. Areas in which the records search showed some results included the following:

- AEC Form 101 "SF Shipping Form" was used for the transfer of accountable nuclear materials to and from AEC sites. Each AEC site kept a set of sequentially numbered forms for transactions to and from each of the other AEC sites. The ORNL sets of forms can no longer be located; they were probably destroyed on schedule. A nearly complete bound set of forms for transactions originating at Y-12 Plant for receipt at ORNL (1948-1970) were located at Y-12 Plant Records, declassified, and duplicated. A review of these forms indicates that no SF material in accountable quantities (e.g., uranium, 1 g; plutonium, 1 mg) was shipped *as waste* from Y-12 Plant to ORNL during the operating period of Burial Ground 5. The AEC forms were classified documents throughout the period of solid waste disposal at Burial Ground 5 (Note 4, Sect. 6.6).

- A study was made in the ORNL central records files of all documents attributed to the ORNL nuclear materials control accountability group during the period of Burial Ground 5 operations. Approximately 280 documents were identified that show transfers to the burial ground (Note 5, Sect. 6.6). While the documents are not comprehensive, they indicate that most transfers of accountable, but not economically recoverable, special nuclear material for disposal occurred as liquids rather than as solids. These liquid transfers would have been made at the ORNL liquid waste treatment system or at a liquid waste disposal pit. The recorded amounts of highly enriched uranium (HEU), enriched uranium (EU), U-233, and plutonium transferred for disposal in Burial Ground 5 as shown in Table 1.

Table 1. Known fissile material at Burial Ground 5 - Nuclear Materials Accountability Group documents

HEU (g)	EU (g)	^{233}U (g)	Pu (g)	Year
25	393	25	0	1961
185	66	0	0	1962
47	6	0	2	1963
145	2139	386	17	1964
317	1017	4	13	1965
455	151	1735	105	1966
1518	501	80	88	1967
369	39	25	292	1968
321	110	403	383	1969
228	30	52	99	1970[a]

[a] The records for 1970 include only 6 months of the year

- The laboratory originally used intra-laboratory form S-5, "Request for Waste Disposal," as an information sheet accompanying waste solution to be dumped in the laboratory liquid waste system. It contained nuclear materials accountability information to assist the tank farm supervisor to keep the fissile material inventory of the tanks correct. At some point, this form was replaced by intra-laboratory form X-775 "Request for Disposal of SS Material to the Lagoon or Burial Ground." [The acronym SS denoted "source and special" nuclear material, a replacement concept for the SF (source and fissile) acronym.] This form was part of an ORNL nuclear materials control and accountability procedure. The procedure allowed a holder of the waste items to petition the laboratory director for disposal of the surplus special nuclear material as waste by showing that it was not economically recoverable. After review and approval, the holder of the waste items could transfer the items to the waste disposal operations and remove the accountability for the items from the holder's nuclear material account. At some time in the past, a group of these X-775 forms was microfilmed and retained by the ORNL Nuclear Materials Control and Accountability Group. The recorded amounts of highly enriched uranium, enriched uranium, U-233, and plutonium transferred for disposal in Burial Ground 5 are shown in Table 2.

Table 2. Known fissile material at Burial Ground 5 - "Request for Disposal of SS Material" documents

HEU (g)	EU (g)	^{233}U (g)	Pu (g)	Year
288	36	2	13	1963
331	614	379	14	1964
995	156	9	126	1967

Table 2 (continued)

HEU (g)	EU (g)	^{233}U (g)	Pu (g)	Year
1037	417	1548	274	1968
509	404	444	1078	1969
139	357	0	537	1970-73

None of these records correlate well; however, the total picture of the nuclear materials accountability record sources confirms that (1) almost no special nuclear material was transferred to ORNL from the Y-12 Plant in routine waste streams, (2) only limited quantities of special nuclear materials (averaging less than one kg per year) were buried in Burial Ground 5 from routine ORNL waste streams, and (3) usually the special nuclear material was a very small contaminant of a large volume of process waste. Generally, if special nuclear material of any quantity was going to be buried in the burial ground, it would have been performed as a non-routine disposal.

6.4.3 Unusual Concentrations of SNM at Burial Ground 5

As noted above, waste contaminated by SNM was frequently sent to Burial Ground 5; however, the waste usually contained only a few grams of fissile material. In 1968, as a criticality safety measure, the burial ground supervision established a fissile well and trench methodology for waste packages containing fissile material. The methodology was set up to implement the NSR system described previously. In general, if a waste package contained enough fissile material to require nuclear materials accountability approval for disposal, it would be placed in a "fissile waste trench."

