PROJECT TASKS 3 & 4

#4032

Health Studies on ROCKY FLATS

PHASE I: HISTORICAL PUBLIC EXPOSURES

FINAL DRAFT REPORT

Reconstruction of Historical Rocky Flats Operations & Identification of Release Points

ChemRisk

COLORADO DEPARTMENT OF HEALTH

Prepared by ChemRisk for the Colorado Department of Health

PROJECT TASKS 3&4
FINAL DRAFT REPORT

RECONSTRUCTION OF HISTORICAL ROCKY FLATS OPERATIONS & IDENTIFICATION OF RELEASE POINTS

AUGUST 1992

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EXECUTIVE SUMMARY

The goal of Task 3 of the Toxicologic Review and Dose Reconstruction Project is to describe the history of operations at the facility as it might relate to off-site exposures. Task 4 activities support the characterization of emission points for releases to the environment. Tasks 3 and 4 involved extensive investigations to address project needs for information describing past operations of the Rocky Flats Plant. The specific objectives of Tasks 3 and 4 are:

- Document the history of the Rocky Flats Plant relevant to off-site releases.
- Describe the historical uses of the materials of concern.
- Further evaluate the potential for release of the materials of concern selected as a result of Task 1 and 2 activities.
- Identify release points for the materials of concern from routine and non-routine (accidental) operations.

This Task 3 and 4 report is divided into the following sections:

Section 1.0 - Introduction to Task 3 and 4 activities.

Section 2.0 - Description of the investigative process used.

Section 3.0 - A general history of routine plant operations.

Section 4.0 - Historical use profiles of the materials of concern.

Section 5.0 - Historical release points of the materials of concern.

Section 6.0 - Historical non-routine (accidental) operations.

Section 7.0 - Summary and conclusions.

Appendices - Interview process (interviewees, questions and preparation).

An index to locate topics of interest which are discussed in the report and a glossary of terminology are provided following Section 7.0. A draft version of the Task 3 and 4 Historical Operations and Release Points Report was reviewed by the Health Advisory Panel, regulatory agencies, plant employees and retirees, and members of the public. Comments received as a result of these reviews resulted in revisions that have been included in this report.

Extensive reviews of information repositories located both on and off the plant site have demonstrated that the mission of the Rocky Flats Plant has remained essentially unchanged since its initial operation until the shutdown of plutonium operations in 1990. Although the plant has grown in physical size, the nature of the processes and the general types of materials used in these processes have remained largely the same since the 1950s. However,

environmental health and safety practices have changed to meet new regulatory requirements. The historical investigation did not identify any additional materials of concern beyond those selected in Task 2.

Environmental monitoring was instituted prior to plant construction and has continued on an ongoing basis since initial plant operation. The initial plant designs included effluent filtering and treatment systems and surface water retention ponds to control radionuclide releases. The records clearly indicate a recognition of the need to control and limit radionuclide releases since the beginning of plant operations, driven by a combination of economic, national security, and health concerns. The extensive reviews failed to identify any historical evidence of undocumented or unmonitored routine airborne releases of radionuclides from the plant to the off-site environment, and this was also generally true for waterborne releases with a few exceptions. In contrast to the extensive monitoring program conducted for airborne releases, the plant typically monitored only known release points of liquid effluents.

Some materials were included on the initial Task 2 list of materials of concern because no information was immediately available concerning the nature of their use and associated potentials for release. Even after the extensive searches and interviews performed as part of this Task 3 and 4 effort, uses of four materials at the plant could not be documented. These materials are benzidine, ethylene oxide, propylene oxide, and 1,3-butadiene. Documentation of the uses and potentials for release of nine other materials of concern indicates that they do not warrant further quantitative evaluation of potential off-site exposures. These materials are benzene, formaldehyde, hydrazine, nitric acid, and compounds of cadmium, chromium, lead, and nickel. The twelve remaining materials of concern, which include seven chemicals and five radioactive elements and their isotopes, will be the subject of the project Task 5 source term development process based on knowledge of their historical uses and routine and accident-related emission sources.

Airborne emission points for each material of concern are described in this report. Surface water emissions have been associated primarily with releases from the terminal surface water retention ponds on the plant site, which have received some plant effluents as well as site runoff. Releases of contaminants to the groundwater may have resulted from seepage from retention or evaporation ponds and from various waste disposal activities or spills.

Review of historical accidents and incidents at the plant site led to the identification of voluminous amounts of information documenting numerous small fires, spills, injuries, and incidents leading to property damage. However, none of the documentation indicated the occurrence of any previously unreported major events potentially impacting the off-site public. Major events of potential interest are those that were studied and publicized following the May 11, 1969 fire in Rocky Flats Buildings 776 and 777, namely the 1957 fire in Building 771 and the resuspension of plutonium contaminated soil from the 903 pad.

1.0 INTRODUCTION

The U.S. Atomic Energy Commission announced its decision on March 23rd of 1951 to build the Rocky Flats plant (Buffer, 1991). The plant was built to increase the quantity and quality of the nation's nuclear arsenal, and has played an important role in the U.S. nuclear weapons complex in the years that have followed. Early plant operations were for the most part kept behind a "cloak of secrecy", with the main off-site concern being centered around two fire incidents in 1957 and 1969 that received public attention, an inadvertent release of tritium to surface waters in 1973, and a waste storage practice that resulted in the spread of contamination to nearby soil during the late fifties and sixties. After the 1969 fire, the public learned for the first time that plutonium had been released routinely and accidently from the plant. In 1984, the site was proposed to be a Superfund site, and in 1989, it was included on the National Priorities List for cleanup of environmental contamination.

Public concern came to a high point in June of 1989 when approximately 100 FBI and EPA agents raided the plant seeking documentation of alleged criminal acts and mismanagement. The Department of Energy subsequently suspended plutonium processing to review and upgrade the plant's safety systems. Following the raid, Colorado's Governor Roy Romer negotiated with Energy Secretary Admiral James Watkins to secure funding for closer scrutiny of the plant's activities by the State to reassure concerned citizens and for health studies to address the public fears of potential health effects.

In June of 1989, an Agreement in Principle was signed by Governor Romer and Secretary Watkins which included DOE funding for increased environmental surveillance and oversight, remediation, emergency preparedness measures, accelerated cleanup in areas of imminent threat, and health studies. Phase I of the health studies is now underway in the form of the Toxicologic Review and Dose Reconstruction study being conducted by ChemRisk for the Colorado Department of Health.

1.1 The Rocky Flats Toxicologic Review and Dose Reconstruction Project

The primary purpose of this project is to reconstruct doses of the materials of concern received by off-site individuals as a result of past Rocky Flats Plant operations. Two points should be emphasized regarding the project scope. First, this project is designed to address exposures from historical operation, not to estimate doses from present and future operations or anticipate future exposure potentials. Secondly, this project is concerned with doses to individuals off the plant site, as opposed to occupational exposures to plant workers. Information pertaining to work-place exposures or control devices will in general only be considered if it is also relevant to prediction of off-site releases or exposures. The

period of interest for this study begins in April, 1952, when "operations began on regular production materials" (Buffer, 1991), and covers the 453 months of plant activities through calendar year 1989.

The Toxicologic Review and Dose Reconstruction Project is broken into the twelve tasks depicted in Figure 1-1. The first several tasks center around what was thought to be the most important contribution that the project could make to further understanding of the potential health impacts of the Rocky Flats Plant, that being a more comprehensive look at all the materials and amounts of materials which have been used at the plant since 1952.

1. Identify Chemicals & Radionuclides Used
2. Select Materials of Concern
3. Reconstruct History of Operations
4. Identify Release Points
5. Estimate Source Terms
6. Select and Model Exposure Pathways
7. Characterize Land Uses and Demographics
8. Perform Dose Assessment
9. Prepare Computerized Database
10. Prepare Annotated Bibliography
11. Assemble Information Repository
12. Provide for Scientific Oversight and Public Involvement

FIGURE 1-1: TASKS OF THE ROCKY FLATS TOXICOLOGIC REVIEW AND DOSE RECONSTRUCTION PROJECT

Task 1 involved identification of the chemicals and radionuclides that have been used on the Rocky Flats site. Unlike some similar dose reconstruction studies which have been undertaken for federal nuclear facilities, this project is concerned with not only radionuclide emissions, but also releases of hazardous chemicals and mixed wastes that are both radioactive and chemically hazardous. To identify the materials used on the site, the ChemRisk team first reviewed radioactive source registries and inventories and chemical inventories produced by the plant staff. The chemical inventories included thousands of chemicals present in very small quantities and some chemicals used in very large quantities.

Examples range from 4 milliliters of vinyl chloride kept in a laboratory refrigerator to over 400,000 pounds of nitric acid used at the plant each year. Classified and unclassified records were also reviewed for evidence of other materials used on the Rocky Flats site. The result of Task 1 was a list of over 8000 materials used on the Rocky Flats site (ChemRisk, 1991a).

The objective of **Task 2** was to select the chemicals and radionuclides that were most likely to have posed an off-site human health hazard under historical routine plant operations. Radionuclides that have been included as materials of concern are all those which were handled in substantial quantity, were associated with production activities, were found in forms that are likely to be released, or were found to be present in plant effluents or in the environment. With the exception of tritium, monitoring data are consistent with the release of only the main production radionuclides from the facility. Tritium is included as a material of concern primarily because of a well-publicized incident in the early 1970s involving off-site release of tritium.

For chemicals, a three-stage screening process was developed to narrow down the list of potential materials of concern. In the first stage, 629 compounds were identified for further, more refined screening as potential materials of concern based on their known toxicologic properties, Rocky Flats release histories, or reported inventory quantities. A second stage of screening was performed to roughly estimate if the quantity of a chemical on-site was sufficient to pose an off-site health hazard. Forty-six potential chemicals of concern emerged from Stage 2 Screening. In the final stage of screening, these chemicals were individually evaluated to determine the likelihood of their release and potential quantity of release based on actual storage and usage practices, likely routes of release, and known behavior in the environment.

Using both qualitative and quantitative screening criteria, and taking into account preliminary knowledge of actual storage and usage practices, it was believed that the materials of concern in Table 1-1 could have potentially been associated with off-site impact from normal operations of the Rocky Flats Plant (ChemRisk, 1991b). The list of materials of concern has not been cast in stone. As the project continues, any newly identified compounds will be evaluated for possible addition to the list of materials of concern. The grouping of the materials of concern in Table 1-1 as Solvents, Metals, or "Others" reflects some knowledge about the most commonly encountered forms of some of the materials, but should not be taken to indicate any assumptions that will be made by the project team in investigating material uses. For example, although chromium is a metal, it will be evaluated in all elemental or metallic forms encountered at Rocky Flats, including salts, ionic solutions, and any other forms revealed during records reviews or interviews.

Pesticides and herbicides have also been used on the site. These materials are not unique to the plant and are not directly related to production processes at the facility. However, the historical presence of these compounds in holding ponds on the site has been the subject of public concern. For this reason, pesticides and herbicides were retained as a group of compounds to be further addressed in this study, but not as materials of concern.

TABLE 1-1: MATERIALS OF CONCERN AS SELECTED IN TASK 2

SOLVENTS	METALS	OTHERS
Benzene	Americium-241	Benzidine
Carbon Tetrachloride	Beryllium	1,3-Butadiene
Chloroform	Cadmium	Ethylene Oxide
Methylene Chloride	Chromium	Formaldehyde
Tetrachloroethylene	Lead	Hydrazine
1,1,1-Trichloroethane	Mercury	Nitric Acid
Trichloroethylene	Nickel	Propylene Oxide
	Plutonium-238,239,240,241,242	Tritium
	Thorium-232	
	Uranium-233, 234, 235, and 238	

Concurrent with the work on identifying materials used on the Rocky Flats site, efforts were underway on **Task 3** activities to recreate the history of operations at the facility as it might relate to off-site exposures and on **Task 4** activities to characterize the emission points for associated releases to the environment (ChemRisk, 1990). **Tasks 3 and 4** of the Rocky Flats Toxicologic Review and Dose Reconstruction Project involved extensive historical investigations to address project needs for information describing past operations of the Rocky Flats Plant. The objectives of the historical investigation are to:

> Document the basic history of the Rocky Flats facility, outlining its physical development and its historical mission,

Document the nature of historical uses of the materials of concern that were identified in Project Task 2,

Identify any significant historical material uses not evaluated as part of the Task 2 selection of materials of concern,

Identify potential points of significant release of materials of concern to the air, surface water, or soil,

To support work to be performed in Project Tasks 5 and 6 by characterizing the potential for the existence of significant uncontrolled radionuclide emissions from normal operations in the past that may have gone undetected by effluent monitoring systems, and to

Identify any accidents, incidents, or waste disposal practices that resulted in contaminant releases with significant potential for off-site transport, also for use in Tasks 5 and 6.

The investigations consisted of an extensive campaign of document reviews and interviews targeting active and retired Rocky Flats employees, local citizens, and other interested parties. The major outcomes of this investigation are an understanding of the historical uses of the materials of concern, identification of accidents which warrant detailed evaluation, and documentation of the nature of associated emission points. This report summarizes the results of these Task 3 and 4 investigations.

1.2 Documentation of Rocky Flats History

The Task 3 and 4 historical investigation is not intended to be a complete history of the Rocky Flats Plant, but rather a documentation of historical plant operations and the identification of release points for chemicals and radionuclides which may have been released to off-site areas. Task 5 activities are aimed at developing estimates of source terms (release quantities) for the materials of concern using the historical information obtained as a result of Task 3 and 4 activities. Relevant exposure pathways for the materials of concern will be selected in Task 6. In addition, the source term estimates from Task 5 will be used to model the transport of the materials of concern to off-site locations in Task 6.

The ChemRisk investigation of Rocky Flats history can be conceptually divided into the areas shown in Figure 1-2. The investigative process that was designed to address these key aspects of Rocky Flats history is described in detail in **Section 2** of this report.

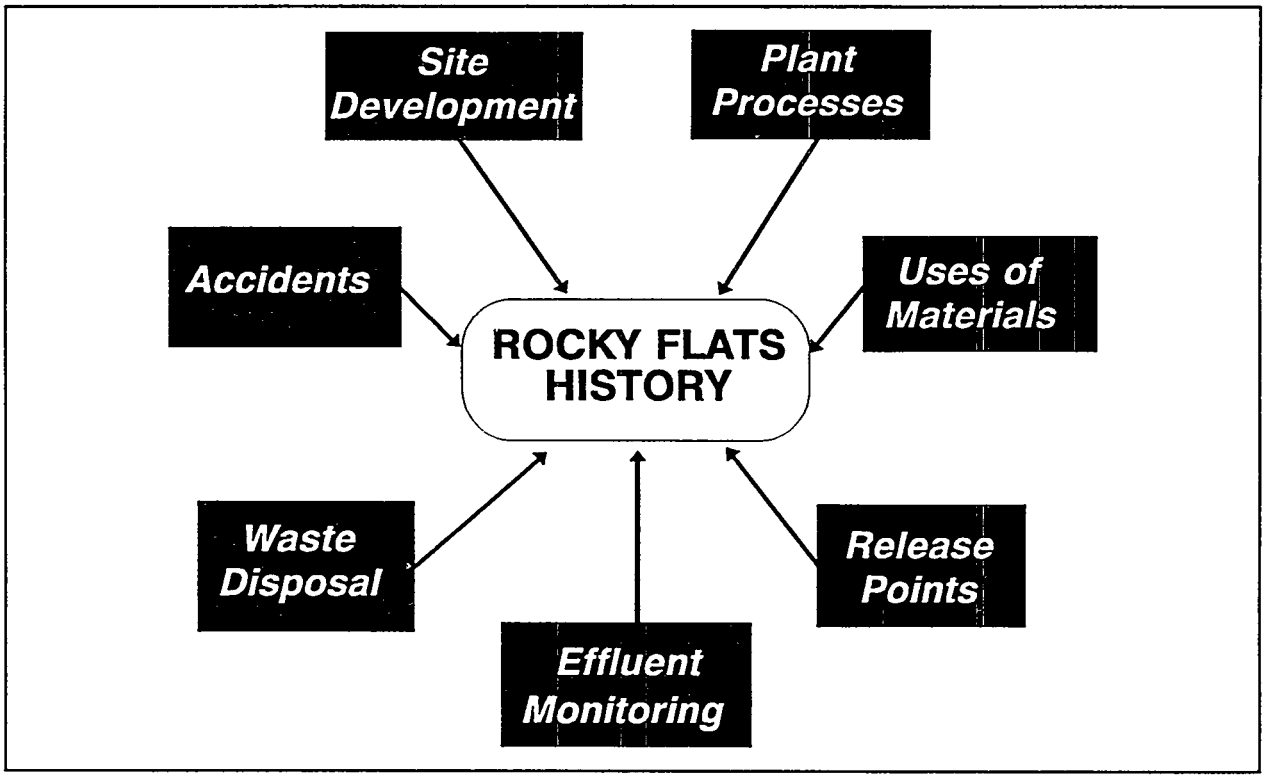

FIGURE 1-2: ELEMENTS OF THE ROCKY FLATS HISTORICAL INVESTIGATION

Site development details were gathered from many varied records, from personnel interviews, and from inspection of aerial photographs. The general history of the development of the Rocky Flats Plant and the evolution of the facilities and processes used at the site to support fulfillment of the mission of the plant are described in **Section 3**.

Current-day plant processes are described in recent unclassified reports prepared for each building to characterize airborne emissions and waste streams. These reports provide a level of detail generally adequate to support a preliminary understanding of uses of key materials. The big challenge has been to go backwards in time and describe how processes and facilities have changed over the years as material substitutions were made and better technology became available.

Uses of the materials of concern were first characterized based on the air emission and waste stream reports mentioned above, chemical use inventories, and other plant records. Interviews and inspections were then used to add to the picture of how each material has been used. Historical profiles of the uses of each material of concern are contained in **Section 4.**

Materials were routinely released to the environment from Rocky Flats via numerous airborne release points and several series of surface water ponds. Historical practices related to release of materials to the environment are described in **Section 5**, as are treatment and monitoring practices that have been applied to each release point.

There are records of numerous waste disposal sites within the Rocky Flats Plant boundary. While most hazardous and radioactive wastes are shipped off-site for disposal, there remain about 178 inactive waste sites within the plant boundaries, some of which have been the sites of burial, incineration, and land application. Chemical and radioactive contamination has spread to the ground water, has been released to soils, and has resuspended to the air and to wider areas of ground surfaces. These disposal practices have not necessarily resulted in off-site exposures to members of the public, but are being documented and evaluated as part of this project.

Accidents, incidents, occurrences, and "as-found conditions" of many types have been documented at Rocky Flats over the years. Details of the investigation of Rocky Flats accidents and incidents are contained in **Section 6**. Lists have been compiled of hundreds of accidents of widely varying significance, ranging from cut fingers to major fires in 1957 and 1969. Information evaluated to-date indicates that three major incidents warrant detailed evaluation as part of this study. These three incidents are the 1957 fire, the 1969 fire, and the 903 pad release. In evaluating the effects of releases associated with the identified accidents, consideration is not being limited to the selected Materials of Concern. All identified constituents of the releases will be evaluated as part of the Task 5 source term assessment process.

The Draft Task 3 and 4 Report was reviewed by the Health Advisory Panel, members of the public, regulatory agencies such as CDH and EPA, and by several plant historians for accuracy. These comments were addressed and individual responses were sent to each person or organization. All corrections and many of the suggestions for improvement made by the various reviewers were incorporated into this final version of the report.

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ChemRisk (1991a). Task 1 Report (R1), Identification of Chemicals and Radionuclides Used at Rocky Flats. Repository Document TW-362.

ChemRisk (1991b). Task 2 Report, Selection of the Chemicals and Radionuclides of Concern. Repository Document TA-723.

2.0 DESCRIPTION OF THE INVESTIGATIVE PROCESS

To date, a general history of the Rocky Flats Plant has not been prepared by the Department of Energy or the various plant contractors. ChemRisk was tasked to create a historical account of facility development and operational processes and practices to support characterization of material uses and estimation of associated emissions. The addition of this information to a general history of the Rocky Flats Plant may be one of the most important contributions of the Toxicologic Review and Dose Reconstruction Project, in that it will serve to further public understanding of historical operations at the facility. The historical knowledge of plant activities will also serve as the basis for the source term (Task 5), transport and pathway modeling (Task 6), and dose assessment (Task 8) that will translate the historical investigation results into a realistic assessment of off-site exposures and shed light on the potential for any public health impacts.

ChemRisk has approached the characterization of Rocky Flats history, and addressed the public perceptions of unreported activities leading to possible off-site hazards, through an extensive program of document reviews and personnel interviews that is described in the following pages. It should be noted that document databases were searched in the most efficient yet comprehensive manner possible. For example, appropriate keywords were often defined during the data entry process and were often different for each database. Therefore, searches were conducted using keywords which most closely matched the subjects of interest for a particular database. In all cases keywords were chosen that incorporated Rocky Flats Plant terminology to ensure that document lists would be as complete as possible.

2.1 Review of Classified and Controlled Access Records

The project team for historical investigations included individuals with Department of Energy "Q" clearances. Team members with Q clearances were given access to all areas of the plant, and were not denied access to any information sources specifically requested for review. Locations of the information sources on the Rocky Flats site that were most important for the historical investigations are shown in Figure 2-1. Searches were performed in the two centralized areas of the plant where documents are officially stored, the Building 706 Technical Library and the Building 881 Archives. Through the interview process, team members were made aware of other useful documents that might not have made it into the 706 library or the 881 archives.

The library and archives hold an enormous amount of documentation, most of which is not of interest to the Project. A large fraction of the records that were found were detailed production records, research and development reports, and weapons stockpile analyses. Not

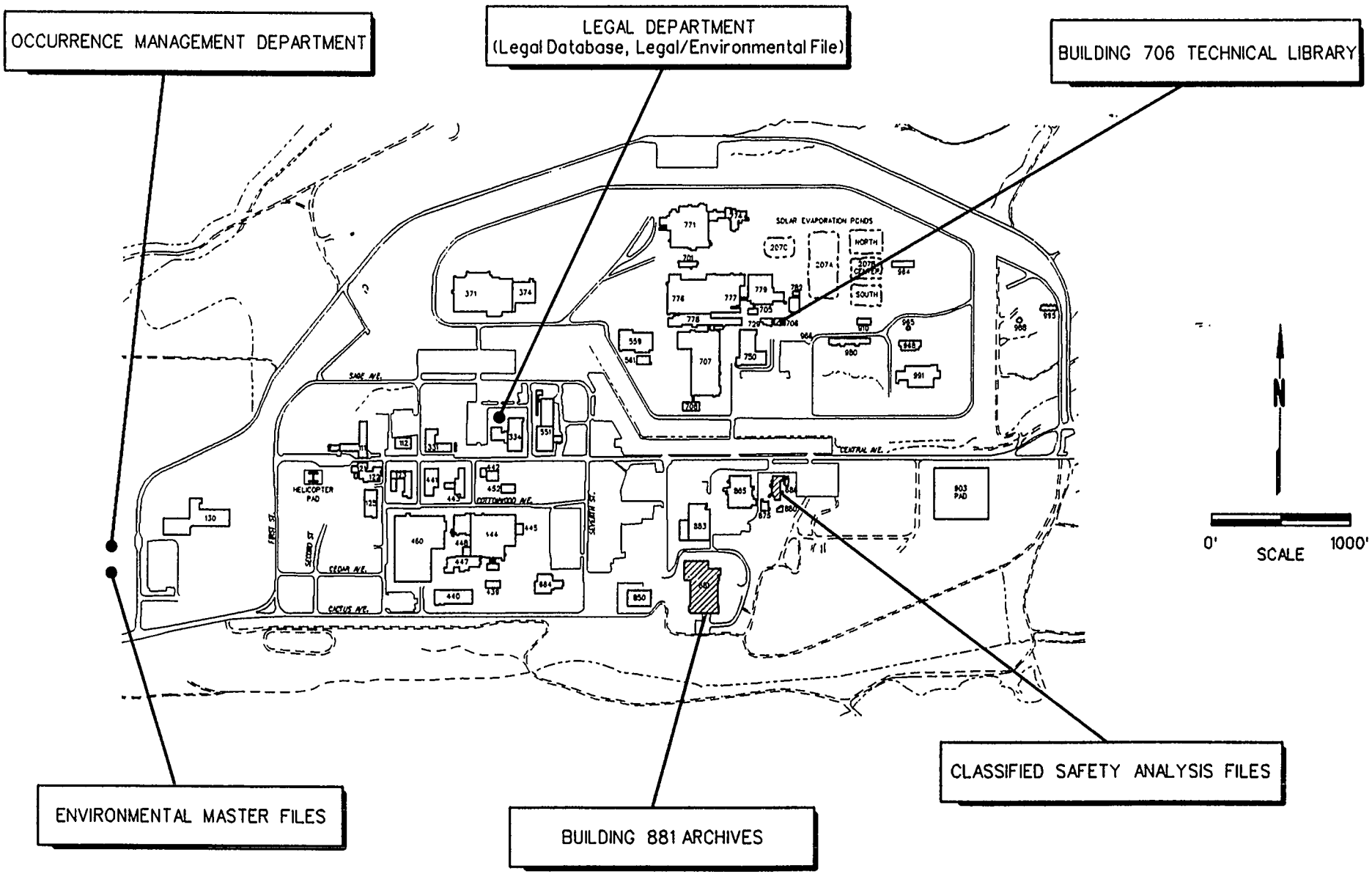

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FIGURE 2-1
ROCKY FLATS FACILITY MAIN
ON-SITE INFORMATION SOURCES

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every document filed at Rocky Flats was read in its entirety, rather the repositories were systematically searched using both directed and random techniques to optimize review of relevant information within the time and budget available to this phase of the project.

2.1.1 The Building 706 Technical Library

At the Building 706 Technical Library, three individuals independently reviewed the 1200 page classified document index in its entirety. Approximately 64,000 classified document entries were reviewed for possible relevance to the project. Each entry consists of a central keyword, other associated keywords, and a document ID number. The index contains multiple listings for some documents under various keywords, so there are less than 64,000 documents contained in the index. For the following keywords from the printed index, the number of "hits" was specifically recorded in investigation field notes to assist in identification of documents of possible relevance to the project:

Material of Concern names	accidents	air pollution
fire	cleaning solvents	compatibility
coolant	corrosion	degreasing
elimination	exposure	filters
health physics	incident	liquid
material balance	solvent	wastes
soils	solidification	ultrasonic cleaning

The most heavily documented keyword searched was "beryllium", which had 689 entries; the next highest was "nickel", with 28 entries. Over a thousand entries were selected as being of potential interest. Titles that appeared to be of use to project team members focusing on different aspects of the investigation were identified for follow-up. In addition, thirty-three classified documents were requested and read in detail while the library search was in progress. Many return trips to the Building 706 Library were made throughout the duration of the historical investigation for researching specific topics within and beyond the areas indicated by the keywords listed above. Relevant information was extracted via note taking or requests for page copies. Notes were reviewed by a classification officer prior to their removal from the site.

The Building 706 Technical Library also contains unclassified records. The unclassified report index consists of six volumes of entries organized by subject categories. This index was independently reviewed for pertinent records by three members of the project team.

2.1.2 The Building 881 Archives

The Building 881 Archives contain written material and photographs sent from many areas of the Rocky Flats Plant and include a wide variety of material, ranging from original hand written notebooks, data sheets, memos, letters and rough draft reports to weekly, monthly, and yearly progress reports, summaries of concerns and problems, formal reports, papers, complete documentation of procedures, and reports on incidents and accidents. These records are stored much the same way as they were sent to Building 881 - in cardboard boxes. The total number of boxes stored in Building 881 is approximately 2,500. In some boxes the content is uniform and similar in nature; in others the material varies widely both in format and in subject matter.

Each box in the Building 881 Archives has a "records storage receipt" inside and also in a file cabinet with all other records storage receipts. Each records storage receipt is essentially an index of the contents of the associated box. In some cases this index is accurate and complete. In other cases, the index may not cover everything in the box. It appears that some box contents might have been generated by employees cleaning their desks or files of written material, with little thought about how this material might later be of interest to another person.

The boxes are assigned and identified by a letter and three digit number, such as "A137", and are stored according to that designation. Words are extracted from the records storage receipts and used as keywords in a secure computer system to facilitate keyword searches.

Based on knowledge of the general areas of interest within the historical investigation and plant terminology, the following keywords were selected and used to identify boxes containing documents of potential relevance to the project:

accident	alpha	carbon tet	chemistry or chemicals
chloroform	compounds	communications files	concentration
contamination	fire	1969 fire	health physics
HS&E	lip	N&FS	industrial hygiene
nuclear safety	PCE	pipe	organic compounds
pollution	release	review	soil
summary	traffic	waste	tetrachloroethylene
waste	waste ops	trichloroethylene	

Keyword searches identified boxes containing records related to the indicated keywords. Approximately 80 boxes were retrieved for inspection. Information of relevance to the project was transferred to hand-written notes which were reviewed by a plant classification

officer prior to leaving the plant site. Approximately 20 boxes surrounding the selected boxes on the shelves were also retrieved and reviewed to add to the random aspect of the search process and to judge the effectiveness of the keyword search process. No records of relevance to the project were found in these randomly selected boxes.

2.1.3 Classified Safety Analysis Files

The Safety Analysis group maintains a file of classified documents to support conduct of safety analyses of plant operations. The documentation includes information concerning accidents and incidents that have occurred at the Rocky Flats facility. Documents within the associated files were reviewed in search of information pertaining to possible chemical or radionuclide emissions from the events. Five documents were reviewed in detail, of which two were determined to be relevant to the project. These two documents deal with historical tritium releases from Rocky Flats, and the information they contain will be included in Task 5 investigations of source terms of the materials of concern.

2.2 Unclassified Rocky Flats Information Sources

Three unclassified repositories relevant to the project have been identified at Rocky Flats. They include the Environmental Master File, Industrial Safety Office files, and Occurrence Management Department records. Each of these information sources is described in the following sections.

2.2.1 The Environmental Master File

The Rocky Flats Environmental Master File (EMF) consists of two powered horizontal file machines, located on-site in Trailer 130C. They are locked by key and combination, with a very limited number of individuals having the key and combination. The primary file machine has sixteen 6-foot long shelves. The second machine has nine 6-foot long shelves.

The EMF was originally set up around 1975, primarily to address the every-day reference and administrative needs of the Environmental Management Group. It still serves that purpose to some extent today, but its primary use is for historical reference purposes. The documents contained in the EMF include summary reports, memorandums generated at Rocky Flats, letter reports and studies, copies of state and federal regulations, DOE reports, copies of documentation seized during the FBI's investigation, sets of monthly and annual environmental reports, and many other miscellaneous documents. No classified documents are kept here as the file is in an unsecured area and, generally, environmental documents

do not contain information regarding the design or manufacture of nuclear weapons and therefore are not classified.

Most of the Rocky Flats documents on file in the EMF were generated in the 1970s and the first half of the 1980s, although some documents go back as far as 1953 and some are dated as recently as 1990.

Arrangement of the EMF

When the EMF review began, it was reported that about 75% of the contents had been catalogued and arranged according to a numbering system. Review of the file resulted in an estimate closer to 50%. The remainder was in no apparent order and uncataloged. Consequently, project team access to the EMF was initially somewhat limited. However, since May of 1991, the EMF has been undergoing a complete identification and organization of its contents, and electronic scanning and cataloging by technicians from Los Alamos. The work has involved up to five people and associated computer equipment. While the cataloging was taking place, EG&G personnel have on occasion retrieved specified documents and have alerted the project team to documents of potential interest. The cataloging was subsequently completed.

Because of the incomplete manner in which the EMF was originally cataloged, there is no way to identify whether all of the documents which were once in the EMF are still present. However, it has been noted that documents of significance were commonly distributed to several people at the time of their generation. Consequently, copies of important documents can usually be found elsewhere. Many of the frequently-cited documents have also been found in the Legal/Environmental Index and/or at the Federal Records Center.

Searches Performed in the Card Catalog

Several searches were performed of the EMF and its card catalog during the time ChemRisk had free, uninhibited access. An initial review of the entire card catalog was conducted to gain familiarity with the various types of topic categories utilized. Then, specific topics were searched with the intent of identifying key documents for the various tasks of the project. The topics and titles found corroborate the report that the file was originally set up to serve as an administrative repository and reference center.

The majority of the contents of the primary horizontal file machine were examined, along with the entire contents of the second. The EMF contains an estimated 15,000 to 16,000 documents. The number rises to over 20,000 if the associated Clean Water files, which were

also reviewed, are included (Helgerson, 1992). The documentation reviewed has been of significant benefit to the project in that it not only documents emissions, but also provides a perspective on many of the environmental activities which have taken place at the plant. In general, most data at the EMF is summary data, consisting of annual and monthly environmental reports.

The following examples of EMF catalog topics were noted in investigation field notes to indicate the content and structure of the file:

Accidents	Carbon Tetrachloride
Air Contamination	Construction
Air Pollution	Contamination
Air Sampling	Cattle
Air Monitoring	Discharges
Americium	Ecology
Analysis	Ecology Council
Beryllium	Effluent Information Systems
Beta	Effluent Monitoring
Biological Data	Effluent Release
Biological Effects	Effluent Reporting
Biological Samples	Effluents
Broomfield	Emergency Response Plan
Burial Sites	Environmental Control

Emissions Data in the EMF

In the review of documents at the Federal Records Center, it was noted that environmental monitoring at the plant has focused on certain portions of the plant; namely, those production buildings in which radionuclides posing a recognized hazard were handled. The data in the EMF largely represent the same areas, but are somewhat more broadly encompassing; presumably due to the changing environmental regulatory requirements which were taking place around the time of the development of the EMF. The data in the EMF also differ in that they are summarized, as opposed to the almost exclusive presence of raw data found in the Federal Records Center.

Accident Information in the EMF

There are few documents pertaining to accidents in the EMF. The reasons for this are two-fold. First, there is a repository on the plant site (the Occurrence Management Files) specifically established for the purpose of maintaining accident records. Secondly, the accident information which is kept at the EMF generally involves only those incidents which were thought at the time to have resulted in offsite impact. A great majority of recorded incidents do not fall in this category.

Historical Information in the EMF

A few documents were found which provided an excellent history of some environmental issues on the plant site. In addition, bits and pieces of historical information were found in related documentation, such as internal memos and other correspondence. However, no summary documents were found in the EMF that provide information on the operational history of the plant.

2.2.2 Industrial Safety Office Files

Industrial Safety records are made up of files documenting "Occurrences", "Supervisor Investigation Reports", "Unplanned Events", "Unusual Occurrence Reports", and "Internal Investigation Reports" covering varying time periods between 1952 and 1989. For the major incidents, a committee was typically formed to perform an investigation and issue a report. The Industrial Safety files typically contain committee reports and detailed supporting documentation. The file for a given incident was considered "open" until corrective actions were identified and scheduled.

2.2.3 Occurrence Management Department Records

The most complete historical record available of all accidents at Rocky Flats is maintained by the Occurrence Management Department of EG&G Rocky Flats in the form of the Summary of Events (SOE) database that covers the period from 1952-1990. The SOE database was created in the early 1980s based on a review of the Industrial Safety Unusual Occurrence Report files and has been updated on an annual basis since that time. At the time of review, the SOE database contained approximately 1,767 accident entries. The Summary of Events database does not include "as found conditions," such as the 903 Pad oil leakage, and it does not always provide information on the off-site release potential of an accident.

2.2.4 Federal Government Information Sources

The Federal Government information resources utilized by the project include the Denver Federal Records Center, the DOE Effluent Information System, the DOE On-site Discharge Information System, the DOE Library in Germantown, Maryland and the Region VIII Office of the U.S. Environmental Protection Agency. Each of these resources is described in the following sections. Off-site information sources which were utilized during the historical investigation are summarized in Figure 2-2.

2.2.4.1 The Federal Records Center

A number of repositories were identified during Task 1 activities which were believed to hold information relevant to the subsequent Tasks of the Toxicological Review and Dose Reconstruction Project. The Denver Federal Records Center (FRC) was identified as a repository holding a large amount of documentation from the plant. To support Tasks 3 through 5, it was necessary to gain an early understanding of the contents of the FRC.

The plant sends its inactive, unclassified documents to be stored at the Denver Federal Records Center until the specified date of destruction. Documents generated at the plant which fall under categories specified in the National Archives and Records Administration (NARA) protocol, are kept at the FRC until their retention period specified in the protocol expires. The General Records and the DOE Records Schedule govern the types of documents to be submitted. Classified documents remain on the plant site. According to official sources at the FRC, any Rocky Flats document which does not come under the jurisdiction of the NARA protocol must, by law, be retained indefinitely as it is the property of the Government. However, the scope of the NARA protocol is so extensive that there are probably very few documents which would fall into this category.

The Rocky Flats documents on file at the FRC were generated under the auspices of three federal agencies; the AEC (Atomic Energy Commission), the ERDA (Energy Research and Development Agency), and the DOE (Department of Energy). Documents are segregated into groups, according to the governing agency at the time of each submittal. Rocky Flats began submitting records to the Federal Records Center in the 1960s, although some of the documents at the repository were generated at an earlier date.

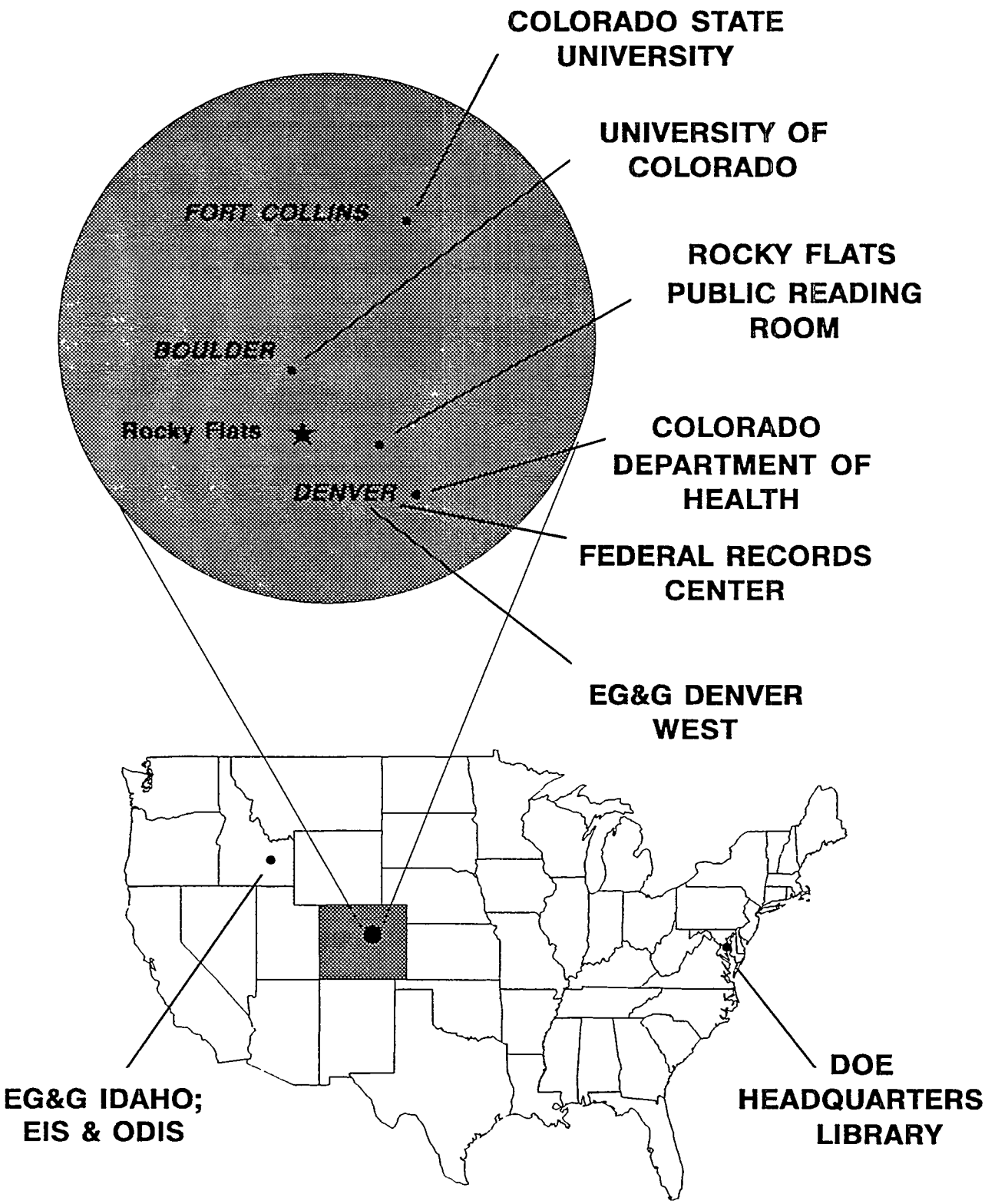

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FIGURE 2-2
OFF-SITE INFORMATION SOURCES

Tracking of Documentation

The FRC maintains a listing called an "Accession Number Master List" which contains the type and amount (in cubic feet or number of boxes) of documents on file. The entries on the Accession Number Master List include the category of documents the boxes contain, the amount, the disposal date, and the year(s) of the documentation involved. The listing does not provide the titles of the documents. To gain more detailed information about what kinds of documentation are in a particular accession, one turns to the "Standard Form 135" of that accession. The information contained on the Form 135s is more detailed than that on the Accession Number Master List, but is still rather generic. To obtain further information about the documentation in a given accession, the documents themselves must be accessed. Access to these two types of listings is uncontrolled, but access to the actual boxes of documents requires written approval from the Rocky Flats Records Group. Photocopying of the records requires additional approval. All requests for access to FRC boxes and document copying were promptly granted.

The documents in storage at the FRC are generally grouped according to the agency governing at the time of the documents' submittal. The October, 1990 printouts of the Accession Number Master Lists show a total volume of 622 cubic feet of documents from the AEC era, 277 cubic feet from the ERDA era, and 2338 cubic feet from the DOE time period, yielding a total volume of about 3237 cubic feet of Rocky Flats documents. The number of documents at the Federal Records Center fluctuates as a result of the various retention times for the documents on-hand and the submission of additional documents from the plant.

Submitted documents are maintained in groups tracked by accession numbers. A thorough review of the Accession Number Master Lists and examination of several groups of documents revealed that the majority of the documentation was not directly relevant to the Toxicologic Review and Dose Reconstruction Project. In fact, only 18.5% of the boxes (594) were initially thought to have potential application to the project. Those which were determined to be of limited or no use to the project include personnel and medical files, time cards, visitor records, gate logs, personnel exposure records, retirement plan files, insurance files, and vendor drawings.

The types of documentation that could potentially be of use to the project include air sample records; radiological survey records; scientific, technical, and research and development reports; waste disposal records; construction completion reports; and some of the general correspondence concerning environmental, health and safety issues.

NARA Protocol Retention Schedules

Most of the documentation has a specified retention period of less than five years. Consequently, potentially useful documentation such as purchasing records provides only a recent record, with no comparable documentation from earlier years.

Even raw analytical data, of which there is a considerable amount in the FRC, has a specified retention period under the current NARA protocol of five years or until the data are verified and entered into a summary document, whichever comes first. Laboratory analysts' log books, found in abundance at the FRC, fall under a similar retention schedule, but in practice are being retained for longer than five years. It was suggested that the governing NARA protocol at the time of the documents' submission probably specified a lengthier retention period.