If a package contained more fissile material than allowed for a *routine subsurface disposal* (the lower control limit at that time was 36 g per drum), it would be placed in a "fissile waste well." It should be noted that the majority of the packages placed in such disposals contained depleted uranium or other non-fissile materials. This occurred because the burial ground supervisors usually made no distinction between 36 g of U-235 and 36 g of U-235 homogeneously mixed with 4000 g of U-238. The trigger that initiated the use of the fissile well and trench methodology was the yellow multilith copy of the nuclear materials accountability form that accompanied a package containing fissile material contamination; if such a form was present, the package was placed in a "fissile waste well" or "fissile waste trench." Since depleted materials are also accountable nuclear materials, the form would be present even if the waste was not fissile. A separate file system was created in the burial ground supervisor office to store the hard copy information for these disposals. This was fortunate because the SWIMS system was not equipped to accurately input data for a package containing fissile material contamination; as a result, the existing SWIMS information significantly overstates the amount of fissile material present in the burial ground "fissile waste wells" or "fissile waste trenches." The existing hard copy fissile well and trench system documents are present at two locations in the Waste Management files and are not repeated here.

There are a few instances where unusual concentrations of SNM were buried at locations other than the fissile well and trench system of Burial Ground 5.

The first instance of a concentration of SNM placed in a disposal in Burial Ground 5 was probably made in June of 1959 to an area of the burial ground denoted as the "high level waste area" (Cowser 1961, fig. 3). It was described as "1650 g of U containing 1536 g of U-235, in ANP In-Pile

Loop equipment and residues from the Volatility Process, ... discarded to the X-10 Burial Ground" (CF 59-6-71).

In August 1962, three drums of shielded reactor fuel containing 807 g of U-235 in 865 g of U as zirconium clad uranium zirconium alloy were buried, one drum per auger hole (Bruce 1962, Brogan 1969).

The Power Reactor Fuel Reprocessing Program sent excess spent reactor fuel sections containing highly enriched uranium, enriched uranium, depleted uranium, plutonium, and thorium to the burial ground. Four auger holes were used for the bulk of the disposal in March 1964 (Bruce 1964, Brogan 1964). An inventory of each item is included in the burial ground supervisor file.

In the mid-1960s, the residue from an accident involving a nuclear weapon was sent for disposal in Burial Ground 5 (Note 3, Sect. 6.6).

In November 1968, one auger hole was used for the disposal of solid reactor fuel solution residue from the Molten Salt Reactor Experiment. The hole contains four packages; about 196 g of U-233 total.

6.5 CONCLUSIONS

Attempts to locate detailed information regarding permanent disposals of solid waste at Burial Ground 5 have been fairly successful. The most important reason for this is that burial ground operations records were made and then kept. It is likely that an archive of memoranda and disposal location records pertaining to the first three years of Burial Ground 5 were destroyed in a building fire in 1961. Based on other records of the time, however, it is extremely doubtful that these destroyed records would have included detailed descriptions of waste characteristics. The principal advantage which these records would provide today would be detailed disposal site locations which could be correlated with waste stream process knowledge.

As at Burial Ground 4, information from disposal records associated with disposals of classified waste materials at Burial Ground 5 can have one of four possible impacts on Remedial Investigation activities at Waste Area Grouping 5. First, the information may confirm a particular source term which has already been identified in ground water sampling. Generally this will be limited to a radionuclide source term since this was the type of disposal data recorded in that burial ground operations period. Conversely, it is very unlikely that environmentally hazardous material will be identified in this disposal data. Again, the fact that environmentally hazardous material is not often shown in the disposal records of the era does not mean that such material is not present.

Second, the information may be of general interest in terms of disposal technique or other disposal aspects. That is, the information provides background information useful for other purposes than that of identifying environmentally hazardous material. For example, the packaging information in a disposal record may reveal that after thirty years in the trench, it is highly unlikely that any of the original packaging is intact. Instead, after thirty years it may be assumed with relatively little uncertainty that the leachable contaminants originally present in the waste materials have been leached from the disposal location. This can affect decisions involving the feasibility of various remedial investigation activities.

Third, the information may reveal previously unknown sources of hazardous environmental contaminants. It is possible that in a few specific disposals toward the end of the operations period, a chemical contaminant such as lead or caustic sludge may be identified. The usefulness of this information may be limited because quantity or other information is not also present.

Finally, the information may affect safety or physical security aspects of the disposal location. This is the most likely impact on the remedial investigation activities since the disposal data forms were primarily configured to record this type of information.

From an environmental protection viewpoint, further investigation of the Burial Ground 5 classified waste disposals associated with ORNL processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified ORNL environmental restoration documents,
- no waste management documentation exists which could provide better information regarding the environmental hazards of waste disposal at that location, and
- even though the waste was packaged at the time of disposal, the effects of the materials on the environment would have been manifest by this point, if they were to occur.

Further investigation of the early 1960s-era classified waste disposals associated with Mound processes are not likely to be productive for the following reasons:

- descriptions of these materials have been previously provided in unclassified Mound environmental restoration documents, and
- no waste management documentation exists which could provide better information regarding the environmental hazards of this waste (bismuth oxychloride liquid and sludge with a high basic pH, radionuclide contaminated lab waste).

While this waste was packaged at the time of disposal, it is inconceivable that packages did not deteriorate to failure very shortly after burial. The effects of the materials on the environment would have been manifest by this point, if they were to occur.

These conclusions are also valid for the waste accepted from other non-ORNL operations in the 1960s. Logically, therefore, any waste materials placed in Burial Ground 5 which would today be regulated under RCRA have already been identified if they are going to be identified. Further, if the location ground water sample wells are not now detecting regulated materials, it is highly unlikely that the classified material disposals of 1959-72 will be a new source of regulated materials. Finally, given the burial ground location, limited depth of burial, time since disposals were made, and climate characteristics of the area, leach rates of detected regulated materials placed in Burial Ground 5 should have reached steady state conditions after 25 years.

In only one case does the classified waste data from Mound indicate a waste which still could have serious impact on remedial activities. This is the disposal of NaK in stainless steel tanks. It is unlikely that this containment has failed. The material would be considered characteristically reactive. Assuming gradual leakage of the containment, environmental damage to the surrounding soil and material in the burial ground trench would be inconsequential; the amount of material involved in two

small tanks is insufficient to affect the White Oak Creek watershed. Subsurface remedial activities in the vicinity of this disposal, however, run the risk of suddenly puncturing the containment and exposing the NaK to moist air. Since the location of this disposal is known, this can be avoided. In perspective, the Oak Ridge AEC facilities used much larger quantities of this material which also would have been discarded in a similar manner in the burial ground. At least one burial ground fire has been attributed to the material; quarry disposal was initiated at the Y-12 Plant to prevent such occurrences.

The Mound waste stream is the most likely source of tritium appearing in Burial Ground 5 ground water sample wells (although ORNL also conducted tritium operations). While it is not credible that significant quantities of the isotope are present in the waste (it is an accountable strategic defense material), the chemical form of the material as a contaminant (in which the tritium atom replaces a hydrogen atom in water or oil molecules) is very difficult to contain, requiring several layers of confinement to prevent the spread of contamination. Even though the outer waste package containment (steel drums) may have failed with time, it may take longer for the other confinements to fail in a disposal site. It cannot be determined with any certainty which confinement materials would have been used in the 1960s and how the lab trash would have been packed. (Since the association of specific radioisotopes with Mound operations was classified at the time, the classification of this waste stream was such that no shipping documents or waste management information contain any descriptions of waste.) From knowledge of the tritium handling processes, however, internally contaminated scrap stainless steel tubing and equipment with plugged openings would be expected to be present as waste; this type of confinement would be relatively impervious to the effects of landfill disposal. As a consequence, it is possible that low levels of tritium will be measured in Burial Ground 5 ground water sample wells until several half-lives of the isotope have expired.

From a security classification viewpoint, the following logic process concerning the classified waste disposition at Burial Ground 5 can be made for waste from ORNL operations:

- most of the ORNL waste buried was unclassified at the time,
- the ORNL waste from naval fuel programs which was classified would still be classified, and
- for disposals after 1961, the specific location of concentrated amounts of SNM can be determined, but there does not appear to be a safeguards vulnerability associated with these disposals.

During 1959-1972, the laboratory reduced its classified cold-war missions to a low level; however, the disposal of solid waste materials from off-site classified defense programs was continued. The following logic process concerning the classified waste disposition at Burial Ground 5 can be made for waste from Mound operations:

- all the waste buried was classified at the time, but the Mound processes that would have generated the liquid and sludge waste have since been declassified,
- no evidence exists to indicate that accountable amounts of SNM were present as waste at Mound operations,
- some Mound operations prepared or handled classified weapon components,

- waste from these site operations is likely to have been sent to Burial Ground 5, and
- these weapon component designs have not been declassified.

It can be concluded, therefore, that environmental remediation activities may present a security vulnerability. Special procedures for conducting remedial activities will be required for the Burial Ground 5 locations where Mound waste is known to be buried.

Waste from the other non-ORNL sites containing classified information might still be classified depending on its source. Y-12 Plant may have sent scrap process equipment used in weapons component manufacture for disposal to Burial Ground 5. K-25 site probably sent scrap from its barrier production facilities. The weapon component designs have not been declassified, nor has the barrier technology. It can be concluded, therefore, that the potential for the presence of these wastes alone requires that specific security procedures be performed for the Burial Ground 5 locations where this waste is known to be buried prior to remediation activities. The NERVA project waste no longer contains classified information, but waste from other sites involved with naval fuel development may still contain classified information.