Some of the types of records have indefinite retention times or times of 75 years. Most of these, however, are medical records of plant employees which are not relevant to this project.

Review of the Form 135s

Although the Form 135s provide a more detailed description of FRC document contents than the Accession Number Master List, they largely consist of information of a general nature. This is particularly true of the earlier years. In some cases, however, the Form 135s provided enough additional information to warrant further investigation in the form of box retrieval and review, to single out a few boxes of interest, or to remove boxes from further consideration altogether.

Documents No Longer at the FRC

Once an accession has undergone some action such as destruction or removal from the FRC, it is moved to another listing called the "Accession Number History List". This listing identifies the documents which were at one time in storage at the FRC but which no longer are there due to destruction, removal or transferral to the 881 Archives or another records center. The History List shows the date of action and a code for what action was taken.

Examination of Rocky Flats Documentation at the FRC

Upon first review, the amount of documentation determined to be of potential use to the Toxicologic Review and Dose Reconstruction Project was approximately 18% of the total Rocky Flats documentation in the FRC. Upon closer examination, the amount of truly useful documentation has been determined to be significantly lower. Out of the approximately 600 boxes of records originally believed to be relevant, the project team has examined the contents of 176. Much of the documentation in these files includes employee medical and exposure records, injury reports, and analytical reports.

The most relevant documentation at the FRC is in the form of raw data, consisting of laboratory analytical reports of individual samples. This type of data makes up a significant fraction of the approximately 3200 cubic feet of Rocky Flats records stored at the FRC. Although some of this documentation may be usable, the quantity of the records and their format would require an extensive amount of effort and time to derive meaningful information from it. For example, it appears that the analytical reports for just about every environmental sample taken on and off the Rocky Flats site are in the FRC. However, no documents were found which explain how the thousands of data points were processed to arrive in their final, summary form in the Site Survey and Environmental Monitoring Reports located in the other repositories.

Emissions Data at the FRC

Since the beginning of operations, effluent monitoring at the plant has focused on certain portions of the plant, namely those areas in which radionuclides or recognized hazardous materials were handled. As general awareness and scientific understanding of various types of hazards and chemicals increased, the number of sampling points and parameters increased or changed to reflect the knowledge and regulatory requirements of the day. Nonetheless, the bulk of the attention has always been on certain manufacturing areas or buildings at the plant. Consequently, the emissions data that resides in the FRC is largely composed of data from less than a dozen buildings: 771, 774, 707, 559, 776, 779, 881, 444, 447, 991, and 995. Sampling data are present for other buildings and areas, but are not as numerous.

The manner in which the information was recorded changed dramatically over the years, not only with regard to format, but also from a content standpoint. In the earlier years, the laboratory information apparently was recorded only in ledger-sized logbooks which consist of little more than sample point, sample date, and a resulting value. Additional information such as the person taking the sample, the person analyzing the sample, the methodology used, control blanks, background samples, number of counts per minute, counting duration,

and pre-analysis decay time are not found in the documentation. Improvements in the reporting were made over the years and the information recorded eventually became more complete. However, regardless of the improvements to the analytical reports, none of the reports were accompanied by information describing the sampling methodology, location of the sampling points or devices, analytical methodologies, or confidence levels.

Summary data were not present at the FRC. Most summary data have been found in the EMF and in other repositories, such as the Rocky Flats Reading Room at the Front Range Community College and the Colorado Department of Health.

Accident Information at the FRC

Also found in abundance were incident and injury reports. Most of these were relatively minor incidents such as cut fingers and minor spills confined to the interior of the buildings. A rough estimate of the number of these reports is in the thousands. Almost without exception, the reports were one-page forms, regardless of the relative significance of the incident. It is known that incidents of a serious nature were investigated more thoroughly than these report forms would indicate. The in-depth investigation reports and supporting documentation are located on the plant site.

Equipment Vendor Drawings at the FRC

There are a number of boxes of vendor drawings and associated information. Much of the documentation included owner's manuals and operating instructions for various pieces of equipment used at the plant. The types of equipment for which there is documentation includes heating and ventilation controls, lathes, milling machines, drill presses, plumbing fixtures, boiler vessels, gasoline pumps, public address system components, stair stringers, and building footings. In most cases, there is no date included on the documentation or identification of the building in which the equipment was installed.

TLD Badge Records and Personnel Exposure Histories at the FRC

There are many boxes of thermoluminescent dosimeter (TLD) and other personnel exposure monitoring records at the FRC. These exposure records are relevant to the indoor, plant environment and worker exposures, and are not directly relevant to this study. Problem areas for worker exposure are not related to off-site releases.

Procurement Files at the FRC

Procurement files do exist and are located at the FRC. However, they have a specified retention period of three to six years, depending upon the dollar amount involved in the particular contract. Consequently, the information which would be available from these types of records is limited to a few years' time. A review of the Accession Number History List verified that procurement records from the years prior to 1984 had been sent to the FRC and eventually destroyed according to schedule.

Project Construction/Completion Files at the FRC

These contain historical information insofar as identifying when major projects were completed. Projects noted on the Form 135s included buildings, waste treatment facilities, and production lines. These files only go back to 1971. Additionally, it was not determined whether these files are all-inclusive of the years represented.

Summary of FRC Content and Utility

Overall, the amount of information at the FRC that would be directly useful to the project is quite limited in comparison to the total volume of documentation. Many relevant records found in the FRC were also found in other repositories on the plant site.

2.2.4.2 DOE Effluent Information System

The DOE Effluent Information System (DOE EIS) is a computer-based management information system for recording and reporting radioactive effluent data for airborne and waterborne discharges that travel off-site from facilities under DOE control. One must be careful to not confuse this EIS with a significant document commonly given the same acronym, the 1980 Final Environmental Impact Statement for the Rocky Flats plant site. The Effluent Information System was developed by Aerojet Nuclear Company (ANC), with the first reports being produced in 1972. Since that time, the system has been revised, and Aerojet, which has been renamed EG&G Idaho, Inc., has operated the system for the DOE Division of Operational and Environmental Safety (Batchelder et al., 1977).

ChemRisk has obtained DOE EIS reports of the effluent data for the Rocky Flats Plant. The EIS presents annual release totals by individual release point for plutonium-239/240 and -238, uranium-233/234 and -238, americium-241, and tritium. The earliest data are for 1956. Early airborne effluent analyses were strictly non-specific measurements of long-lived

alpha emitters. At various points in time since the 1950s, more advanced analytical techniques facilitated identification of specific elements and their radioactive isotopes.

The DOE EIS contains effluent data as reported by the DOE based on annual reporting from Rocky Flats. ChemRisk has not yet completed the independent verification process for the data or the necessary review of the associated monitoring systems, analytical procedures, quality control practices, or reporting conventions. These areas of data quality and interpretation are being addressed as part of Task 5 source term investigations. To provide a historical context for the emission monitoring data which will be a critical part of the basis for radionuclide source term estimation, key elements in the data quality evaluation are discussed here.

The data provided in the DOE EIS do not provide a complete emission history for each Rocky Flats building over its operational history. Some effluent data reporting lags behind or pre-dates the initial operation of some buildings. In some cases, apparent mismatches between reported construction dates of a building and appearance of associated effluent data arises from the fact that construction took several years to complete. In other cases, a building was structurally complete, with effluent monitoring in place, before the time that the production processes destined for the building became fully operational. The above situations notwithstanding, there are cases when a building is known to have been operational for some period before data are reported in the DOE EIS. There are also gaps in the data for certain analyses of some buildings.

Conventions for inclusion of measurements below the limits of detection are not clear. For some time period, DOE instructions reportedly called for results measured below the minimum detectable activity (MDA) to be assumed to be present *at* the MDA. A common practice in effluent reports is to affix a "less than" sign to totals which include results assumed to be at the MDA. There are no provisions in the EIS reports provided to us for identification of "less than" values. Reports that comment fields within the EIS have been used to somehow indicate inclusion of "less than" values have not been substantiated.

Contents of the comments fields, which also have been alleged to contain beryllium emission data, have not been made available. The extent to which incident related emissions have been included in the DOE EIS is also not clear. It is apparent that some major accidental emissions have been excluded, while some more minor accident-related emissions have been included. The criteria for inclusion of accident related emissions is therefore unclear.

The transitions between analytical methods and reporting conventions are also not clear. For example, in the early years, airborne effluent analyses were non-specific long-lived alpha emitter measurements. In the DOE EIS, the results were in some cases attributed to plutonium-239/240 by association of the materials handled in the building in question. Over

the years, analytical methods and reporting conventions evolved substantially. The record provided by the DOE EIS does not by itself provide enough information to support interpretation of the data. The history of Rocky Flats effluent quantification practices is being characterized as part of Task 5 activities.

Information obtained from EG&G Idaho includes a Narrative Information Database Master List which describes each release point entered in the system for the Rocky Flats site (USDOE, 1991). For each release point, the narrative database describes the discharge point name, operations generating associated pollutants, waste treatment systems provided, monitoring systems, and sample collection frequency. This information is utilized in the discussion of historical release points in Section 5 of this report.

2.2.4.3 DOE On-Site Discharge Information System

The DOE On-site Discharge Information System (ODIS) is a computer-based management information system for recording and reporting radioactive effluent data for *on-site* airborne and waterborne discharges at facilities under DOE control. The system was developed by Aerojet Nuclear Company (ANC), with the first reports being produced in 1972. Since that time, the system has been revised, and Aerojet, which has been renamed EG&G Idaho, Inc., has operated the system for the DOE Division of Operational and Environmental Safety. (Batchelder et al., 1977). Since the focus of this study is on exposures to off-site individuals, the ODIS contains information that is not directly applicable to this project, but may prove to be useful in source term development efforts to characterize emission sources of interest.

2.2.4.4 The DOE Energy Library in Germantown, Maryland

In the early stages of the project, a computer search of the Department of Energy's Energy Database was performed to identify publicly available reports relating to the Rocky Flats site specifically and more general reports addressing topics applicable to assessment of potential environmental impacts of the plant. Based on the results of that search, documents at the DOE Energy Library in Germantown, Maryland were reviewed. A number of documents of relevance to the Toxicologic Review and Dose Reconstruction Project were located and were added to the project information repository.

2.2.5 Pertinent Regulatory Documents

Rocky Flats Plant operators have produced a number of documents in response to regulatory requirements that compile information that is potentially relevant to dose reconstruction efforts. A number of these documents are identified in the following sections.

2.2.5.1 Colorado Department of Health Files

The Rocky Flats documentation in the various departmental files at the CDH is relatively recent and consists primarily of responses to regulatory requirements and inquiries made by the Department of Health. ChemRisk has access to much of the same documentation in the repositories on site and has sought this information concurrent with accessing other documents onsite.

The CDH Department records which have been reviewed include:

- Air Division Files,
- Hazardous Materials and Waste Management Division Files, and
- Radiation Control Division Files.

2.2.5.2 Air Pollution Emission Notices

Air Pollution Emission Notices (APENs) are reports which the State of Colorado requires be submitted to their Air Pollution Control Division to document significant sources of emissions of key pollutants within the State. An APEN is required for any process or activity which has the potential for an uncontrolled emission greater than one ton per year for any pollutant, or greater than 1 pound per day for any hazardous or toxic pollutant.

Hazardous pollutants are listed in applicable Air Quality Control Commission regulations, and toxic pollutants are taken as those on the "Massachusetts List" (Beckham, 1990). Criteria air pollutants are carbon monoxide, lead, nitrogen oxides, sulfur oxides, ozone, and particulate matter less than ten microns in size. ChemRisk has reviewed all APEN reports prepared by EG&G Rocky Flats.

APEN reports have been prepared for essentially all Rocky Flats buildings, or groups of buildings or facilities. These reports document the configurations of the air handling systems, the processes conducted in the building, vents and/or stacks associated with emissions, and assumptions and factors used to calculate controlled and uncontrolled emissions. The APENs describe modern-day plant processes and activities, and are, except

for a few inserted statements about past activities in several buildings, not useful sources of historical information.

Based on reviews of the APENs, building summaries were generated that identified the processes associated with airborne emissions of the materials of concern selected in Task 2. The Massachusetts List includes all of the chemicals identified as materials of concern for the project, but all of the materials of concern have not been identified by the Rocky Flats Plant as having emissions that qualify for reporting under the APEN program. The building summaries were used to assist the project team in conducting interviews of active or past employees knowledgeable in the operations of each building.

2.2.5.3 Waste Stream & Residue Identification and Characterization Reports

The Waste Stream and Residue Identification and Characterization (WSRIC) Program was undertaken for EG&G Rocky Flats to identify and characterize waste streams and residues generated or stored at the Rocky Flats Plant. The series of approximately 100 WSRIC reports was prepared to fulfill requirements contained in the Agreement in Principle between the DOE and the State of Colorado.

A WSRIC report was prepared for each major building, describing the associated waste streams and residues based on field investigations and waste sample analyses. The information includes details on the nature, quantities, and hazards associated with hazardous, radioactive, and mixed hazardous and radioactive wastes. One of the main goals of the WSRIC was to determine which wastes and residues should be land disposal restricted (LDR), in other words excluded from land burial as a disposal method.

ChemRisk reviewed selected WSRIC reports for process descriptions and details on the uses of the materials of concern, primarily for those buildings for which APEN reports were not yet complete at the time interviews were conducted.

2.2.5.4 Information Related to Section 104(e) of CERCLA

The "104 E Report" consists of Rocky Flats' response to EPA's request for additional information under Section 104(e) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (Rockwell, 1990). The information sought by the EPA was requested under very broad, all-encompassing questions. Rocky Flats provided a twelve-volume reply document, which provided fairly detailed information in response to some of the question areas, and identified where the information to answer many of the

other question areas could be located. Most of the twelve volumes of supporting documentation includes samples of documentation kept at the plant site.

The greatest benefit to the Rocky Flats historical investigation from the 104(e) documentation was confirmation that the project team had been independently conducting its information searches in what were identified in the 104(e) report as the most effective places to acquire the identified information.

2.2.5.5 Safety Analysis Reports

Safety Analysis Reports (SAR's) provide a detailed examination of a facility with respect to the likelihood of significant accidents occurring in that facility and the resulting consequences, for the purposes of designing and determining the adequacy of engineered safety features. Preparation of an SAR includes examination of the facility's physical characteristics (age, type, and materials of construction), the underlying geological conditions, and the processes and activities within the facility. An SAR also determines how all of these factors could affect or be affected under various catastrophic circumstances. The Reports summarize this examination, the information gathered, and the conclusions drawn regarding the adequacy of the facility's safeguards.

The SAR analyses also include investigations of the facility's past accident and incident history and the histories of similar facilities, but the Safety Analysis Reports themselves do not elaborate on or provide references for those accidents reviewed.

The first regulatory requirement for SARs was established in the 1970s, so none date from earlier years. At the time that Rocky Flats SARs were reviewed for this study, approximately a dozen had been written, primarily for the major production buildings and their related auxiliary buildings. An individual currently involved with the SAR process indicated that about half of the SAR's were in draft form and half were finalized. Currently, the plant is attempting to prepare SAR's for all of the major production processes and production buildings.

The following is a listing of the SAR documents which were available for review:

707 Appendices, Draft, 1/84	
774 Report, Revised 10/81	
444 Report, Revised 2/82	(includes 445, 446, 447, 448, 449, 427, 453, 454, 457)
991 Report, Revised 11/81	(includes 996, 997, 998, 999, Tunnels, 985, 989)
881 Report, Revised 2/82	(includes 830, 864, 882, 885, 887, & 890)
865 Report, Revised 2/82	(includes 827)
374 Report, Revised 8/1/81	
559 Report, Final 6/87	(includes 560, 561, 562, 563, 528)
776/777 Report, Final 6/87	

Review of the SAR's revealed that they contain little historical information and no emissions data. Because the SAR's were produced at different times, the format and content is inconsistent. Some contain a general chronology of the construction years of the building and its subsequent additions, and some do not. Some contain detailed descriptions of the processes within the buildings, and some are very generalized.

The SAR's have some utility for the project, in that a few provide a good snapshot of the processes within a building at a particular point in time, and some provide historical construction information.

2.2.6 Records Related to Litigation

Litigation associated with the plant has generated the need for information and the creation of a number of significant resources. The following sections identify some of the resources that were created as a result of litigation activities.

2.2.6.1 The Legal Database

This database represents the documents seized by the FBI and subpoenaed by the Grand Jury in the environmental criminal investigations against Rockwell. The database consists of an index and electronic images of the documents seized and subpoenaed. The documents were recorded by optical character recognition techniques and stored on magnetic tape. A copy of the database is maintained by the EG&G Legal Group in Trailer T-334C.

ChemRisk cannot view the database itself or have free access to its use because it is attorney-client privileged in nature. However, the Rocky Flats Plant Legal Department has performed searches on the database while team members were present and allowed the documents to be previewed on the terminal screen to support selection of those documents which were of apparent utility to the project. Because of the focus of the FBI and the Grand Jury, the documents generally cover the 1980 to 1989 time frame. As a result, the database has little historical value and as a result relatively few documents were retrieved.

2.2.6.2 The Legal/Environmental (Church Litigation) Files

The Legal/Environmental File was established around 1975 by Rockwell and DOE attorneys in preparation for lawsuits brought against the plant by neighboring landowners. It is sometimes referred to as the Church Litigation File.

During the file's development, the plant was canvassed for any documentation which related to environmental issues. The files of various operational groups on the plant site were reviewed for pertinent information, such as the "Medical, Health and Safety" files, and "Materials" files. Any information found which was felt to be related to environmental issues was entered into the collection. Entries of documentation into the file continued for approximately three years. As a result, the Legal/Environmental File consists of a large variety of documentation, covering the time period between 1952 and approximately 1978.

Because the information in the file was to be accessed by attorneys for the plaintiffs and eventually become public information, the file contains no classified documents. Several of the documents are declassified versions of classified records. Nonetheless, the file is not short on documentation. It contains approximately 20,000 documents in five four-drawer filing cabinets.

A review of the "source" field in the database shows that documents were obtained from Dow, Rockwell, the AEC, ERDA, and DOE. Documents originating from offsite groups were also found, including Los Alamos and Lawrence Livermore Laboratories and subcontractors who performed environmental work for the plant. In addition, the files in the Federal Records Center were searched at the time of the file's development to locate and retrieve any documentation from this resource. As a result, the types of documentation in the file is quite varied. The content includes annual and monthly reports, internal memos, letters, charts, graphs, and photographs. Some of the documents listed in the file's index have been seen in other repositories, such as the EMF and FRC, during other phases of the investigation.

The Legal/Environmental File documents were at one time located in the Building 706 Library on the plant site, but were moved to Las Vegas in 1990 to be copied for archival and legal purposes. A copy of the files was returned to the plant site in May, 1991 and is currently located in legal offices in T-334C. ChemRisk was provided unimpeded access to these files as soon as they were returned to the plant.

Legal/Environmental Index

The documents which went into the Legal/Environmental File were cataloged and indexed into a database, called the Legal/Environmental Index (LEI), which has been placed on the plant's central VAX computer network. Because the database is located on the plant's central computer, access can only be obtained by authorized persons. Some training is also necessary for users to become proficient in use of the system. Nonetheless, the LEI is the key to efficiently identifying any documents in the Legal/Environmental File pertaining to a particular subject.

Searches Performed On The Legal/Environmental Index

Numerous searches of documents in the LEI have been performed. The listings on printouts from the database are arranged according to accession number (assigned to a document according to the order in which it was received), and includes the title, author, source, Bates numbers (chronological numbering of the individual pages in the file), and a description of the document.

The first search included a number of keywords, word roots and various permutations, for example "effluent, radionuclide, pluton, americium, beryllium, uran, tritium, carbon tetrachloride, and tetrachloromethane". The resulting printout was sixteen inches thick and listed over seven thousand documents. The Bates numbers, which indicate the cumulative page numbers of all pages contained in the file, indicated in the associated printout that there were over 80,000 pages of documentation in the Legal/Environmental File. Because this first search was performed on all of these keywords as a group, the printout was unwieldy and poorly organized for effective index review.

Subsequent searches were performed in an effort to separate the issues relative to the various project tasks and to make the resulting printouts more manageable. This was done by performing searches on single keywords, word roots or abbreviations, or keywords that belong to a common group.

The selective searches that were performed on the LEI included:

1. CHEMICAL
2. INVENT(ORY)
3. ACCIDENT, INCIDENT, UNUSUAL, OCCURRENCE, EVENT, UNPLANNED,INVESTIGATE
4. SITE SURVEY
5. ENVIRONMENTAL MONITORING REPORT
6. HIST(ORY)
7. ANNUAL
8. MONTHLY
9. HEALTH PHYSICS
10. SAFETY
11. EMISSION, RELEASE, STACK, SOURCE
12. LAND, DEMOGRAPH, POPULATION
13. WASTE, BURIAL
14. SAMPLE
15. BERYLLIUM
16. HIGHLIGHT
17. HISTORY
18. 1957 FIRE
19. 1969 FIRE
20. 903 PAD, HELICOPTER PAD, LIP AREA
21. BENZIDINE, P-DIAMINODIPHENYL
22. PROPYLENE OXIDE, METHYLOXIRANE, PROPENE OXIDE
23. BUTADIENE, BIETHYLENE, VINYLETHYLENE, ERYTHRENE, PYRROLYLENE, BIVINYL
24. ETHYLENE OXIDE, OXIRANE, ANPROLENE
25. BENZENE, BENZOL
26. HYDRAZINE, DIAMIDE, DIAMINE, HYDRAZYNA
27. CADMIUM
28. NICKEL
29. CHROMI(UM,C)
30. MERCURY
31. LEAD
32. METHYLENE CHLORIDE, DICHLOROMETHANE, METHYLENE DICHLORIDE, DCM
33. CHLOROFORM, TRICHLOROMETHANE
34. TETRACHLOROETHYLENE, PERCHLOROETHYLENE, PCE, TETRACHLOROETHENE
35. TRICHLOROETHENE, TRICHLOROETHYLENE, ETHINYL TRICHLORIDE, TCE
36. 1,1,1-TRICHLOROETHANE, METHYL CHLOROFORM, CHLOROTHENE
37. FORMALDEHYDE, METHANAL, OXOMETH, FORMIC ALDEHYDE, METHYLENE GLYCOL
38. NITRIC, AZOTIC, HYDROGEN NITRATE
39. PESTICIDE/HERBICIDE

The resulting printouts, totalling over three feet thick, were first reviewed to identify summary documents that were produced with regularity, such as annual, monthly and weekly reports. A listing was made of each type of document and which issues of periodic reports were in the Legal/Environmental File. This list served to identify any issues that were missing and to provide a specific listing of documents to be obtained for the project. Issues of a document that were determined to be missing from the L/E File were sought in the other repositories. Examination of the printouts created from the searches identified several types of summary documents which were produced with regularity.