Subsurface remedial activities are unlikely to be approved in the vicinity of the disposal location of the residue from the nuclear weapon accident.

6.6 REFERENCES FOR SECTION 6 AND ADDITIONAL READING OF INTEREST

6.6.1 Waste Management File References

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SWSA-5 Logbook 1-3-61 to 3-20-62. Burial Ground 5 Notebook, entries from January 3, 1961 to March 20, 1962.

SWSA-5 Logbook 3-21-62 to 6-15-62. Burial Ground 5 Notebook, entries from March 21, 1962 to June 15, 1962.

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SWSA-5 Logbook 1-4-71 to 12-23-75. Burial Ground 5 Notebook, entries from January 4, 1971 to December 23, 1975.

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SWSA-5 Daybook 7-24-64 to 7-2-65. Supervisor's Daybook, entries from July 24, 1964 to July 2, 1964.

SWSA-5 Daybook 1-13-71 to 3-31-71. Supervisor's Daybook, entries from January 13, 1971 to March 31, 1971.

SWSA-5 Daybook 4-1-71 to 6-30-71. Supervisor's Daybook, entries from April 1, 1971 to June 30, 1971.

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SWSA-5 Daybook 10-18-71 to 2-16-72. Supervisor's Daybook, entries from October 18, 1971 to February 16, 1972.

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6.6.2 ORNL Laboratory Records File Documents

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ORNL Organizational Charts, Volume III, 1960 - 1980, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

6.6.3 ORNL Engineering Records Drawing Files

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E-18850. Burial Ground Grid System, Carbide and Carbon Chemical Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 4, 1954.

6.6.4 ORNL Engineering Records Survey Files

Petree 1995a. Compiled Computation Folder, Burial Ground 5, Number 1 and Number 2, A.H. Petree, September, 1995.

Petree 1995b. Compiled Computation Folder, Burial Ground 5, Number 3, A. H. Petree, September, 1995.

Petree 1995c. Compiled Computation Folder, Burial Ground 5, Storage in North Area, Number 1, A.H. Petree, September, 1995.

6.6.5 Special Notes

Note 1. Individual survey logbooks assigned to the radiation protection technicians assigned to the area which included Burial Ground 5 still exist, are nearly complete for the period 1959/1980, and are located at Laboratory Records under the names of the individual technicians. It is clear that burial ground contamination control surveys were routine and of comparatively little concern.

Note 2. The files are located with the ORNL Waste Management files at ORNL Laboratory Records. A summary of the information in these files is presented ORNL/S/INT-94/REV-1, ORNL Disposals of Off-site Waste (U), secret work sheet prepared 7/16/97, (S-RD).

Note 3. Detailed items of correspondence associated with this disposal are located with the ORNL Waste Management files at ORNL Laboratory Records and consist of the following:

- Memo from C.M. Hopper to H.B. Piper (U), 2/17/88 (S-RD)
- "Notes on Material Burial Problem" (U), 3/18/88, 3/21/88, and 6/14/89 (S-RD)
- "Report on Material Disposal" (U), Memo from C.M. Hopper to H.B. Piper, 1/30/89 (S-FRD)
- "Status of Review for Other Burial Materials and Our Burial Condition," Memo from H.B. Piper to C.M. Hopper, 2/20/89 (unclassified)
- "Review of Assumptions and Calculational Study Results of a Burial Concern"(U), Memo from C.M. Hopper to H.B. Piper, 2/24/89 (S-RD)
- Letter from Karen Daniels to H.B. Piper, 8/11/89 (unclassified)
- "Groundwater Monitoring for Radionuclides," 8/18/89 (unclassified)
- "Study of Buried Material at ORNL" (U), H.B. Piper, 9/8/89 (S-RD)
- "Material Burial at ORNL" (U), Letter to E. Owings from A.H. Hunter, 9/26/89 (unclassified)
- "Compliance with DOE Order 5480.5, Safety of Nuclear Facilities" (U), Letter from R.M. Westfall to O.B. Morgan, 6/2/93 (S-RD)
- "Compliance with DOE Order 5480.5, Safety of Nuclear Facilities" (U), Letter from O.B. Morgan to Dr. R.O. Hultgren, 9/20/93 (S-RD)

Note 4. The declassified bound volumes of these AEC 101 forms are located at Y-12 Plant Records. Duplicate copies are located with the ORNL Waste Management files at ORNL Laboratory Records.

Note 5. The ORNL Laboratory Records CF files were sorted for any record associated with H.F. Stringfield, the ORNL accountability representative for nearly twenty years. Each available record was examined for waste disposal references.