Some of the types of periodical documentation found in the LEI include:

Site Survey Monthly Progress Reports, starting in 1953
Site Survey Annual Progress Reports, starting in 1952
Monthly Summary - Accident, Occupational Disease and Fire Experience, 1968-1974
Annual Summary - Accident, Occupational Disease and Fire Experience, 1968-1974
Annual Summary of Industrial Fire and Property Damage Reports, 1968-1974
Minutes of Executive Safety Council Meetings (monthly), 1954-1975.
Industrial Hygiene Monthly Progress Reports, starting in 1953
Health Physics Status Report for Buildings 440, 444, 881, 883, 886, and 991: 1966-1975.
Weekly Highlights for Health, Safety and Environment

The printouts were also reviewed to identify any one-time or limited-issue documents that appeared to be of significance to the particular project tasks. Listings of these were created for retrieval. Overall, the Legal/Environmental File has been the single most useful repository, primarily because of the extent of documentation from the early years of Rocky Flats activities. ChemRisk has requested and received over 635 documents from the Legal/Environmental File to-date.

2.2.6.3 Files Gathered by Attorneys for Jim Stone

In 1986, former Rocky Flats employee Jim Stone filed a suit against the plant for wrongful discharge, and in 1988 Requests for Discovery were filed by attorneys for Jim Stone which involved a number of issues. By December of 1988, a total of approximately 60 boxes of documents were gathered by EG&G Legal Department staff in response to the Requests for Discovery for review by the plaintiff. Thirty-seven of the boxes came from the 881 Archives and the Federal Records Center. At the time of this report, the documents still remained in storage in Building 130 but will soon be returned to their origins, as the Court has rendered a decision in the case.

Review of the listings of the contents of the boxes indicated that the records largely consisted of indoor air samples, documentation of employee exposures, and records pertaining to the employment history of Mr. Stone and his co-workers at Rocky Flats. A relatively small portion appeared to have some historical information useful to the project. The contents of those boxes which appeared from the listings to be of use were reviewed. The review of the selected boxes verified that there was limited useful information in this assembly of documents. Copies of relevant documents from this source have been entered into the project repository.

2.2.7 Records of Concerned Individuals and Organizations

Records generated or held by groups or individuals not affiliated with the plant were also sought as part of the investigations for this project. The following sections describe these resources.

2.2.7.1 The Cobb Files

Currently retired in New Mexico, Dr. John C. ("Jock") Cobb has been involved in a number of health issues in Colorado. His career included service as Professor of Preventive Medicine at the University of Colorado (CU), member of the Governor's Scientific Advisory Panel of Colorado, member of the Wirth Task Force on Rocky Flats, member of the Air Pollution Control Commission of Colorado, and member of the Governor's Task Force on Uranium Enrichment.

Approximately 10 linear feet of Dr. Cobb's files were loaned to the project team by Health Advisory Panel member Dr. Ken Lichtenstein for review and extraction of material pertinent to the project. The files are accompanied by two metal boxes of 3"x5" index cards, containing approximately 350 cards. The files were provided to ChemRisk prior to their submittal to the CU Western History Archives by the American Friends Service Committee. They have been examined and subsequently forwarded on to CU.

The entire contents of the Cobb Files were reviewed. Most of the documents did not pertain specifically to Rocky Flats. Approximately 15 documents were identified in the Cobb Files as relevant to the project that were not already in the project information repository.

2.2.7.2 The Johnson Files

Dr. Carl J. Johnson (1929-1988) was the Director of the Jefferson County Health Department from 1973 to 1981. During that time, he was an outspoken critic of the Rocky Flats Plant, authoring several papers concerning the radioactive contamination of, and cancer incidence in, the Denver and Jefferson County areas. His papers and files now reside at the Western History Archives in the Norlin Library on the Boulder campus of the University of Colorado. A guide to his files has been put together by the staff, and is useful in locating items of interest.

Overall, there are 167 boxes of Johnson's files plus numerous travel maps and posters which are described in the guide. Upon review of the guide, 17 boxes were determined to be pertinent to this study; the contents of these were examined. Many of the documents found in the Johnson files had previously been obtained by the project team. A total of 21 documents were identified as useful to the study and copies were obtained for addition to the project repository.

2.2.7.3 The Martell Files

Edward A. Martell has long been an outspoken scientist and concerned citizen about nuclear issues. He became well known in the Denver area as a result of his participation in and subsequent subcommittee work for the Colorado Commission for Environmental Information (CCEI). It was during his chairing of the CCEI subcommittee on Rocky Flats that the soil contamination east of the plant became widely known.

Mr. Martell was interviewed by ChemRisk to discuss many historical issues and obtain access to his files concerning Rocky Flats. In addition to the verbal information, he provided ChemRisk with copies of pertinent documents relating to his CCEI work on Rocky Flats. Copies of these documents also reside in the Western History Archives of the CU Norlin Library in Boulder.

2.2.7.4 Rocky Flats Environmental Monitoring Council

The library at the Rocky Flats Environmental Monitoring Council offices contains approximately 200 documents. Many documents are several volumes in length, and many are also in the Rocky Flats Public Reading Room. A few located here were not found in the Rocky Flats Public Reading Room, but virtually all have been identified in at least one of the repositories on the plant site, as the majority originated from the plant. The Environmental Monitoring Council's documents are not catalogued.

2.2.8 Citizen Contributions

A few citizens in the communities near Rocky Flats have contributed documents for the Toxicological Review and Dose Reconstruction Project. Most notably, Paula Elofson-Gardine supplied the project with a listing of the most significant incidents which have occurred at the plant, and Jan Pilcher provided documents pertaining to plant history and emissions during the early years.

2.2.9 Other Information Sources

A number of information resources consulted by the project staff did not fall in any of the above categories. These sources of information are described here.

2.2.9.1 CSU Dept of Radiology and Radiation Biology

Staff and graduate students of the Colorado State University at Fort Collins Department of Radiology and Radiation Biology have performed a number studies at Rocky Flats beginning in the 1970s. The Department maintains a library associated with these studies, along with a selection of international works on radiation issues not specific to Rocky Flats. The documentation maintained provides little historical information, but may provide useful information for upcoming tasks dealing with environmental transport and dose assessment.

2.2.9.2 The City of Broomfield Water Department

The City of Broomfield Water Department provided a document which outlines the history of the Rocky Flats Plant and other plant related issues. The Water Department has a file of background information on which it was based. Most of the information is comprised of events from the 1980s, with relatively few entries from earlier years. The document provides a good account of the controversies arising from and surrounding Dr. Carl Johnson's work.

2.2.9.3 Aerial Photographs

Aerial photographs from various sources have been reviewed to assist in documentation of the Rocky Flats Plant development and to provide confirmation of some activities affecting the environment. The initial photographs reviewed were assembled as part of an "Aerial Photographic Analysis Comparison Report, US DOE Rocky Flats" prepared by Lockheed

Engineering and Sciences (Helmstadt, 1988). That report includes 13 aerial photographs, with dates ranging from 1953 to 1988. The purpose of the study was to compare waste disposal and environmental management practices described by the Rocky Flats Plant with visual evidence of such practices obtained from the black and white, color, and infrared photographs obtained at the various steps in plant development.

The maps of site development contained in Section 3 of this report were spaced in time to coincide with certain photographs from the above report. The maps were initially prepared based on modern-day computer drafting files of Rocky Flats facilities and building construction and initial operation dates obtained from various plant records. The maps were then checked against the aerial photographs in the report by Helmstadt, and were modified to reflect appearances of roads, ponds, and other recognizable features.

A series of additional aerial photographs were obtained from the Rocky Flats Photography Department. The dates of these photographs range from 1957 to 1991, and for the most part the photographs provide a close-in view of plant configuration or appearance of selected areas of the facility. These photographs, like those described earlier, were examined to verify written accounts of site development and environmental activities.

2.2.9.4 EG&G Employee Communications Department

In preparation for the 40th anniversary of the plant, the Employee Communications Group has been tasked to develop a history of the plant. The resulting document is "Highlights in Rocky Flats Plant History" by Pat Buffer (Buffer, 1991). Although limited in the amount of information concerning production operations, the document contained some information which has been utilized by the project.

2.2.10 Interviews

In addition to the review of documentation from repositories and other sources, extensive interview activities were mounted to verify the collected data and to obtain additional information. This section describes this interview process.

Interviews to Support Selection of Materials of Concern

A series of brief interviews was conducted to characterize the likelihood of release of selected chemicals based on actual storage and usage practices as a part of Task 2 efforts.

To determine whether a chemical should be identified as a material of concern, the following questions were posed to individuals familiar with the use of the chemical:

- Is the quantity of the chemical on hand reported in the chemical inventories reasonably accurate?
- Is there any indication that the reported quantities are not representative of years prior to 1974?
- How is annual usage quantity related to quantity kept on hand?
- For initial screening, annual use was assumed to be 10 times the quantity on hand. Is that assumption reasonable?
- What fraction of the annual usage quantity is released to the environment? (For initial screening, 25% of annual usage was assumed to be released.)

Some chemicals were eliminated from further consideration as Materials of Concern based on knowledge of actual use characteristics collected during this phase of preliminary chemical usage investigations. A complete discussion of this process can be found in the Task 2 report (ChemRisk, 1991a).

Interviews to Document Historical Uses of Materials of Concern

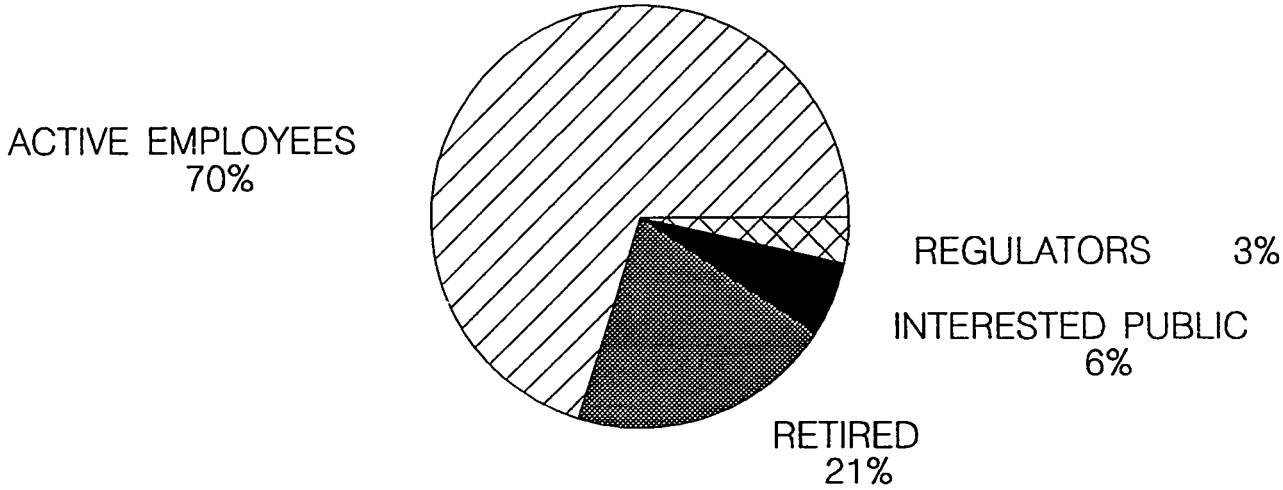
To supplement the information gathered from written document reviews, an extensive program of interviews with current and past Rocky Flats Plant workers was conducted. The interview process involved a concentrated effort in August and early September of 1991. Interviews aimed at specific question areas of Rocky Flats history have continued at a decreased frequency up to the date of report preparation. As summarized in Figure 2-3, ChemRisk teams interviewed over 80 individuals, with a combined total of over 1900 years of experience at the Rocky Flats Plant. The average interviewee had 24 years of work experience at Rocky Flats. Many started as part of the 1969 fire cleanup, and a significant fraction began in entry level positions and worked their way up to managerial positions.

Interviews Supplemented Document Reviews.

Over 90 Formal Interviews Conducted To-Date.

Over 1900 Years of Plant Experience.

Average Experience of 24 years.



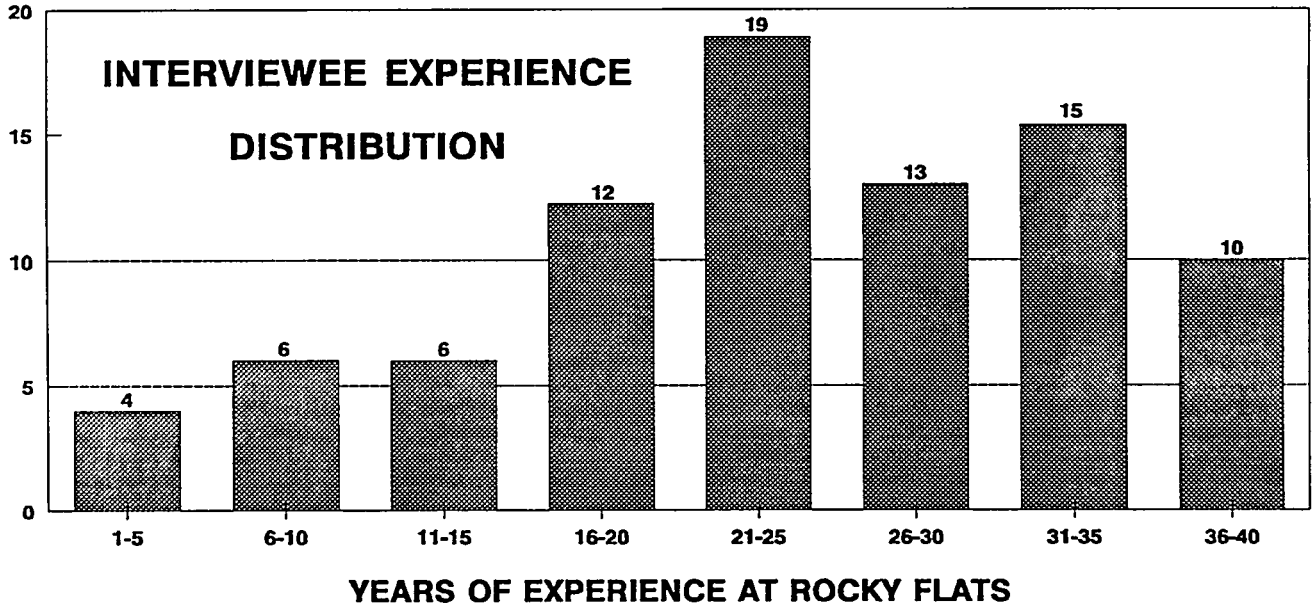


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FIGURE 2-3
THE INTERVIEW PROCESS

There was wide variation in the level of detail remembered with regard to historical practices and events. For the most part, individuals were very cooperative and helpful and willing to share what they knew relative to the project. There were between eight and twelve individuals who declined to be interviewed on the advice of their attorneys because of the on-going Grand Jury investigation. There have been at least 75 individuals who have testified before the Grand Jury. ChemRisk interviewed some of them. It does not appear that any of the individuals who declined interviews are exclusive sources of the information needed for the project.

Two teams of two interviewers were used for the most part, to allow for optimal efficiency in covering the areas of concern and recording the information offered. A description of the project and an outline of the interview questions were provided to the interviewees in advance of the day of their interview. Each interview lasted about one hour, but some were longer (up to three hours in length), and a couple were shorter. Some individuals were interviewed in groups. The group approach was found to be helpful, as individuals were able to jog each others' memories and bring out additional information that probably would not have surfaced in individual interviews.

To assist in preparing for the interviews, summaries were prepared of the information available for each of the key buildings. The information in the building summaries included descriptions of the processes in each building that used materials of concern based on information in the Air Pollution Emission Notices, radioactive effluent data from the DOE Effluent Information System, chemical inventory records from 1974 and 1988/89, and items of historical significance obtained from various records. Interview questions were prepared and sent to interviewees in advance of the scheduled interview. As a result, interviewees often arrived at the interview with notes to answer our questions and in some cases, with copies of documents and information on additional persons to interview. A copy of the interview questions is presented as Appendix C. It should be noted that the interview questions were prepared to focus the interviews on key issues and areas where ChemRisk was lacking information at that time. Interviewees were also encouraged to discuss any topics outside of the specific questions which they felt might be of interest to us.

During the interviews, information was recorded in hand-written notes which were later reviewed by EG&G Classification Officers. In a few cases, classified information was physically cut out of the interview notes. All items excised from interview notes dealt with, or might enhance one's knowledge of the configurations of materials within the Rocky Flats Plant's main product, the bomb triggers. None of the items that were cut from interview notes have been important to the conduct of the project.

Historical information relevant to the project is generally not classified. However, in some cases, cleared members of the project team were offered information about design features of Rocky Flats products or production processes that related to some of the Materials of Concern. These details are not important to the general history of Rocky Flats operations, but a certain level of knowledge of the types of products produced by the plant and the associated processes was found to enhance the ability of the project team to properly focus efforts for characterizing uses of the materials of concern.

The hand-written interview notes have since been typed and reorganized into a standardized format corresponding to the key areas of investigation. Interview statements based on rumors or hearsay that were discredited when individuals directly involved with the event in question were interviewed, were not retained in the record. A complete set of interview records is included in the project information repository (ChemRisk, 1991b).

After the interviews were conducted, key pieces of information gained were added to the appropriate building summaries. The information contained in the building summaries has also been rearranged into summaries for each material of concern. These summaries formed the bases for the material use profiles presented in Section 4 of this report.

A list was also prepared of materials that were mentioned as being used at the plant, but that are not on the list of Materials of Concern. Each chemical was reviewed to determine if it had been evaluated and eliminated in the Task 2 chemical selection screening process, or if it needed to be further evaluated at that time. Statements people made about relative production levels at various points in time were also assembled so that any recurring themes could be extracted. Sample statements include "by 1964 they had the pedal to the metal and going full bore" and "the addition of Room 114 to building 771 increased throughput by a factor of from 20 to 25 times".

ChemRisk is also tracking all the potential points of contact recommended by interviewees, noting those which have already been interviewed and those which might be useful for future follow-up questioning. Many of the people named are retired, some have passed away, others have proven difficult to locate, especially when they have been commonly known at the plant by nicknames which do not correspond to their actual names.

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3.0 A HISTORY OF ROCKY FLATS PLANT OPERATIONS

The history of the Rocky Flats facility is described in this section in terms of its mission, the progression of site development, and the various functions the plant has performed.

3.1 Missions

The Rocky Flats site had two main historical missions during the period of operations from 1952 until 1990, production of "triggers" for nuclear weapons and processing of retired weapons for plutonium recovery. The plutonium triggers, also known as "pits", are the first-stage fission bombs used to set off the second-stage fusion reaction in hydrogen bombs. Plutonium has historically been imported from the Hanford Reservation in Washington State and the Savannah River Plant in South Carolina, and is also recovered at Rocky Flats from retired warheads and manufacturing residues. Parts are formed and machined from plutonium, uranium, beryllium, stainless steel, and various other materials.

In general, the mission and activities at the plant have remained essentially the same since the plant began until 1990 when plutonium operations were suspended. The plant was intended from the beginning to be a manufacturing facility, not a facility to design or conduct elaborate or exotic experimentation for nuclear weapons or components. Such research was intended to be performed at Los Alamos and Lawrence Livermore Laboratories, with the two of them competing in the development of designs for new nuclear weapons. Interviews and documentation have confirmed that the primary activities at the Rocky Flats Plant have involved the manufacture of nuclear weapons components; specifically, triggers.

The phases in the life of a nuclear weapon are described in Table 3-1. The primary mission of Rocky Flats has historically involved Phases 4, production engineering, through 7, retirement of the weapon. The bulk of the manufacturing work at Rocky Flats, however, involves the production start-up and quantity production of Phases 5 and 6. Phase 4 production engineering work is conducted at the plant and is very intensive, but does not last as long as the two phases that follow it. Rocky Flats also has a role in the retirement of the weapons, dismantling the components it originally produced to retrieve and recycle the materials.

Phase 1 - Weapon Conception: studies which indicate that a weapon concept warrants a formal study for a weapon program.

Phase 2 - Program Feasibility Study: If the concept of the weapon proves to be feasible, the result is a DOD-DOE agreement on the division of responsibilities for the weapon's development and procurement.

Phase 3 - Development Engineering: The weapon is developed according to military requirements, resulting in complete design information.

Phase 4 - Production Engineering: The design information is adapted to a manufacturing system. The adaptation involves product and process engineering, tooling, prototype production and inspection, and test and handling procedures.

Phase 5 - First Production: Production of the weapon begins according to the specifications developed in Phases 3 and 4. Success of this phase results in the authorization for stockpile production.

Phase 6 - Quantity Production and Stockpile: Weapons are produced in quantities specified. Evaluation of the weapon continues during production to identify and incorporate potential improvements or technical advances.

Phase 7 - Retirement: The weapon is removed from the arsenal stockpile and dismantled (USDOE, 1977).

TABLE 3-1: THE SEVEN PHASES IN THE LIFE OF A NUCLEAR WEAPON

Although the mission of the plant and the activities to carry out that mission have generally remained the same, three events have had a significant impact on the operations at the plant. The first was a change in the concept of the weapon in the late 1950s which required additional manufacturing facilities and placed a heavier emphasis on plutonium. The second was the Department of Defense's decision to have a "single mission" weapons manufacturing complex, eliminating the redundancy of operations between the plants. The third was the advent of the Cold War which fueled the nuclear arms race.

In the early years of the U.S. nuclear weapons program, the manufacturing complex was set up to provide redundancy of facilities. Hanford at one time manufactured plutonium pit components. Hanford's plutonium component production facilities reportedly mirrored those of Rocky Flats, and the two plants were manufacturing essentially the same product. At the same time, the Oak Ridge Y-12 plant was manufacturing uranium components similar to those at Rocky Flats. Los Alamos also had a small facility for production of triggers.

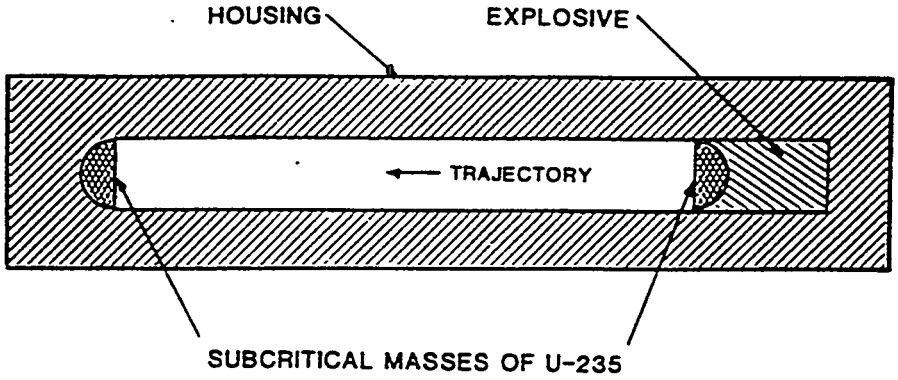
In the early 1960s, the government decided it was too expensive to maintain the duplicate weapons manufacturing facilities, and converted to the "single mission" concept, where the various facilities became specialized providers of the key weapons components and services. Hanford lost all contract work for the pits in the early 1960s, and Rocky Flats became the primary facility for that facet of weapons production. The single mission concept was also responsible for Rocky Flats' enriched uranium work being relocated to the Oak Ridge Reservation in 1964 (ChemRisk, 1991; RE-891[31,67,39,36]).

Historical investigations have indicated that the overall manufacturing facilities and production processes have remained largely the same over the years, although with periodic refinements. The lack of major changes is primarily because there have been only three basic trigger designs since the beginning of plant operations, with the manufacturing of the first two designs phasing out within the first five years of production. The major changes to trigger design have been to increase yield with less fissionable material, a miniaturization effort. Major changes in more recent years have been in the areas of delivery, guidance, and tracking systems - not the trigger concepts.

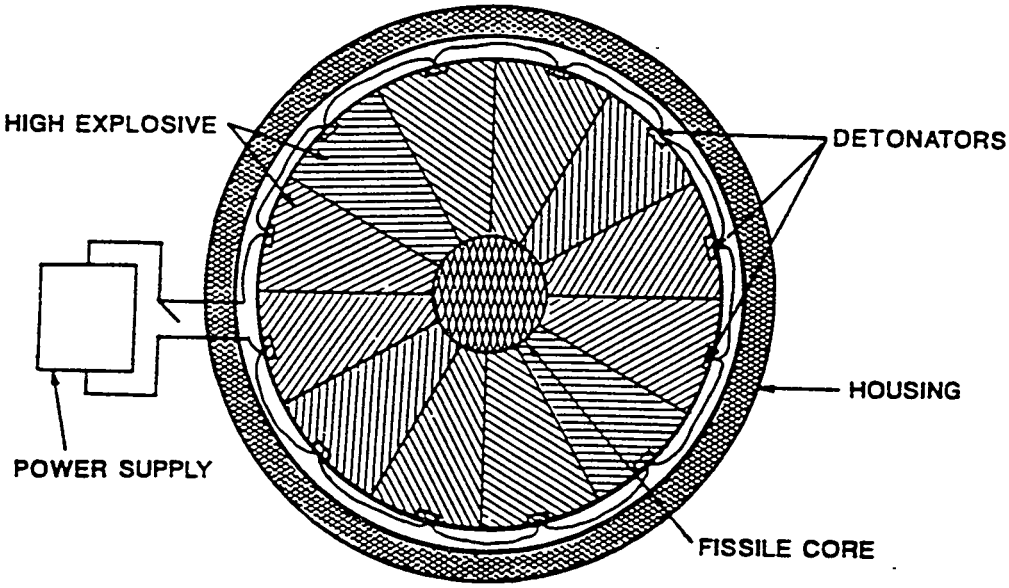
The first two basic pit designs built at Rocky Flats were solid units made mostly of uranium. They were essentially derivations of the "Fat Man" and "Little Boy" weapons dropped on Japan. The Fat Man design made at Rocky Flats had a small plutonium core surrounded by a large amount of enriched uranium and then by high explosives. Detonation of the explosives was precisely timed so that the uranium and plutonium would be compressed to a reduced volume to induce criticality. The Little Boy was also called the "gun assembly" because it incorporated two opposing, cylindrical-shaped masses of enriched uranium which were forced together by an explosive charge on one end. When forced together, criticality was achieved.

The concept and design of the unit changed around 1957 to a sealed hollow unit which used much less uranium while incorporating more plutonium (ChemRisk, 1991; RE-891[31,48,50,67,55]). Like previous designs, the sealed unit used high explosives to force the materials together, but the geometry and the larger amounts of plutonium used created a more powerful explosion with a smaller, lighter design. This enabled the finished weapon to be carried by missile and, with further miniaturization, could even be delivered by artillery. Schematic diagrams of the gun type and implosion weapon systems are shown in Figure 3-1 (Cuddihy and Newton, 1985).

GUN TYPE NUCLEAR DEVICE



IMPLOSION TYPE NUCLEAR DEVICE



SOURCE: Cuddihy and Newton, 1985

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FIGURE 3-1
SCHEMATIC DIAGRAM OF GUN TYPE
AND IMPLOSION WEAPON SYSTEMS

Since 1958, pit designs have remained largely the same, although the relative amounts of the materials used, dimensions, and a few other design features of the units have varied from model to model. The primary materials of construction have generally remained plutonium, uranium, beryllium, aluminum, and stainless steel, however the relative proportions have varied between models. Some models incorporated some more exotic materials, such as cadmium, vanadium, silver, and gold, but the amounts have been relatively minor in comparison to the primary five materials. The plant has also performed "Special Order" work. This type of work is outside the production of weapon components, but most often involved prototype development work. Special fabrication, testing, and assembly are provided for weapons development programs. For example, the work may involve the production of a prototype pit that incorporates different materials or geometries. In some cases, Special Order work has involved work indirectly related to war reserve programs, such as the development of safer shipping containers and transportation vehicles for nuclear materials and weapons (USDOE, 1980).

The plant's mission often included manufacturing of components for other portions of the weapon because it had the facilities and expertise to handle the materials involved. For example, the stainless steel reservoirs which hold the tritium for "boosting" weapon yield are manufactured at Rocky Flats, even though they are not a part of the pit. Beryllium components are also manufactured at Rocky Flats for other parts of the weapon.

3.2 Site Development

Construction activities relating to the Rocky Flats site began in 1951 in a building converted from an old garage at 13th and Glenarm in Denver, where the Austin Company and Rocky Flats employees initially worked. Ground-breaking for the first permanent buildings at the site of the Rocky Flats Plant began in July of 1951 for what is now known as Building 991. Later that year, construction also began on Buildings 771, 444, and 881. By April of 1952, the first operations began on regular production materials. At the beginning of 1953, some of the utility facilities on site were still incomplete; water was being brought in from Boulder in tank trucks and heat was provided to the occupied buildings by a locomotive which was temporarily brought on-site for generating steam. Nonetheless, the first production products were completed and shipped off-site that year from a plant that appeared as shown in Figure 3-2.

By 1954, the plant appeared as shown in Figure 3-3 and was fully operational, with initial plant construction essentially completed with a total of about 700,000 square feet of building space. As shown in Figure 3-4, plant employment grew steadily from 133 people in 1951 to 3,101 in 1963 (Buffer, 1991; USDOE, 1980; Putzier, 1982).

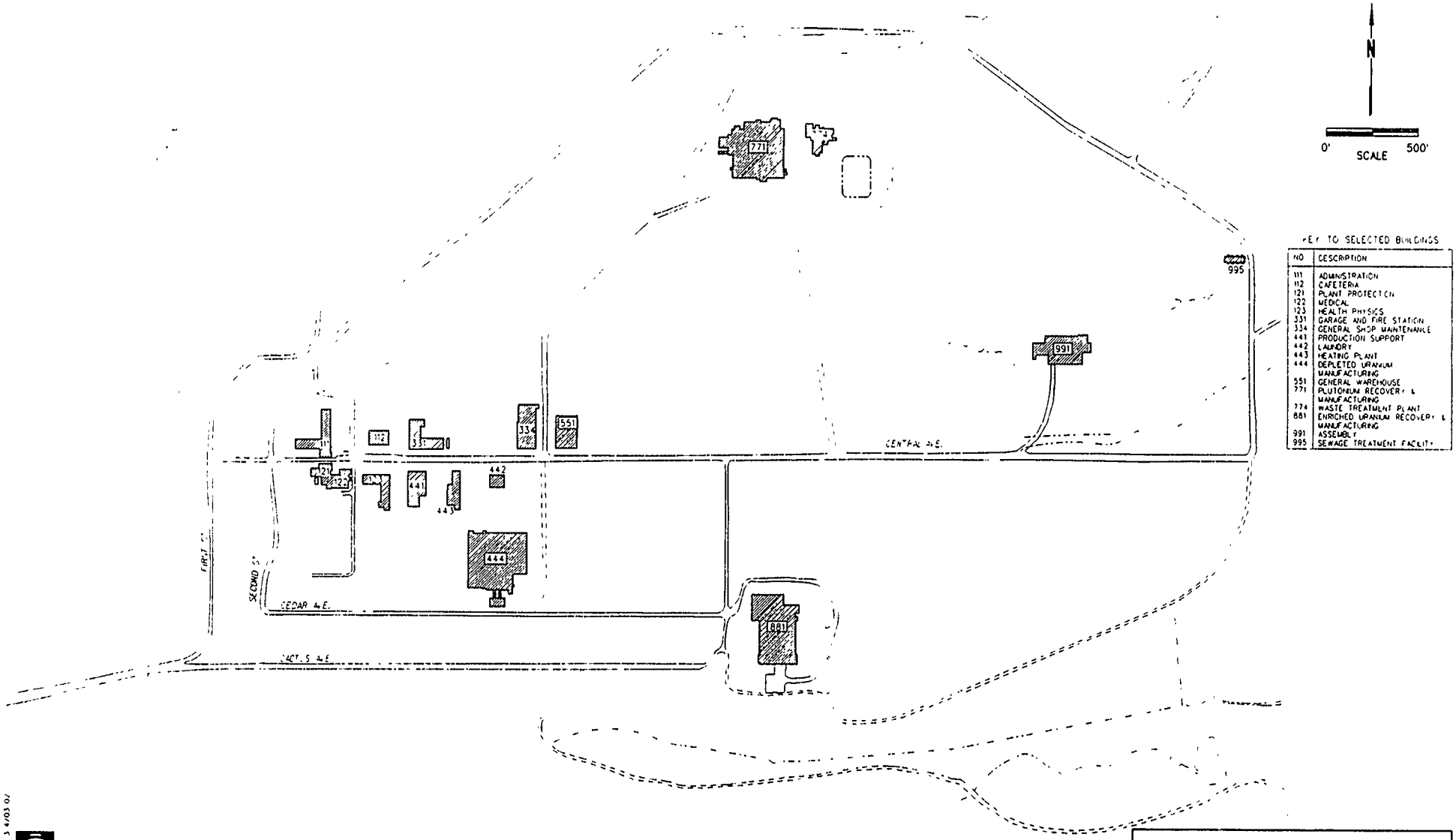

FIGURE 3-2
ROCKY FLATS FACILITY
AS IT APPEARED IN 1953

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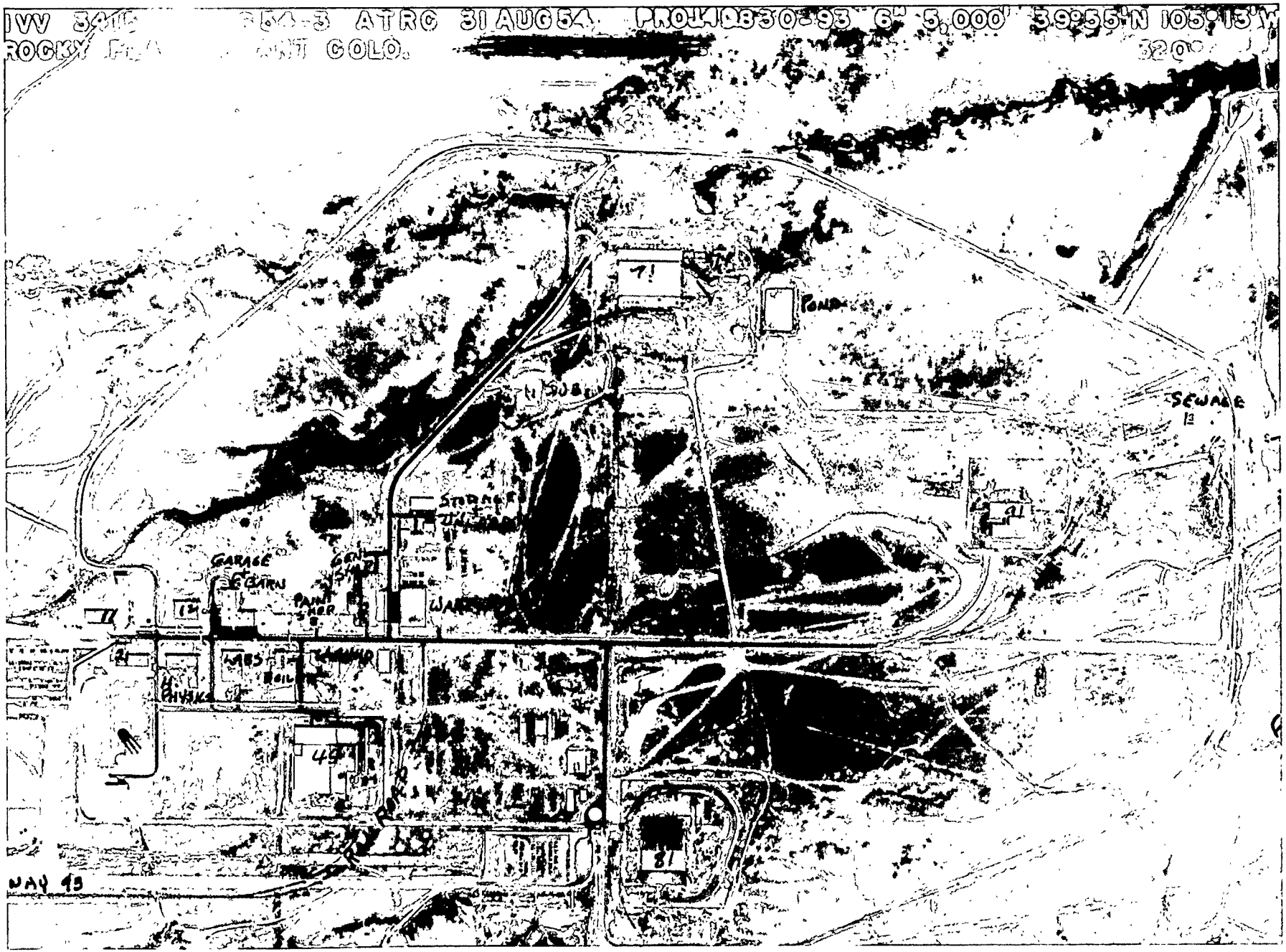
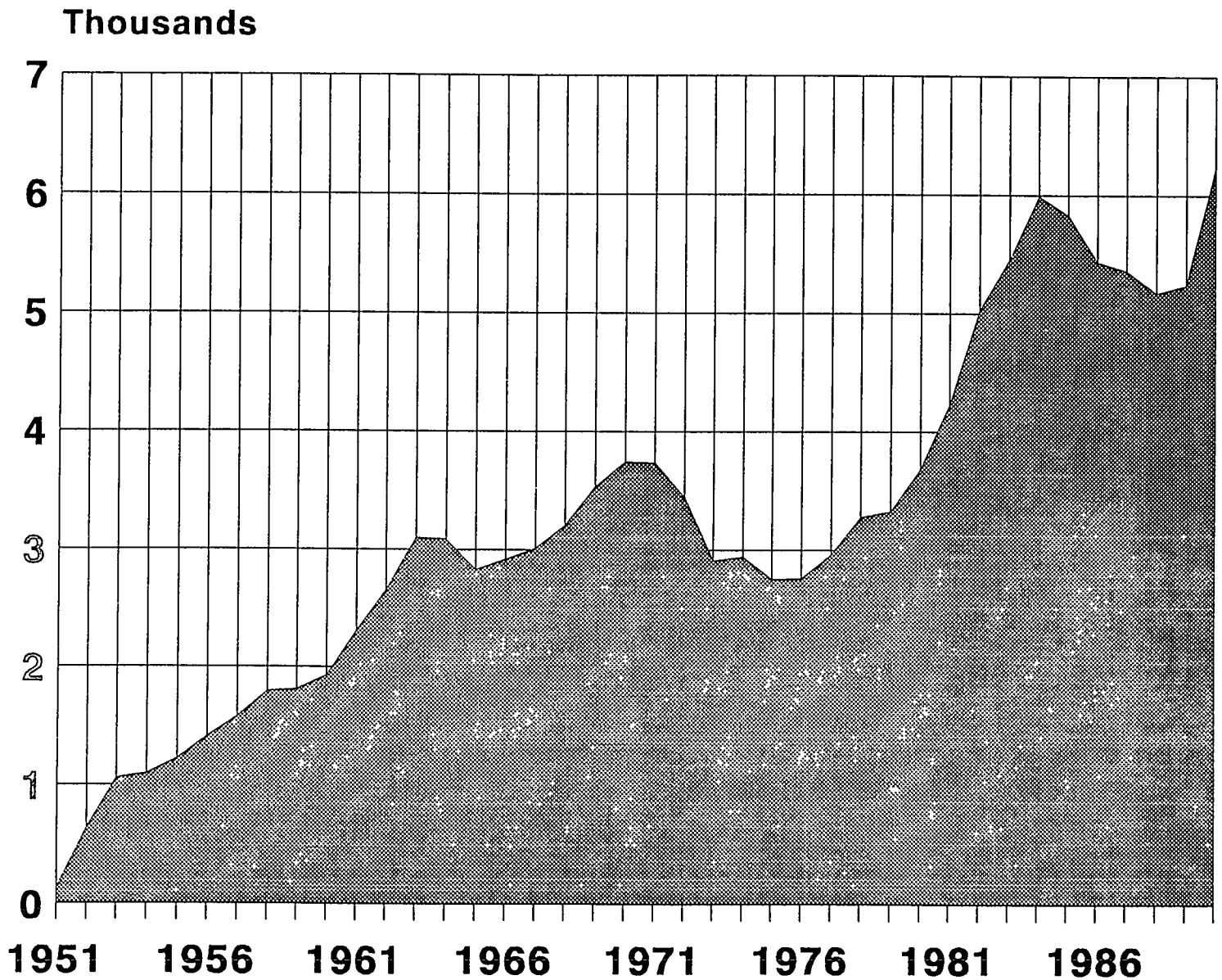


FIGURE 3-3. 1954 AERIAL PHOTO OF THE ROCKY FLATS PLANT



SOURCE: Buffer, 1991

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FIGURE 3-4
ROCKY FLATS PLANT
EMPLOYMENT LEVEL TREND

Originally, the plant was separated into four areas of operation. These areas were known as the A, B, C, and D Plants, and were established according to the four primary types of work which took place at Rocky Flats. The site was so undeveloped at that time that there were still large spans of meadow between the four plants, with gravel roads connecting them. The A Plant included Building 444 operations, which involved almost exclusively the fabrication of depleted uranium parts. What is now known as Building 881 was known as the B Plant, which recovered enriched uranium and manufactured components from the same. What was known as the C Plant is now Building 771. The C Plant housed plutonium operations, and the D Plant in Building 991 was the center of final product assembly operations. Each building was designed to be self-contained so that if any of the plants became inoperative, the remainder could continue to fulfill their functions (Putzier, 1982; ChemRisk, 1991; RE-891[39]).

Security in the 1950s was so tight that only a handful of people had clearances to get into more than one building, and most employees had no idea what went on in areas of the plant other than their own. Plant employees were bussed from the front gate to their buildings, since no personal vehicles were allowed on-site. It has even been reported that some managers couldn't gain access to their own production personnel in the areas in which they worked (Putzier, 1982; Buffer, 1990).

Additions to the facilities at Rocky Flats have been almost continuous since 1951. A few periods, however, have involved more construction than others. A major facility expansion was initiated in 1955 and was referred to as Part IV construction. A second major plant expansion, Part V construction, began in 1967 **(USDOE, 1992)**. Another was in 1956 and 1957, with the addition of ten buildings, most of which were directly related to the change of the weapon concept to a hollow unit and anticipated production increases. This buildup included the construction of Buildings 447, 776, 777, 883, 997, 998, and 999, along with additions to Buildings 444, 881, and 771.