7. CLASSIFIED WASTE AT MODERN BURIAL GROUNDS (1971-85)

7.1 KNOWN HISTORICAL OVERVIEW

By the early 1970s, very little classified waste was being placed in permanent burial ground disposals at Oak Ridge National Laboratory. The laboratory no longer had classified missions which would generate classified waste, and documentation regarding the movement and placement of SNM was downgraded in classification level. The ORNL waste disposal operations had become administratively complicated, reflecting the advent of modern waste disposal regulations and the differences in type and suitability of ORNL solid waste matrices for landfill disposal. Waste was segregated for storage or disposal as determined from its isotope content, fissile material content, security classification of the waste matrix, and other considerations. Burial Ground 5 was segmented to account for this segregation. The southern area of Burial Ground 5 reserved for "low-level" waste had nearly been filled by 1970, and the bulk of the solid waste disposal operation was moved to Burial Ground 6 (SWSA-6) in early 1973. The southern sector of Burial Ground 5 (SWSA-5S) continued to be used occasionally for burial of non-transuranic waste materials until July 1973, as discussed in Sect. 6.

The northern sector of Burial Ground 5 (SWSA-5N) continued to be used for burial of transuranic waste materials until April 1982. After termination of permanent disposal operations, the location has been used for above- and below-ground storage of waste packages until the present. As far as can be determined from recorded information, no classified waste was buried in the transuranic waste sector of SWSA-5N.

In 1972 a small area of SWSA-5N was fenced and set aside for disposal of classified waste packages from off-site locations, but this area was rarely used for the disposal of classified waste. Instead SWSA-6 was usually used for the occasional classified waste disposal.

In 1980 correspondence to DOE, ORNL formally objected to the use of SWSA-5N and SWSA-6 for two disposals of classified waste from naval program sites, without success (Lenhard 1980a, 1980b, 1980c, 1980d, 1980e; Postma 1980a, 1980b). Eventually (~ 1985) DOE no longer authorized classified waste to be sent to ORNL from other sites.

7.2 DOCUMENTARY EVIDENCE

Considerable detailed information regarding permanent disposal of solid waste at SWSA-5N and SWSA-6 during this period (1971-1985) is available and has been archived for research and review. A detailed index of this information is available, but is not reproduced here because it contains little information regarding classified waste. The reason for this is (1) there are only about twenty known instances of classified waste disposals at ORNL since 1972, and (2) documentation about such disposals was deliberately suppressed to provide security protection for the waste materials.

Burial ground logs for Burial Ground 5 provide little information about the classified waste disposals made during this period. The last SWSA-5 log (SWSA-5 Logbook 1-4-71 to 12-23-75) was used to record disposals made to the north sector of Burial Ground 5 (SWSA-5N). As far as can be determined from the log and other records as well as anecdote, no classified waste was buried in the transuranic waste sector of SWSA-5N.

One trench disposal of classified waste (1975) is shown in that log for the small area of SWSA-5N that was fenced and set aside for disposal of classified waste packages from off-site locations. This trench disposal still contains classified waste. Another classified waste disposal from a different off-site generator was also placed in this trench, but it is not shown in the log. About five other disposals were made to auger holes in this classified waste disposal area, but are also undocumented in any of the waste management records. As far as has been determined at this time (1997), only small highly classified waste packages from Department of Defense projects were ever placed in this area. It is known anecdotally that the disposals were backfilled with concrete to prevent unauthorized recovery of the waste materials. Again anecdotally, descriptions of these waste materials involve military equipment such as electronics subjected to high radiation fields.

Similarly, burial ground logs for SWSA-6 provide little information about classified waste disposals. The first SWSA-6 log (SWSA-6 Logbook 1-27-72 to 10-11-74) was used to record the last disposals made to "fissile waste wells" and "fissile waste trenches" for the NERVA program in 1973. This was the last bulk classified waste stream accepted at ORNL disposal facilities from off-site generators. Two other disposals of a few drums each are shown for Bettis and Knolls Atomic Power Laboratories in this log. These are naval fuel development program wastes. SWSA-6 continued to be the disposal location for the occasional (~ once every other year or so) classified waste package from Bettis or Knolls. About five other disposals of small highly classified waste packages from Department of Defense projects were made to auger holes in SWSA-6, but are also undocumented in any of the waste management records. Again, it is known anecdotally that the disposals were backfilled with concrete to prevent unauthorized recovery of the waste materials, and the descriptions of these waste materials involve military equipment such as electronics subjected to high radiation fields.

SWIMS entries also record the data for the waste burial operations performed at SWSA-5N and SWSA-6. Since the SWIMS entries were prepared from burial ground log entries until some point in the later 1970s, the data are essentially the same as that in the logs, allowing for data entry error. Two versions of the SWIMS Mod I data base exist; one containing all the entries is located in the Waste Management files at Lab Records; one with all the known disposals of classified waste deleted is located at Waste Management Records (Bldg. 3001) for routine access. The routine access version uses the Knowledge Man[2] software to access the data and produce reports on demand. The complete SWIMS-I data base at Lab Records is accessed by FoxPro or Access software. The SWIMS Mod II and Mod III data base volumes were not separated into two versions because by the time SWIMS Mod II data entry began (1975), the disposal data for the few landfill disposals of classified waste after this time were generally not recorded in SWIMS.