A few years later, Rocky Flats became the primary manufacturer of triggers under the single mission concept, at a time roughly coincident with the onset of the Cold War. The result was a dramatic rise in production at Rocky Flats in the 1960s. By 1964, the plant appeared as shown in Figure 3-5, and the work force reached a plateau of around 3,000 people that lasted about 15 years. Other build-ups included the beginning of an expansion including Building 559 in 1967, and several significant buildings coming on-line in the early 1970s (Buildings 440, 707, 750, and 865) and at the beginning of the 1980s (Buildings 371 and 460) (Buffer, 1991; unknown author, HS-404).

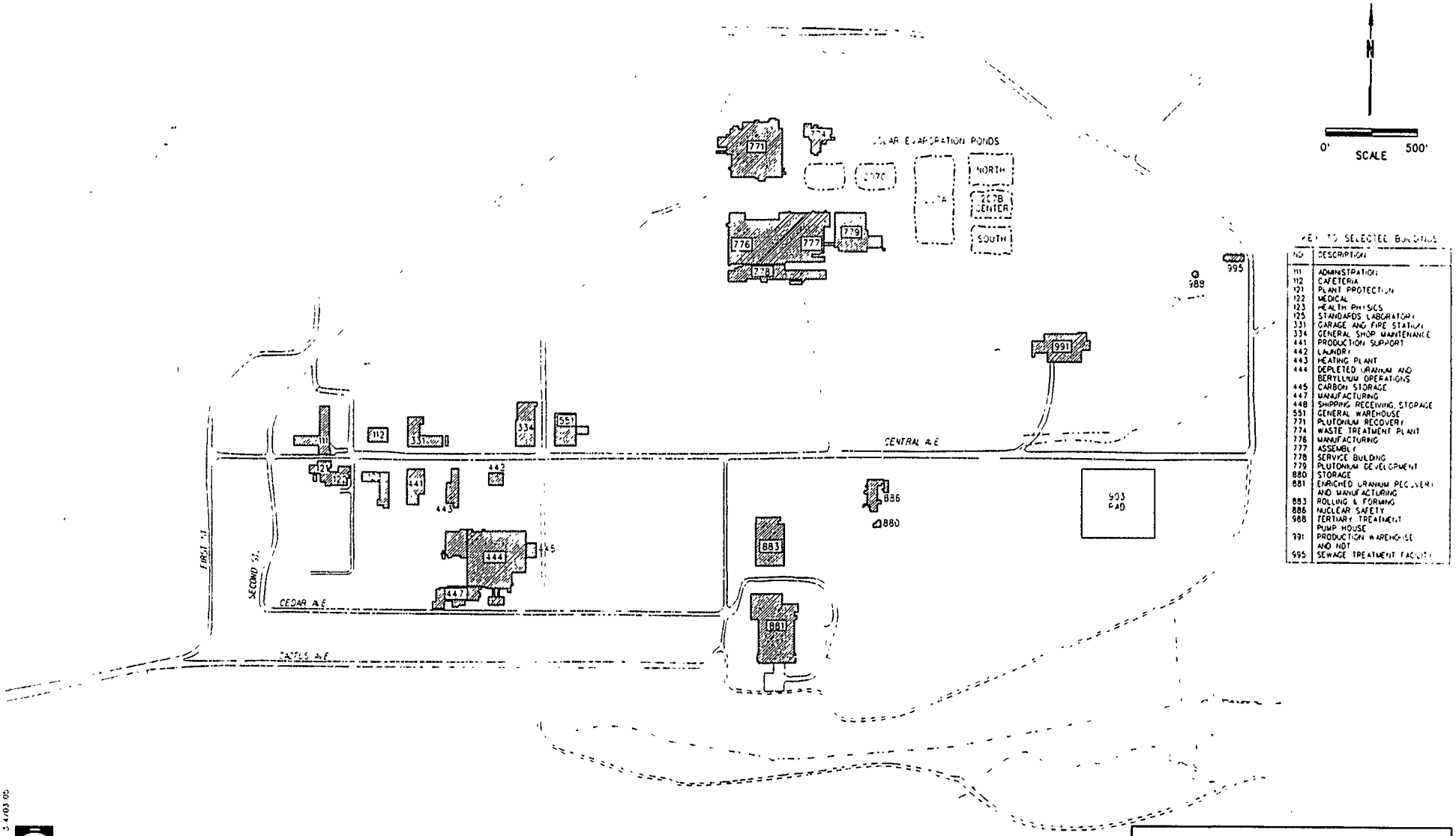

FIGURE 3-5
ROCKY FLATS FACILITY
AS IT APPEARED IN 1964

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The early 1980s also showed a significant upturn in Rocky Flats employment, with a peak at 5,990 in 1984. Representations of the developing plant as it appeared in 1971, 1980, and 1990 are shown in Figures 3-6 through 3-8. By 1990, the total building space grew to approximately 2.5 million square feet. Today, the Rocky Flats site appears as shown in Figure 3-9.

3.3 The Main Functions of Rocky Flats and their Development

Stated in the simplest terms, the Rocky Flats Plant is largely a manufacturing facility consolidating the production and support activities necessary for fabrication of nuclear weapon components. This discussion of Rocky Flats operational history is broken down into the following main functional areas of plant activity:

- Component Manufacturing and Assembly
- Material Recovery and Purification
- Research and Development
- Waste Processing
- Plant Support

To manufacture a trigger, facilities, equipment, and personnel must be developed to conduct precision metalworking and assemble fissionable and non-fissionable materials. In the case of Rocky Flats, the fissionable materials have nearly always involved uranium and plutonium, and the key non-fissionable components have for the most part been beryllium, aluminum, and stainless steel. The primary production materials used at Rocky Flats are among the most expensive and tightly controlled in the world.

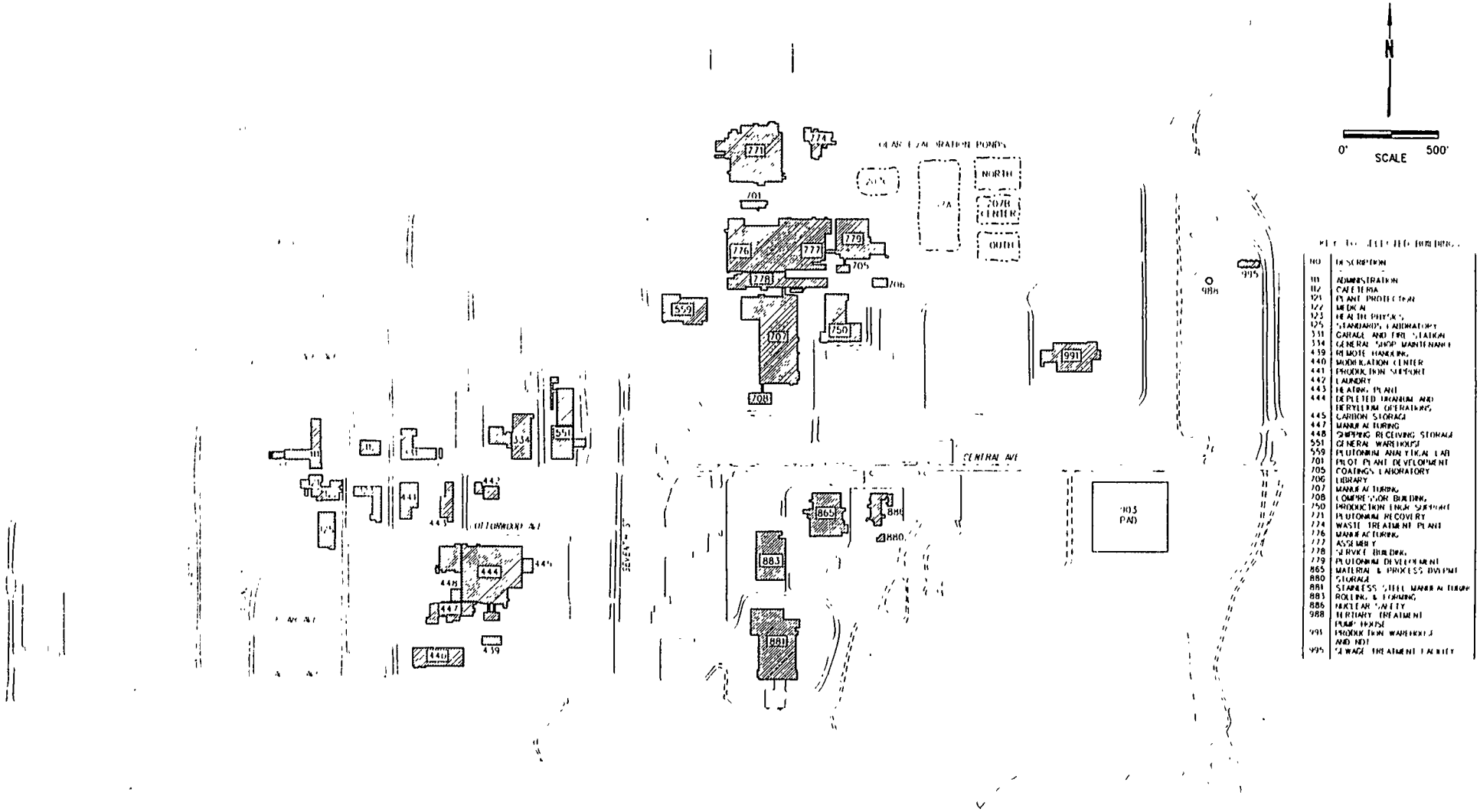
Although the general types of activities performed at the plant have not significantly changed during the course of its history, there have been a few notable changes in specific operations at the plant. In the late 1950s there came a greater emphasis on the use of plutonium in the weapon design rather than the heavier amount of enriched uranium used in earlier models. This, coupled with the transfer of enriched uranium contract work to the Oak Ridge Reservation in 1963, resulted in most of the enriched uranium work moving out of Rocky Flats by 1964. Beryllium has nearly always been present at Rocky Flats, but it wasn't actually used in full-scale, production operations until 1958. Prior to

that, it was involved in the earlier phases of weapons development. Americium recovery also did not start until 1957 (Putzier, 1982). In addition to functioning as a step in the plutonium recovery process, the americium line was actually a cash producer. Until the americium market demand fell off in the 1980s, americium was widely used in smoke detectors, batteries, and medical diagnostic tracers (ChemRisk, 1991; RE-891[34,43,62,65]). Stainless steel component work came to Rocky Flats in 1964 from the American Car and Foundry Company in Albuquerque. That contractor lost its agreement with the Atomic Energy Commission for economic reasons and the contract went to Dow at Rocky Flats. Stainless steel operations (known as the "J Line") began in Building 881 and were there until 1984, when they were moved into Building 460, which was newly constructed to house those operations and some from Building 444. These "consolidated manufacturing" operations remain in Building 460 today (ChemRisk, 1991; RE-891[31,35,39,27]).

During the course of manufacturing these metal products, wastes are produced which consist of the fissionable and non-fissionable materials, associated lubricating and cleaning compounds, and other materials such as rags, slags, clothing, tools, and paints. Since these wastes include materials that are extraordinarily costly to procure and are sensitive in terms of national security, it was economically imperative to recover these materials from wastes prior to their disposal.

Since the plant opened, there has been a heavy emphasis on recovering fissionable materials from manufacturing residues. During the period of waste oil storage in the area now known as the 903 pad, the scientists and engineers at the plant were attempting to develop means to recover both the fissionable materials and the oils which they contaminated (Seed et al., 1971). For various reasons, acceptable recovery methods were never devised, and the waste oils were finally treated by fixation with cement and shipped off-site for burial. Facilities to perform recovery and purification of plutonium and uranium were among the first to go into operation at Rocky Flats.

Research and development has always been a part of the activities at the plant (Campbell, 1986; USDOE, 1980). The focus of the work, however, has not been in the area of weapons design or development. Rather, it has been directed toward three areas: 1) basic understanding of the materials handled at the plant (for example, metallurgy of plutonium and uranium), 2) improving the recovery and purification of those materials, and 3) improving the manufacturing operations and assembly techniques.



NO	DESCRIPTION
111	ADMINISTRATION
112	CAFETERIA
121	PLANT PROTECTION
122	MEDICAL
123	HEALTH PHYSICS
125	STANDARDS LABORATORY
311	GARAGE AND FIRE STATION
314	GENERAL SHOP MAINTENANCE
439	REMOTE HANDLING
440	MODIFICATION CENTER
441	PRODUCTION SUPPORT
442	LAUNDRY
443	HEATING PLANT
444	DEPLETED URANIUM AND BERYLLIUM OPERATIONS
445	CARBON STORAGE
447	MANUFACTURING
448	SHIPPING RECEIVING STORAGE
551	GENERAL WAREHOUSE
559	PLUTONIUM ANALYTICAL LAB
701	PILOT PLANT DEVELOPMENT
705	COATINGS LABORATORY
706	LIBRARY
707	MANUFACTURING
708	COMPRESSOR BUILDING
750	PRODUCTION ENGR SUPPORT
771	PLUTONIUM RECOVERY
774	WASTE TREATMENT PLANT
776	MANUFACTURING
777	ASSEMBLY
778	SERVICE BUILDING
779	PLUTONIUM DEVELOPMENT
865	MATERIAL & PROCESS DVLPMT
880	STORAGE
881	STAINLESS STEEL MANUFACTURING
883	ROLLING & FORMING
886	NUCLEAR SAFETY
988	TERTIARY TREATMENT PUMP HOUSE
991	PRODUCTION WAREHOUSE
995	SEWAGE TREATMENT FACILITY

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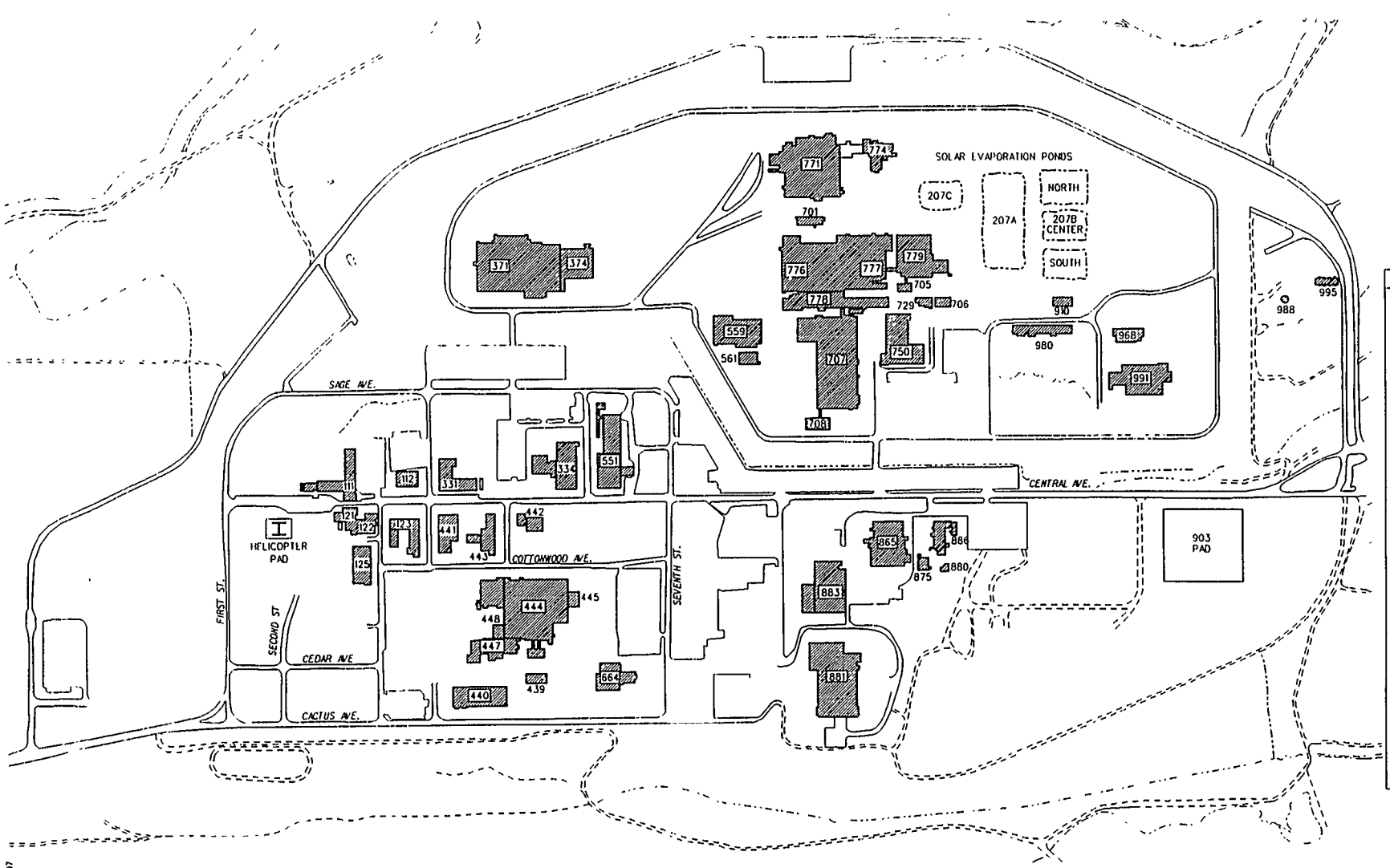
FIGURE 3-6
ROCKY FLATS FACILITY
AS IT APPEARED IN 1971



KEY TO SELECTED BUILDINGS

NO	DESCRIPTION
111	ADMINISTRATION
112	CAFETERIA
121	PLANT PROTECTION
122	MEDICAL
123	HEALTH PHYSICS
125	STANDARDS LABORATORY
331	GARAGE AND FIRE STATION
334	GENERAL SHOP, MAINTENANCE
371	PLUTONIUM RECOVERY
374	PROCESS WASTE TREATMENT
439	REMOTE HANDLING
440	MODIFICATION CENTER
441	PRODUCTION SUPPORT
442	FILTER TEST LABORATORY
443	HEATING PLANT
444	DEPLETED URANIUM AND BERYLLIUM OPERATIONS
445	CARBON STORAGE
447	MANUFACTURING
448	SHIPPING, RECEIVING, STORAGE
452	MANUFACTURING SUPPORT
551	GENERAL WAREHOUSE
559	PLUTONIUM ANALYTICAL LAB
561	FILTER PLENUM BUILDING
664	WASTE STORAGE AND SHIPPING
701	PILOT PLANT DEVELOPMENT
705	COATINGS LABORATORY
706	LIBRARY
707	MANUFACTURING
708	COMPRESSOR BUILDING
729	FILTER PLENUM BUILDING
750	PRODUCTION ENGR SUPPORT
771	PLUTONIUM RECOVERY
774	WASTE TREATMENT PLANT
776	MANUFACTURING
777	ASSEMBLY
778	SERVICE BUILDING
779	PLUTONIUM DEVELOPMENT
865	MATERIAL & PROCESS DVLPMNT
875	FILTER PLENUM BUILDING
880	STORAGE
881	STAINLESS STEEL MANUFACTURING
883	ROLLING & FORMING
886	NUCLEAR SAFETY
910	REVERSE OSMOSIS FACILITY
968	CONTRACTOR WAREHOUSE
980	STORAGE
988	TERTIARY TREATMENT PUMP HOUSE
991	PRODUCTION WAREHOUSE AND NDT
995	SEWAGE TREATMENT FACILITY

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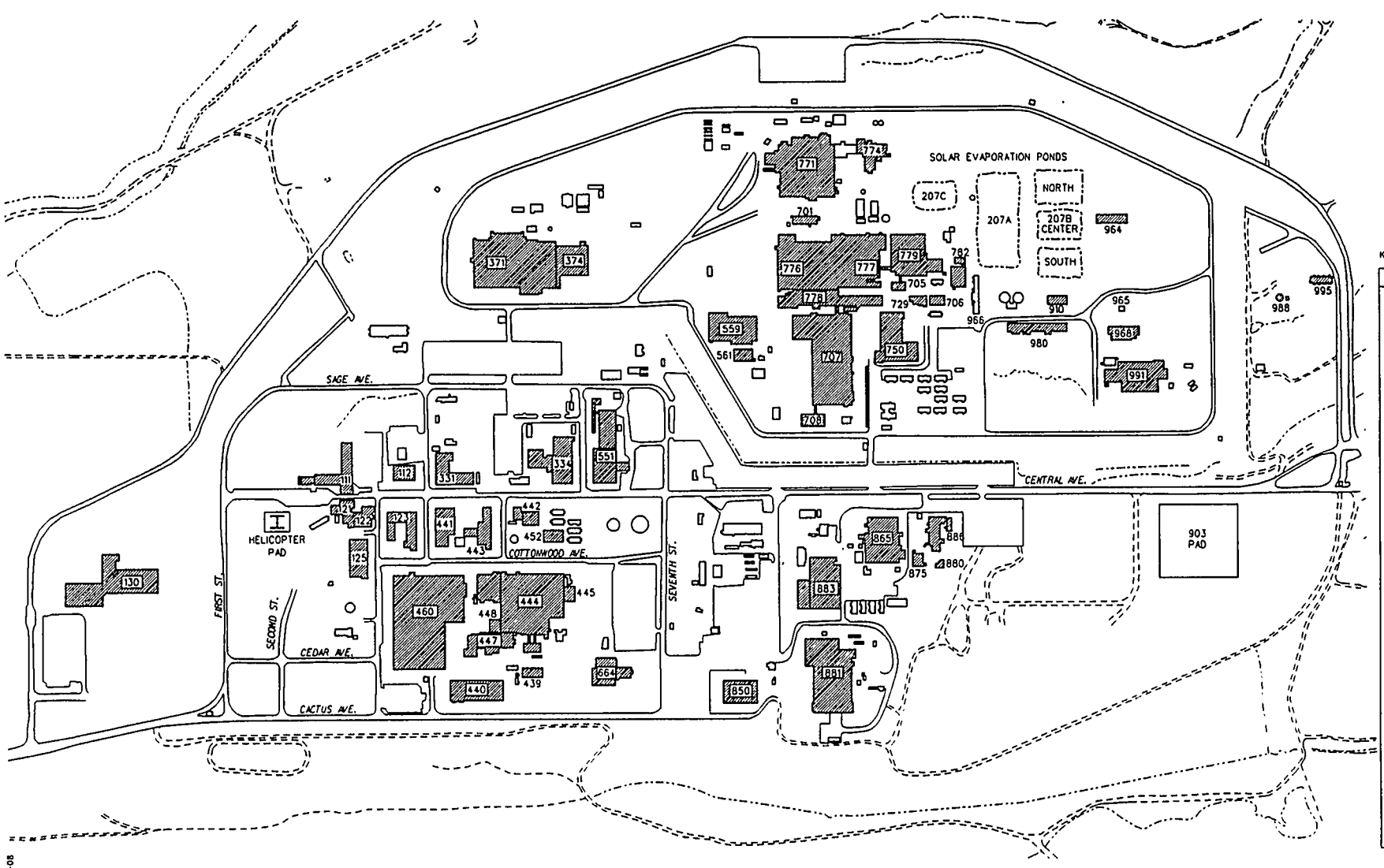
FIGURE 3-7
ROCKY FLATS FACILITY
AS IT APPEARED IN 1980



KEY TO SELECTED BUILDINGS

NO	DESCRIPTION
111	ADMINISTRATION
112	CAFETERIA
121	PLANT PROTECTION
122	MEDICAL
123	HEALTH PHYSICS
125	STANDARDS LABORATORY
130	PRODUCTION SUPPORT
331	GARAGE AND FIRE STATION
334	GENERAL SHOP; MAINTENANCE
371	PLUTONIUM RECOVERY
374	PROCESS WASTE TREATMENT
439	REMOTE HANDLING
440	MODIFICATION CENTER
441	PRODUCTION SUPPORT
442	FILTER TEST LABORATORY
443	HEATING PLANT
444	DEPLETED URANIUM AND BERYLLIUM OPERATIONS
445	CARBON STORAGE
447	MANUFACTURING
448	SHIPPING, RECEIVING, STORAGE
452	MANUFACTURING SUPPORT
460	CONSOLIDATED MANUFACTURING
551	GENERAL WAREHOUSE
559	PLUTONIUM ANALYTICAL LAB
561	FILTER PLENUM BUILDING
664	WASTE STORAGE AND SHIPPING
701	PILOT PLANT DEVELOPMENT
705	COATINGS LABORATORY
706	LIBRARY
707	MANUFACTURING
708	COMPRESSOR BUILDING
729	FILTER PLENUM BUILDING
750	PRODUCTION ENGR SUPPORT
771	PLUTONIUM RECOVERY
774	WASTE TREATMENT PLANT
776	MANUFACTURING
777	ASSEMBLY
778	SERVICE BUILDING
779	PLUTONIUM DEVELOPMENT
782	FILTER PLENUM BUILDING
850	LOGISTICS
865	MATERIAL & PROCESS DVLPMNT
875	FILTER PLENUM BUILDING
880	STORAGE
881	R & D AND GENERAL SUPPORT
883	ROLLING & FORMING
886	NUCLEAR SAFETY
910	REVERSE OSMOSIS FACILITY
964	STORAGE BUILDING
965	STORAGE
966	CONTRACTOR SHOPS
968	CONTRACTOR WAREHOUSE
980	CONTRACTOR SHOP
988	TERTIARY TREATMENT PUMP HOUSE
991	PRODUCTION WAREHOUSE AND NDT
995	SEWAGE TREATMENT FACILITY

FIGURE 3-8
ROCKY FLATS FACILITY
AS IT APPEARED IN 1990

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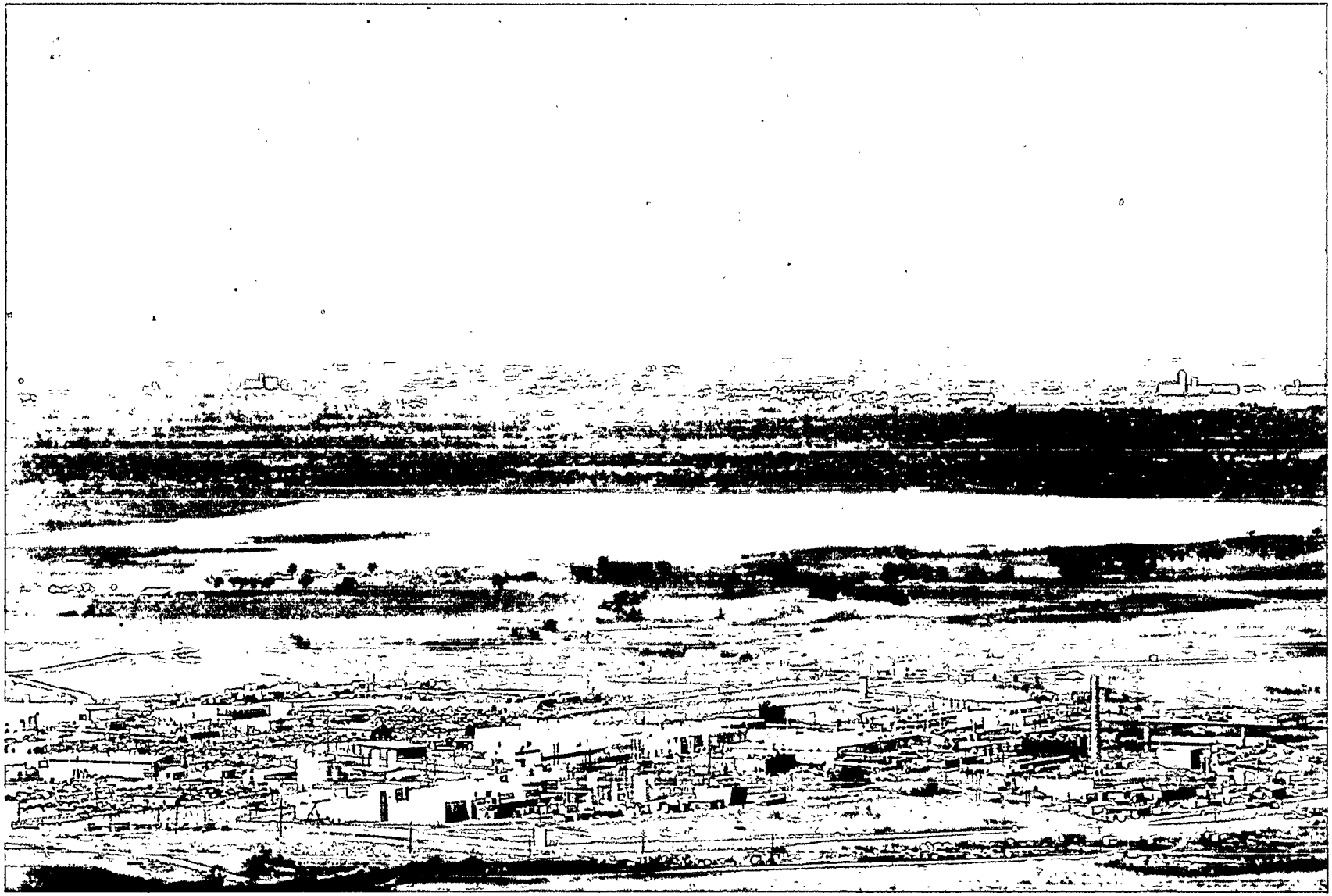

FIGURE 3-9. THE MODERN DAY ROCKY FLATS FACILITY (JUNE, 1991). VIEW IS TO THE EAST

Research and development activities have also focused on understanding the causes of accidents, thereby reducing the potential for future injuries and liability. One example of this was the 1964 plutonium/carbon tetrachloride explosion in Building 776, which sparked a number of R & D projects that examined the interaction of plutonium with a variety of solvents.

Waste processing, to varying degrees, has always been a part of the activities at the plant. The Atomic Energy Commission recognized the potential health impact posed by releases of radioactive contaminants into the environment, and set requirements for monitoring airborne and waterborne effluents and recordkeeping under which the plant was required to operate since the day it opened. The waste processing practices have varied over time as scientists' understanding of radiation improved, knowledge in the area of waste technology progressed, and tighter regulatory requirements were enacted. Because of its size and location, the plant has always had its own sanitary waste treatment facilities in addition to those handling industrial wastes.

The plant has a number of support groups which are typical to many large manufacturing facilities, such as administrative and finance organizations, utilities and facilities management groups, and health and safety personnel. The plant has some support organizations which are unique because the plant handles a large amount of radioactive materials in various forms. One is the Criticality Lab, or Nuclear Safety Group, which is dedicated to identifying and directing control of the potential for spontaneous nuclear fission chain reactions (criticalities) in the conduct of plant activities. Another unique support function has been provided by the Filter Testing group, which provides pre- and post-installation testing of the high efficiency particulate air (HEPA) filters used in ventilation exhaust systems and performs testing of personnel respirators. These and other support activities are discussed in Section 3.3.5, Plant Support.

3.3.1 Material Recovery and Purification

The purpose of Recovery Operations is to recover and purify the fissionable material used in the weapon systems which are of strategic importance. As much of the material as is economically feasible is recovered from wastes generated during the manufacturing processes, since these materials are extremely expensive, difficult to obtain, and controlled for national security reasons. The manufacturing wastes can vary from rags contaminated with a small concentration of material to almost pure metal turnings generated by machining operations.

At Rocky Flats, recovery has always been a part of operations, and the plant has always operated under requirements which dictate how much nuclear material could be present in the various types of wastes discarded by the plant. For some time Rocky Flats performed recovery on manufacturing wastes bearing plutonium, americium, and uranium. Recovery operations in recent years were limited to plutonium materials, as enriched uranium operations were moved to the Oak Ridge Reservation, and americium operations have been scaled back due to the lack of a market for the radionuclide.

Plutonium Recovery and Purification

When Building 771 became operational in 1953, the operations performed there included both plutonium recovery and purification and plutonium component manufacturing. Plutonium operations began in the spring of 1953, and were designed as a copy of the Los Alamos plutonium facility. The first personnel hired to operate the 771 recovery line were sent to Los Alamos to learn the operations there prior to working in the building. In 1953, there was only one "Chem Line" in operation. It had the capacity to produce plutonium buttons of approximately 300 gram size. Later, in 1955, an "East Chem Line" started up which had the capability of producing buttons of a two kilogram size. Both lines operated for a while, producing plutonium metal. Eventually, the capacity of the operations reached approximately 12 kilograms per day. Around 1965, the complexity and demand on the operations had increased to a point that the original cafeteria was taken over as a production area and a new cafeteria and offices were built on to the north end of the building (Putzier, 1982; Navratil and Miner, 1984). The expanded production area was used for the addition of five dissolution lines, which roughly increased the plutonium recovery throughput by a factor of 20 over that of the original facility (ChemRisk, 1991; RE-891[65]).

In 1968, the decision was made to replace Building 771 recovery operations. Ground-breaking took place in 1973 for what was to become Building 371. The new facility was plagued with problems from the onset of construction, and delays prevented "cold start-up" before 1981. Design flaws finally resulted in Building 371 chemical processing being shut down in 1985 before ever achieving full-scale operation (ChemRisk, 1991; RE-891[33,65] and Crisler, 1991).

In the very early years, Building 771 housed essentially all of the plutonium operations; recovery, fabrication of metal buttons from plutonium nitrate solution, and component fabrication and storage. At that time, assembly of the plutonium components with non-plutonium components was done in Building 991. Many of the plutonium fabrication

operations were moved from Building 771 to building 776 when it came on line in 1958, with the recovery operations staying in 771 (Putzier, 1982).

Originally, plutonium at Rocky Flats came from Hanford as plutonium nitrate in small, stainless steel florence flasks packaged in cylindrical steel carrying cases shaped like small telephone cable reels. The nitrate was vacuum-transferred into a vessel where plutonium dioxide was precipitated by the addition of hydrogen peroxide. The dioxide was converted to fluoride, which was converted to a metal button by calcium-iodine reduction. Later, plutonium also came in the form of buttons from Hanford. Occasionally, plutonium nitrate feed was also received from the Oak Ridge Reservation. Around 1959, these shipments dropped off, and the majority of the plutonium feed to recovery and purification operations was recycled material, either from site returns, the foundry, or the waste products from the recovery operation itself. Site returns are weapon components that have been retired and returned to Rocky Flats for disassembly and recovery of materials. Some of the plutonium which went through the system at this time came from outside sources in the form of plutonium dioxide (Putzier, 1982; Navratil and Miner, 1984). Later shipments of plutonium were made in the form of metal buttons from Savannah River.

Plutonium recovery has always been a batch-oriented process, conducted in glove-boxes similar to those in Building 707 shown in Figure 3-10. Capabilities of some of the associated facilities and equipment have changed to produce larger batches more efficiently. For example, around 1963, a continuous rotary fluorinator was installed which allowed greater control and more consistency in that step of the process. As a result, larger batches of plutonium could be handled. Since the beginning of operations, the basic recovery process has undergone relatively little change (Tesitor, 1971). Most changes have been refinements to provide for more throughput and changes to the facilities to improve worker safety. Those changes to the recovery operation processes which could have impacted emissions are discussed below.

In the mid 1960s, Rocky Flats made pits and other components for "Safety Shots" in addition to routine production. The Safety Shot testing was done to characterize the potential hazards that could arise from accidents involving nuclear weapons, that is accidents in which no nuclear explosion occurs, for example as a result of airplane crashes or missile malfunctions. This testing was not conducted at the Rocky Flats Plant. The nuclear weapons or weapon components were placed alongside conventional explosives, and the conventional explosives were then detonated. These "shots" were performed under varying conditions to assess the potential for dispersal of radioactive material or nuclear weapon detonation. Some of the tests involved placing other nuclear weapons or pits at various proximities to a nuclear explosion to determine if the components would

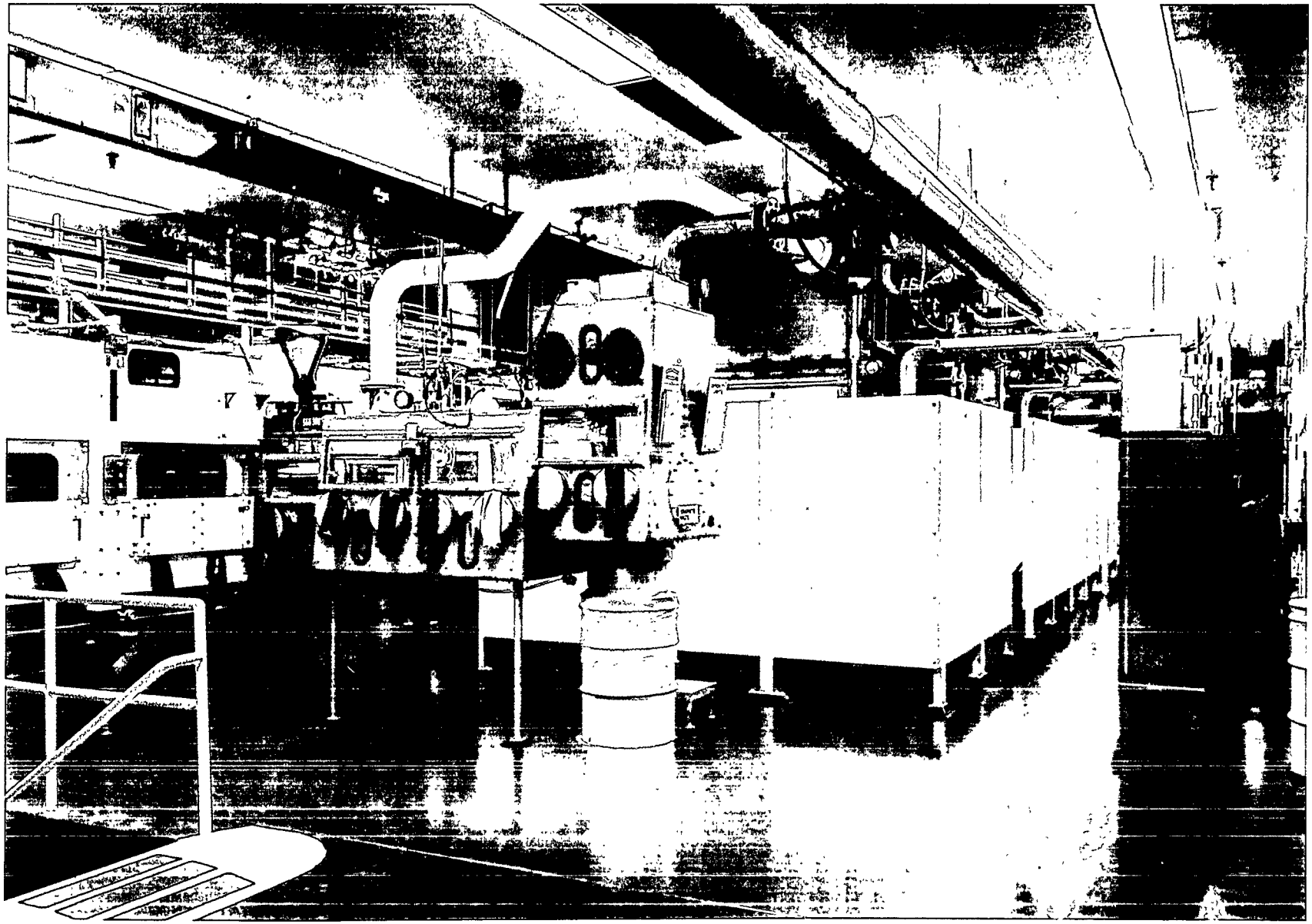

FIGURE 3-10. A TYPICAL GLOVE-BOX LINE. GLOVE-BOXES ARE WIDELY USED AT ROCKY FLATS FOR CONTAINMENT DURING MATERIAL PROCESSING.

remain functional, would be rendered inoperable, or would detonate. Still other tests involved detonating only a single point of the high-explosives cluster surrounding the pit to determine if the design was "one-point safe", in other words did not yield a nuclear explosion.

Rocky Flats also produced components from other metallic radionuclides on a limited basis for incorporation into pits for "Special Order" operations. The inclusion of these radionuclides as tracers (namely neptunium -237, americium-240, plutonium-238, and an isotope of curium) into the makeup of the triggers allowed scientists to track the reactions of the detonation (ChemRisk, 1991; RE-891[9,31,43,52]).

"Special Recovery" processed the plutonium tracer materials. Eventually, leftover tracer materials had to be taken out of the plutonium streams, and that too became part of Special Recovery operations. Today Special Recovery operations include the Oralloy and Part V Leaching lines, in which surface impurities are removed from enriched uranium and plutonium components (Rockwell, 1981; ChemRisk, 1991; RE-891[9,27,43]).

Plutonium recovery operations are depicted in Figure 3-11. The recovery process is often described in terms of functional divisions - "fast" and "slow" recovery operations. The fast side basically processes plutonium nitrate solution, turning the liquid to a solid (powder) and then to metal. The slow side receives those materials which have more impurities, and as a result require more pre-processing before entering the fast side process of conversion to metal (Crisler, 1991).

Prior to implementation of the molten salt extraction process in 1968, almost all plutonium-bearing materials went through slow recovery operations, for example reactor generated plutonium, site returns, metal chips, and foundry skull and other forms of high purity metal residues generated by machining operations. These materials had to first be put into a plutonium nitrate form via the slow side operations and then introduced into the fast cycle line for conversion to a solid and reduction to metal. Since the introduction of the molten salt extraction (MSE) process in 1968, some of the essentially pure plutonium metal, such as the metal from site returns, has gone through MSE to remove americium ingrowth and has then been forwarded directly to plutonium foundry operations in Building 777 for casting and subsequent processing into plutonium components. The need for these materials to go through the chemical recovery process was eliminated. As a result, slow cycle recovery now receives materials such as effluents and waste products from the fast cycle, rags, paper goods, sweepings, and other wastes. It no longer processes the purer forms of plutonium. As before, though, materials which have gone through the slow recovery cycle are then sent through the fast cycle for further purification.