A complete set of detailed engineering records concerning SWSA-5N and SWSA 6 exist. Thus, *when these coordinates have been recorded*, the location of a trench coordinate or auger hole can be readily located twenty-five years later. It is fairly clear from the fact that detailed disposal locations can be determined for classified AEC, ERDA, and DOE program waste packages but not for waste packages from highly classified Department of Defense generators, that the locations of the Department of Defense waste packages have been deliberately suppressed in ORNL unclassified documentation as a security protection measure. In general, as far as can be determined, the exact locations after January 1972 for these packages can no longer be ascertained except by those personnel who supervised the disposals. ORNL no longer retains classified documents or security clearances at the level of classification of the waste packages.

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[2]Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof.

The Isotope Sales Department continued to handle the correspondence between ORNL and the off-site waste generators for burial ground services. Isotope Sales documents dealing with solid waste for SWSA-5N and SWSA-6 were turned over to the ORNL Waste Management and Remedial Action Division when the disposals of waste from outside the Oak Ridge Reservation ceased in 1985 (Note 2, Sect. 6.6). These files show 15 AEC authorized disposals of classified waste to SWSA-5N and SWSA-6, covering the period from 1973 to 1985. The bulk of the shipments came from the NERVA rocket engine program. A review of SWSA-5N and SWSA-6 logs and SWIMS data indicates that the Isotope Sales files do not represent the complete number of disposals from outside the Oak Ridge Reservation; a good estimate is that the documents for another five disposals from 1973 were either not handled by the Isotope Sales Department or have been suppressed. However, these existing files do provide the most comprehensive view of the classified materials still available.

As noted previously, by 1980 ORNL management began to formally object to classified waste disposition at essentially unprotected disposal areas. About 1985, policy changes at the local DOE operations office precluded further disposal of classified waste at ORNL disposal areas from off-site generators.

Only one other instance of classified waste disposal at ORNL facilities is known after 1985. During remediation of the K-25 White Wing Scrap Yard, items with the potential for containing classified information were removed from the site and placed in SWSA-6. The scrap yard never had any documentation.

7.3 CONCLUSIONS

Attempts to identify permanent disposals of classified solid waste at SWSA-5N and SWSA-6 have been fairly successful. The most important reason for this is that burial ground operations records were made and then kept. These records can be correlated with Isotopes Sales records of the period. The records show that little classified solid waste was placed at either location from 1971-1985. Classified waste was essentially no longer generated at ORNL and bulk disposals of classified waste from other sites ceased by 1973. Only occasional disposals of classified waste occurred from 1974 to 1985.

From an environmental protection viewpoint, further investigation of the SWSA-5N and SWSA-6 classified waste disposals at ORNL are not likely to be productive for the following reasons:

- descriptions of materials from AEC, ERDA, and DOE programs have been previously provided in unclassified ORNL environmental restoration documents,
- descriptions of materials from Department of Defense programs indicate that the waste quantities are small and the waste is not environmentally hazardous,
- no waste management documentation exists which could provide better information regarding the environmental hazards of waste disposal at that location, and
- even though the waste was packaged at the time of disposal, the effects of the materials on the environment would have been manifest by this point, if they were to occur.

From a security classification viewpoint, the following logic process concerning the classified waste disposition at SWSA-5N and SWSA-6 can be made for waste from ORNL operations:

- most of the ORNL waste buried in the two burial grounds was unclassified at the time,
- the ORNL waste from naval fuels programs which was classified would still be classified,
- the specific location of concentrated amounts of SNM from ORNL can be determined,
- but there does not appear to be a safeguards vulnerability associated with these disposals.

Waste from the other non-ORNL sites containing classified information might still be classified depending on its source. Items from the K-25 White Wing Scrap Yard have not been declassified. The NERVA project waste no longer contains classified information, but waste from other AEC, ERDA, and DOE sites involved with naval fuel development may still contain classified information. The waste from the Department of Defense programs is still classified.

It can be concluded, therefore, that the potential for the presence of these wastes alone requires that specific security procedures be performed for the SWSA-5N and SWSA-6 locations where this waste is known to be buried prior to remediation activities. Unlike classified waste disposals at the other ORNL solid waste burial grounds, the exact sites of these disposals can be identified, so the impact on remedial activities at either of the two burial grounds should be minimal.

7.4 REFERENCES FOR SECTION 7 AND ADDITIONAL READING OF INTEREST

Lenhard 1980a. J.A. Lenhard to Dr. H. Postma, correspondence, subject: Burial of Navy Classified Waste, Department of Energy, Oak Ridge, Tennessee, February 19, 1980.

Lenhard 1980b. J.A. Lenhard to Dr. H. Postma, correspondence, subject: Burial of Navy Classified Waste, Department of Energy, Oak Ridge, Tennessee, March 27, 1980.

Lenhard 1980c. J.A. Lenhard to Dr. H. Postma, correspondence, subject: Acceptance of Transuranic Contaminated Waste from KAPL, Department of Energy, Oak Ridge, Tennessee, October 17, 1980.

Lenhard 1980d. J.A. Lenhard to Dr. H. Postma, correspondence, subject: Acceptance of Transuranic Contaminated Waste from KAPL, Department of Energy, Oak Ridge, Tennessee, November 24, 1980.

Lenhard 1980e. J.A. Lenhard to Dr. H. Postma, correspondence, subject: Acceptance of Transuranic Contaminated Waste from KAPL, Department of Energy, Oak Ridge, Tennessee, December 16, 1980.

Postma 1980a. H. Postma to J.A. Lenhard, correspondence, subject: Request for Burial of Navy Waste, Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 21, 1980.

Postma 1980b. H. Postma to J.A. Lenhard, correspondence, subject: Acceptance of Transuranic Contaminated Waste from KAPL, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24, 1980.

SWSA-5 Logbook 1-4-71 to 12-23-75. Burial Ground 5 Notebook, entries from January 4, 1971 to December 23, 1975.

SWSA-6 Logbook 1-27-72 to 10-11-74. SWSA-6 Notebook, entries from January 27, 1972 to October 11, 1974.

Y/DS-196. *Inventory of Disposals Conducted at ORNL Burial Sites from the Y-12 Plant (U), February 1957 through August 1983*, Product Optimization Department, Y-12 Plant, Oak Ridge, Tennessee, June 29, 1984. Declassified.

8. RELEVANCE OF CLASSIFIED WASTE TO CERCLA DECISIONS

Remedial investigation documents have been prepared for CERCLA-regulated sites in both the Melton Valley and Bethel Valley watershed areas of ORNL. These documents refer to the classified waste disposals made at the solid waste burial grounds and point to the uncertainty associated with these disposals as possibly being a factor in regulatory decision making.

8.1 RELEVANCE TO RISK EVALUATION

This report shows that the disposals of classified waste should not be factor in making either general or specific decisions about remedial activities. Indeed, it answers specific questions which have been asked about the effect of the presence of classified waste on such decisions.

1. Is a classified report detailing the locations of classified waste necessary? To answer this question, several other questions need to be asked. Would such a report contain the known or potential locations of waste that was *classified at the time of disposal*? If so, nearly all the burial ground disposal locations except most of SWSA-5N and SWSA-6 would be so designated. Would such a report contain instead only the known or potential locations of waste that is *still classified at the present time*? If so, an accurate knowledge of the type, quantity, and disposal location of each formerly classified item would be needed as well as a formal evaluation of its status by security managers. After reading Sects. 2-7, it should be clear to the reader that this will not be possible. In short, there is not enough accurate information available to prepare a classified report that would be of any value to regulatory decision making. Instead, if some action is proposed for a particular area of a burial ground, the available records can now be quickly searched to determine if the presence of classified waste will need to be a planning factor.

2. What is unique about classified wastes? After reading Sects. 1-7, it should be clear to the reader that there is nothing unique about classified waste from an environmental hazard viewpoint. Classified waste is simply waste that contains information that is restricted by security managers. It may or may not have contained a hazardous component at the time of disposal. It may or may not still contain a hazardous component after years of exposure in the burial location. In most cases, the chemistry associated with classified waste has been discussed generically in unclassified reports. Should it be desired, the details of the chemistry associated with a specific classified process or waste form may be discussed directly by regulatory managers with ORNL security managers using the specific classification guides for reference. For example, should details of naval fuel process chemistry be required for environmental regulatory purposes, cleared regulatory personnel can simply arrange to be given a briefing to assure themselves that any potentially hazardous materials in a waste stream have been identified.

3. Are the risk assessments that have been performed adequate? The answer to this question is that the risk assessments are as accurate as they can be made. They can only be as accurate as the information used to produce them; and from the limitations of the waste information shown in Sects. 2-7, it is clear that much more information might be desirable. This is true of both the unclassified waste information as well as the classified waste information. The limitation of the classified waste data is not in the security classification; it is the fact that the information was never accurately recorded or archived at the time of disposal. In short, to have more accurate information will require excavation and examination of the waste. Whether or not the risk assessments are adequate depend upon what action is planned. For the foreseeable remediation alternatives, the

existing risk assessments are adequate; it is highly unlikely that the presence of classified waste at a particular location will affect the risk of performing or not performing a particular activity.

4. Do the remedial investigation reports contain all the pertinent CERCLA information? Again, the answer is that reports are as accurate as they can be made. For the foreseeable remediation alternatives, the existing reports contain the pertinent information; it is highly unlikely that the presence of classified waste at a particular location will affect the decisions to perform or not perform a particular activity.

5. How well do the remedial investigation reports cover the rationale for the uncertainty with classified data? The question assumes that there is an acceptable level of certainty in the data associated with unclassified waste disposals made at the same time as the classified waste disposals. As has been shown in Sects. 2-7, the original information sources for both unclassified and classified waste disposals are essentially the same, originally prepared by the same persons, and have the same level of uncertainty. The only difference in the data is that the unclassified information has been given uncontrolled release. The pertinent information for classified information has, in almost all cases, been released nonspecifically. The remedial investigation reports were prepared by personnel without security clearances and the classified data had not been centralized and correlated at the time those reports were in preparation. This report provides the full perspective that could not be provided in those remedial investigation reports.

8.2 RELEVANCE TO REMEDIAL ACTIONS

This report shows that the disposals of classified waste will be a factor in the planning of remedial activities at the CERCLA sites. For some types of activities, they will affect how the activities are performed. The effect of the disposals upon remedial activities will be dependent upon the location and type of proposed activity.

As shown in Sects. 2-7, it is highly unlikely that there is a short -term or long-term threat from the presence of classified waste at a site that is simply being monitored. The original purpose of placing the waste in the disposal trench or auger hole was to isolate the waste safely from the biosphere. In general, from a hazardous material viewpoint, this seems to have been successfully accomplished, and the residual environmental threat is seen to be the dispersion of radionuclides. It is conceivable that small amounts of hazardous material originally buried in high integrity packaging might be released at some point in the future. However, the older the disposal, the less likely such packaging would have been used or is still intact; and the newer the disposal, the more likely the exact location of such a disposal would be known for monitoring. In any case, for example, if a glass carboy of spent acid should suddenly fail fifteen feet below the surface, it is not likely that the effect of such a small release would be noticeable. Logically, this threat must also exist for the unclassified waste disposals at the same CERCLA site.

For sites at which ground penetration activities are planned, the threat is similar but site dependent. Activities at locations where disposals were made after about 1965 can avoid classified waste disposals, since in general the exact location of such a disposal would be known. Activities at locations where classified disposals were made prior to this time run a greater risk of impacting an unreleased hazardous material. Again, logically this threat also exists for the unclassified waste disposals at the same CERCLA site. Clearly the precautions taken to protect the workforce or the environment during such activities would be similar if not identical. It can be concluded therefore that the classified waste data does not measurably contribute to the degree of uncertainty stated in the

remedial investigation risk assessments. Again, the risk assessments are as accurate as they can be made. They can only be as accurate as the information used to produce them; and from the limitations of the waste information shown in Sects. 2-7, it is clear that much more information might be desirable. This is true of both the unclassified waste information as well as the classified waste information. Interestingly enough, when the overall data base is examined, more is known about classified disposals than about unclassified disposals. This is because most of the waste deposited in the burial grounds was transferred by "dumpster;" only unusual disposals required specific data such as radionuclide or billing data. Classified waste disposals, particularly those from other sites tended to be unusual disposals, requiring specific data to be obtained by burial ground supervisors. Hence, the classified data has no effect on the risk assessment uncertainty.

The principal effect that the presence of classified waste will have on remedial activities is administrative. During the planning phase, a security vulnerability analysis will be required. This is performed by security management personnel and takes place in about 90 days; a formal report is issued. If the assessment concludes that the proposed activities represent a security vulnerability (e.g., an excavation of an area in which classified waste is suspected to be present), the remedial activity planning must include a formal security plan and specific security procedures, approved by the security managers. Such a plan typically requires that the remedial activity area be isolated, guard patrols activated, and actual activity work performed by cleared personnel. Usually, the waste will be examined for classified information by a cleared knowledgeable person as it is excavated. Waste found to contain classified information would be segregated and secured for later classified storage and disposal.

8.3 CONCLUSION

This report has summarized in an unclassified format what is known and not known about the disposal of classified solid waste materials at specific CERCLA sites at ORNL. The summary has been prepared to remove as much confusion as possible about disposals of classified solid waste materials. For future reference and further detailed research in specific areas of regulatory interest, the report has indicated where details of classified solid waste material disposals have been archived. Document lists have been included for each burial ground location.

Previously prepared remedial investigation reports have described the risks and requirements associated with CERCLA activities at burial ground locations affecting the Melton Valley and Bethel Valley watersheds. This report has demonstrated that logically there is no significant additional environmental protection vulnerability resulting from the disposal of classified solid waste materials. In addition, the report has indicated where administrative requirements and restrictions to any proposed remedial activities will be necessary.

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