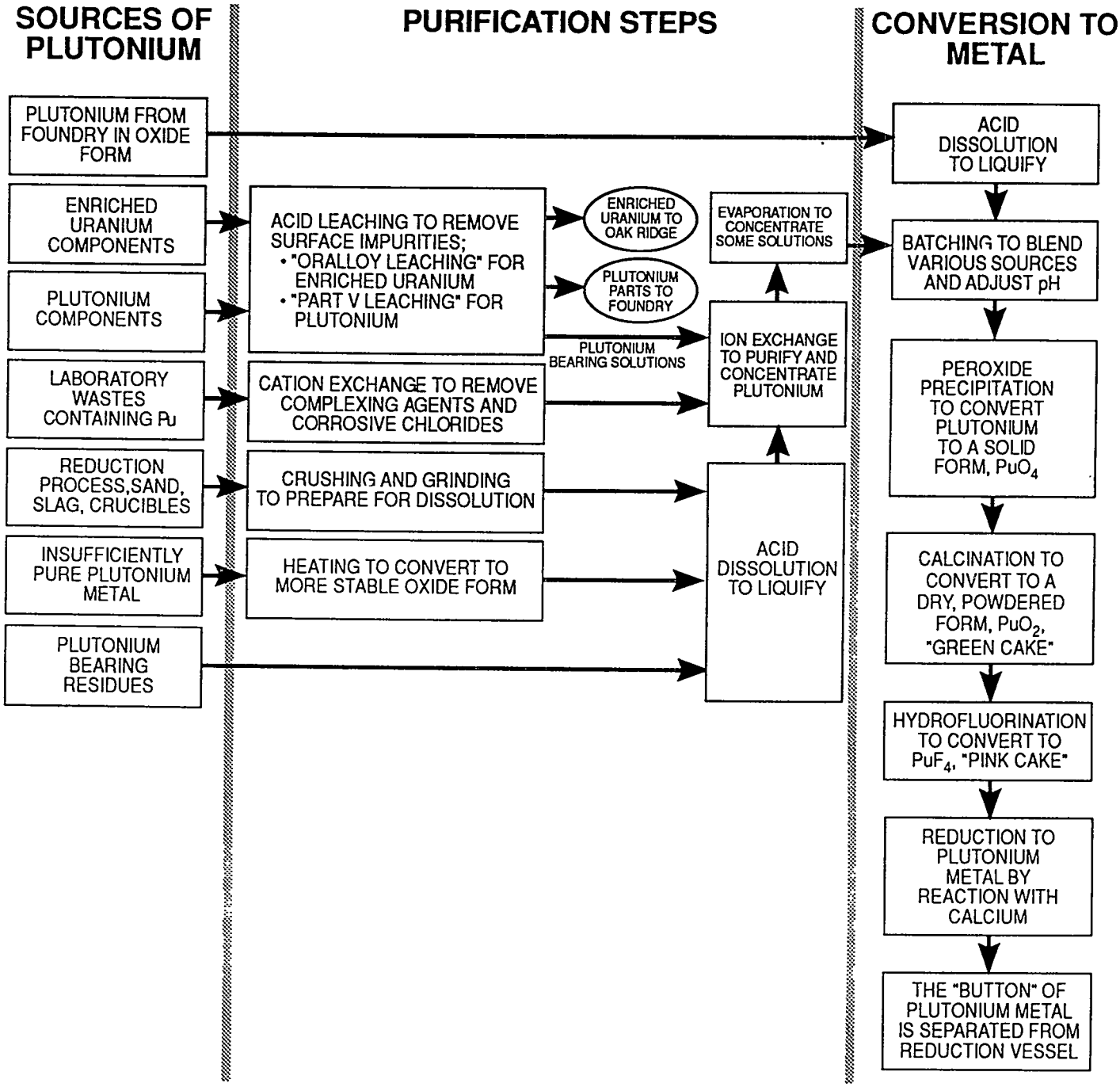

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FIGURE 3-11
PLUTONIUM RECOVERY PROCESS

One of the primary objectives of the recovery operation is to process the waste material until it can be safely and economically discarded. To provide a quantitative target by which to measure the discardability of wastes, limits have been set which define concentrations of radioactive contaminants in materials which will be discarded or processed for recovery. These economic discard limits (EDLs) identify the concentration of a particular nuclear material present in a waste product, below which it is not economically feasible to attempt recovery. Below the EDL, the material can be disposed of as radioactive waste.

In plutonium operations, the basic fast cycle recovery operations involve an aqueous dissolution process, followed by precipitation, calcination, hydrofluorination, and reduction steps to return the solute back into metallic form. Nitric acid is the primary chemical used in the dissolution steps, although the operation also involves aluminum nitrate, calcium fluoride, and water. After dissolution, the nitrate mixture undergoes a peroxide precipitation step which converts the plutonium to solid plutonium peroxide, which in turn is heated (calcined) to change it to plutonium dioxide, a powder that is often called "green cake". The plutonium dioxide is then reacted with anhydrous hydrogen fluoride vapor in a rotary tube to convert it to plutonium tetrafluoride, "pink cake." The PuF_4 is then reduced by reaction with calcium to convert it to plutonium metal. The final product "button" is washed and moved to storage until needed for production feedstock. Liquid wastes which are generated by fast cycle recovery are either transferred over to slow cycle recovery or sent to building 774 for treatment, provided duplicate sampling demonstrates that residual radioactivity concentrations are within acceptable levels.

Slow recovery operations involve different types of processes, depending upon the nature of the wastes to be handled. For example, combustible residues, such as plastic bags and Kimwipes, are incinerated to reduce the bulk of the materials and convert the plutonium to an oxide form. The slow side also receives effluents from the fast cycle for further recovery of any plutonium in those streams. Other processes are designed to recover plutonium from lab wastes, molten salt process residues, and other solutions by various methods including dissolution and cation or anion exchange. The resulting nitrate solutions from the slow cycle processes are then introduced into fast cycle operations prior to the peroxide precipitation step.

There are three primary recovery processes in slow recovery: anion exchange, dissolution, and cation exchange. The most significant of these is probably the anion exchange process, which receives effluents from the other two. Anion exchange primarily receives effluents from the fast cycle precipitation operation, with the dissolution and cation exchange operations contributing to a lesser degree. Dissolution gets its feed, in part, in the form of incinerator ash. The feed may also be made up of plutonium dioxide from

oxidation operations in Building 771 and other buildings. The resulting effluent goes to anion exchange. Cation exchange feed comes from lab wastes and the chloride salt processes. The main reason for the cation exchange operation is to remove chlorides, which can create severe corrosion problems for the anion exchange equipment, from plutonium bearing materials that contain them. Once these materials go through the cation exchange, they can then be transferred to anion exchange without complications.

Prior to 1960, dissolution was followed by a solvent extraction step which used tributylphosphate as the solvent and dodecane as the diluent. The solvent extraction was followed by cation exchange. Around 1960, solvent extraction was eliminated from the recovery process line because the materials going through the recovery process were becoming more and more varied. A new process was required which could handle the variety of feed materials. The solvent extraction process was replaced by anion exchange. This was made possible by raising the molarity of the solution following dissolution by adding higher molarity nitric acid. The resulting solution could then be sent directly on to anion exchange. The process has since remained the same (Crisler, 1991; ChemRisk, 1991; RE-891[11,43,9,49]).

Liquid wastes which were generated from the plutonium recovery processes that were below established concentration limits for radioactivity were sent to liquid waste processing operations in Building 774 to be processed. Liquid waste generated by the recovery processes which exceeded radioactivity limits were reintroduced into the feed materials for the recovery operations and run through the process again.

The airborne emissions from Building 771 have always been controlled to some degree since the building came on line in 1953. In the early years, control was primarily achieved by a double stage of HEPA filtration to capture particulate materials. Since the production radionuclides were generally in particulate form, the HEPA filters were well suited for control of radioactive emissions.

For the most part, however, there were no control devices for the non-radioactive chemical vapors or gaseous materials, with the exception of scrubbers on the hydrofluorinator and the calciner, which have always been in place to reduce acid emissions from these processes. The Building 771 incinerator has always been equipped with a scrubber as well, and has a separate plenum with HEPA filtration (Navratil and Miner, 1984; ChemRisk, 1991; RE-891[47,49,50, 63,13,27,21]).

There is a large, double tower scrubber on the main plenum system which was installed in the late 1960s to control nitric acid emissions. After the large scrubber was installed, it was noticed that the cooled scrubbing wash did an excellent job of drying out the

plenums; it was cooled to 6 °C, and so would dehumidify the glove-box air. As a result, all of the "wet" glove-boxes were switched over to this plenum a few years after the scrubber went into service (ChemRisk, 1991; RE-891[21]).

For the most part, emissions from 771 have been controlled by HEPA filtration. Originally, the building filtration consisted of two stages of HEPAs. Following the 1969 fire in Buildings 776 and 777, two more stages were added for protection against a similar fire in Building 771. The production area glove-boxes are on plenum systems with yet two more stages of HEPA filtration, for a total of six stages of filtration. Laboratory operations in Building 771 go through a total of four stages of filtration (ChemRisk, 1991; RE-891[47, 49,50,63,13,27,21]).

Uranium Recovery and Purification

Rocky Flats at one time had a recovery line for enriched uranium. Enriched uranium is defined as uranium having a larger fraction of fissionable U-235 than the approximate 0.7% found in naturally-occurring uranium. The enriched uranium processed at Rocky Flats has typically contained about 93% U-235 by weight. Enriched uranium was processed at Rocky Flats during the period when the Department of Defense maintained duplicate facilities to manufacture each major weapon component or material. The Oak Ridge Y-12 Plant was the other enriched uranium facility.

Building 881 was constructed in 1952, and at that time housed enriched uranium component manufacturing, including machining and fabrication of parts. When the chemical recovery line began enriched uranium recovery from metal residues created in the manufacturing processes in 1954, Building 881 then housed all enriched uranium operations, from casting to forming, machining, assembly, recovery, and purification. The raw material came from the Oak Ridge Reservation, primarily in the form of hockey puck-size "buttons" of pure metal, although other forms were also provided in smaller quantities, such as uranyl nitrate and alloy scraps (Crisler, 1991).

Uranium recovery operations in Building 881 were modeled after processes developed during and after World War II at Los Alamos and the Oak Ridge Reservation. The Building 881 process was similar to the 1950s plutonium recovery process that included solvent extraction. Uranium recovery had fast and slow sides and involved similar chemistry, but dibutylethylcarbutol was used as the solvent instead of the tributyl phosphate and dodecane used as the solvent and diluent in plutonium recovery. Overall, the basic plutonium and uranium recovery operations were similar in almost all respects (Navratil and Miner, 1984).

Building 881 also operated solvent stills to enable the plant to discard spent solvents, oils, and mixtures of the two. The "heels" of the stills were scrubbed with nitric acid to reclaim the uranium, and then were discarded as well. There have been reports that some of the distilled solvent was reused, but it has been estimated that the amount of distilled solvent which was accepted for reuse was only about ten percent. The discarded oil was drummed and sent to an area known as the "Mound" and was later moved to the Building 903 drum storage area.

For some time, the 881 chemical recovery operations included an "oralloy leaching" operation, in which returned or rejected enriched uranium weapons parts were subjected to a spraying of hot nitric acid to remove residual plutonium surface contamination. Some amount of uranium would also be removed by the acid leaching. Associated solutions were evaporated, and the concentrate precipitated with ammonia gas, calcined to a dry oxide form, and analyzed for plutonium content. Oxide that was sufficiently high in plutonium content was sent to the Savannah River Plant, while that which was low in plutonium content was sent to the Oak Ridge Y-12 Plant for recovery of the uranium. Over time, the exhaust system associated with the oralloy leach process accumulated a build-up of plutonium, which was eventually removed with the plenum filters and treated as plutonium waste.

Building 881 was constructed with the intention of conducting enriched uranium machining operations. To minimize the escape of radioactivity to the atmosphere, manufacturing and laboratory operations were exhausted through a main plenum equipped with HEPA filtration prior to release through a stack. The floors in the process areas were surfaced with stainless steel sheeting with welded seams to contain spills and facilitate cleaning.

When chemical recovery operations were installed a short time later, they were equipped with scrubber systems to treat air streams prior to release to the main, HEPA-filtered plenum. There were three types of scrubber systems; acid, caustic, and hydrofluoric acid (HF). Each was downstream of the processes for which they were suited. The dissolvers, vacuum stills, and several of the storage tanks exhausted to the acid scrubber. The hydrofluorinator was the only process on the HF scrubber. The caustic scrubber received the gasses from the two other scrubbers and sent them on to the building exhaust system. The spent scrubbing solutions were recycled through the recovery process to further reclaim any uranium collected.

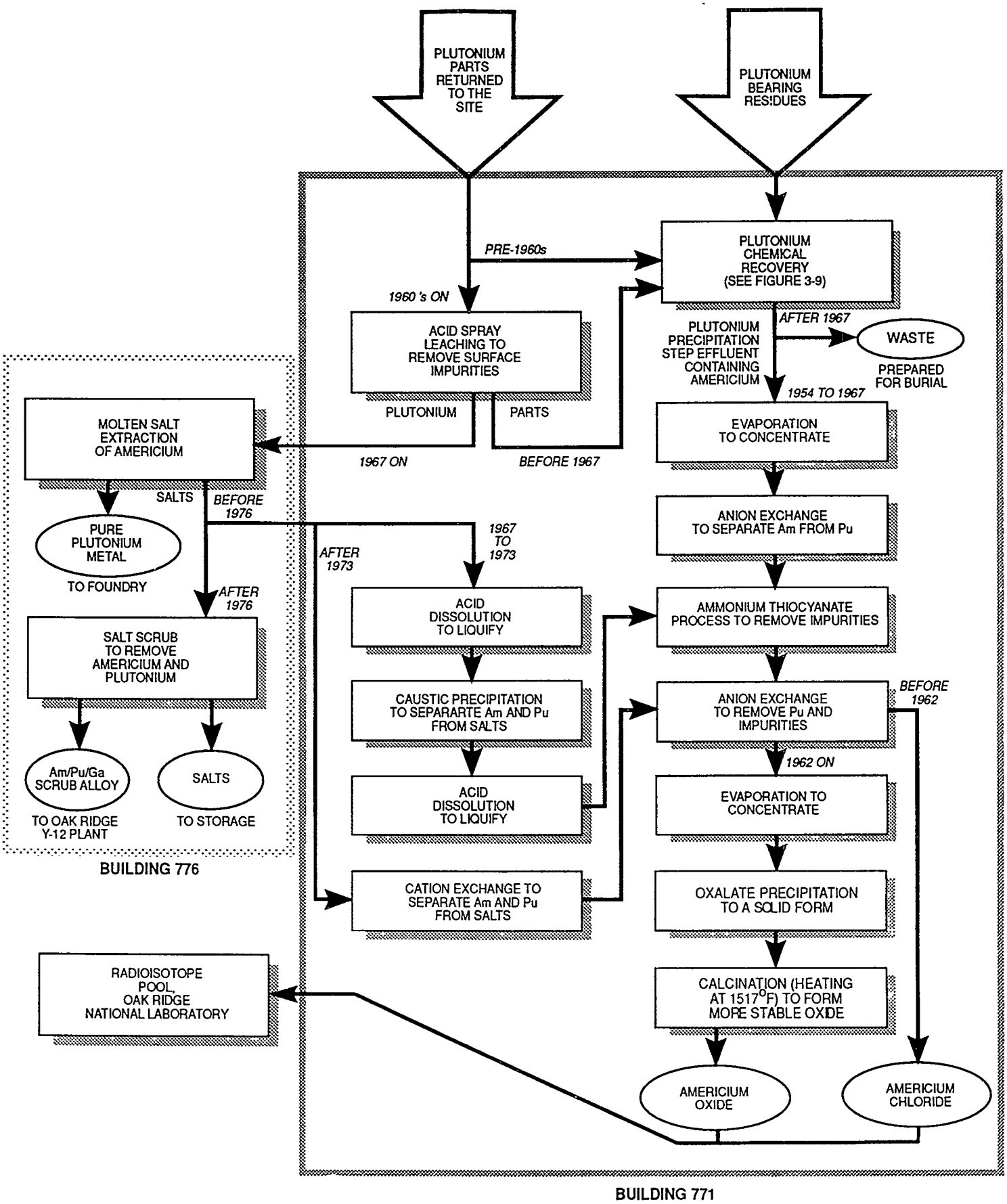
When the Department of Defense decided to eliminate the redundancy in the weapons manufacturing facilities, enriched uranium operations were given entirely to the Oak Ridge Reservation. Consequently, uranium operations in Building 881 were shut down

in 1962 and subsequently decontaminated and decommissioned. The building was "completely idle" from approximately 1964 to 1966, at which time stainless steel operations became operational after relocation from Albuquerque, New Mexico (ChemRisk, 1991; RE-891[39,48,31,67,36]).

Americium Recovery and Purification

The need to process americium at Rocky Flats resulted from increases in both production at the plant in the mid-1950s and the number of site returns. There was a pressing need to deal with the americium being encountered in the plutonium handled at Rocky Flats, since in-growth of Am-241 from Pu-241 decreases the effectiveness of the plutonium and creates a personnel exposure problem stemming from its gamma ray emissions. The plant had a backlog of americium-containing sludge which was being generated from the plutonium recovery peroxide precipitation step effluent. As a result, in 1957 an americium line was put into Building 771. From the late 1950s until the late 1970s, americium was recovered and purified at the plant for resale. Americium was used in medical diagnostic tracer procedures, in ionization type smoke detectors, and in static eliminators. The Atomic Energy Commission requested that Rocky Flats provide americium for use as a medical tracer. The demand for americium dropped off in the late 1970s, and the americium removed in the plutonium purification process subsequently went to Building 774 to be processed as a radioactive waste. Currently, americium operations are limited to those molten salt extraction operations needed to purify plutonium metal (Putzier, 1982; ChemRisk, 1991; RE-891[65,62,43,4, 49]). In 1986, DOE declared americium a waste product and the material has since been discarded in associated waste streams.

The processes historically used at Rocky Flats for extraction, purification, and recovery of americium are depicted in Figure 3-12. Americium operations have evolved through three methods of recovery and purification. From the time the americium recovery operation started up in 1957 to 1967, the feed for the process was the filtrate from the peroxide precipitation step on the plutonium recovery line. This was the era of the first method used for americium recovery and saw little change, except for the addition of a few additional steps in 1962 to create a more stable product form. In 1967, the feed for americium recovery became the salts from the new Molten Salt Extraction (MSE) process. From 1967 to the late 1970s, the processes used for americium recovery evolved. The original recovery process evaporated the plutonium peroxide precipitation effluent and separated the americium that remained in solution by anion exchange. The americium-containing column effluent went on to a very tedious and complicated operation known as the ammonium thiocyanate process. The resulting product was pale pink americium chloride.



ChemRisk
A Division of McLaren/Hart

FIGURE 3-12
HISTORICAL AMERICIUM EXTRACTION, RECOVERY, AND PURIFICATION PROCESSES

A slight change was made to the ammonium thiocyanate process in 1962 by adding oxalate precipitation and calcination steps, which resulted in an americium oxide product that was preferred because of its stability. Nonetheless, the process during this entire period was "messy," resulted in a disproportionate amount of waste solutions, and created personnel exposure problems due to the relatively large amount of manual operations and maintenance required. Worst of all, the americium recovery rate was as low as ten to twenty percent (Crisler, 1991).

In 1967, the Molten Salt Extraction process came into being and became the feed source for americium purification. In MSE, molten americium-bearing plutonium is brought into contact with molten NaCl-KCl-$MgCl_2$ salt, and the Am is separated from the Pu by equilibrium partitioning with the salt by oxidation-reduction reactions. The advantage to the MSE process was that the plutonium metal from site returns could go through MSE and then directly to the foundry for re-casting without the need for the plutonium metal to be oxidized (burned), dissolved, and sent through the chemical plutonium purification process (fast recovery) before it could go to the foundry.

The americium-bearing MSE salts presented a new feed source for americium purification. In preparation for the ammonium thiocyanate process, the salts went through dissolution, hydroxide precipitation, and anion exchange. There were personnel exposure problems associated with the hydroxide precipitation step, and in 1973 it was replaced with a cation-exchange procedure. The entire process underwent one more major change in 1975, in which the ammonium thiocyanate steps were eliminated and the americium was recovered from the anion effluent by oxalate precipitation with subsequent calcination to form the more stable oxide (Putzier, 1982).

Since 1976, MSE salts have gone to the salt scrub process instead of to americium purification. Salt scrub makes a "scrub alloy" of Am, Pu, and gallium that is shipped to Oak Ridge for further processing. By 1979, the demand for americium had dropped to a point where it was no longer economically feasible to recover and purify. Americium was still present in site returns and needed to be extracted to maintain acceptable plutonium purity. MSE operations had kept the americium isolated from the plutonium recovery operations in Building 771 for several years, resulting in a cleaner stream of plutonium entering recovery operations. Americium recovery and purification operations were shut down in 1980, and americium work was limited to that required to extract americium from the plutonium metal in site returns.

3.3.2 Component Manufacturing and Assembly

When the plant began operations in the early 1950s, the majority of the components were enriched uranium, depleted uranium, and plutonium. The plutonium fraction was considerably smaller than the other two materials. When the "A Plant" (now Building 444) started operating in 1953, it was devoted entirely to depleted uranium manufacturing. A short time later, limited beryllium operations went in on a pre-production scale to prepare for the upcoming changes in the weapon. Enriched uranium operations were in "B Plant", now Building 881. There was a heavy workload of enriched uranium operations during those first few years because the design of the pit incorporated a relatively large amount of the material. The plutonium operations at that time were relatively small, and Building 771 (then "C Plant") housed essentially all plutonium manufacturing and recovery. All of the components from these three areas were assembled in what is now Building 991, then called the "D Plant" (Crisler, 1991).

During this time frame, the nation's weapon manufacturing complex consisted of dual facilities for the fabrication of weapon components. Hanford was manufacturing plutonium components like those made at Rocky Flats, and the Oak Ridge Reservation was manufacturing uranium components. The components from these two other plants were shipped to "D" Plant (Building 991) at Rocky Flats for assembly, as were components from "B" and "C" Plants on site. At the time, the majority of depleted uranium components manufactured in "A" Plant went directly to the Pantex Plant in Texas (ChemRisk, 1991; RE-891 [74, 75, 78]).

In 1957, there was a change in the concept of the weapon which resulted in a shift in the relative amounts of the materials used in the pits. More plutonium was called for, in a design that required considerably more plutonium machining and handling. Consequently, Buildings 776 and 777 went into service to handle the increased plutonium workload and 771 became primarily recovery operations. Building 776 was the plutonium machining facility and Building 777 took over most of the assembly operations from 991. Building 991 was then destined to be utilized for storage and research and development, although it was a few more years before all assembly operations had moved out.

The new concept also required beryllium components. There had been some beryllium operations in Building 444 in preparation for regular pit production, and in 1958 beryllium operations became a significant portion of Rocky Flats' work (Campbell, 1986). The components manufactured in Building 444 no longer went directly to Pantex. Instead, they began to be incorporated into the final assembly operations in Building 777. The depleted uranium workload decreased significantly as beryllium became more prevalent in the new design.

The shape of the components in the new weapon concept required a significant amount of rolling and forming of both types of uranium, and space in existing facilities became inadequate. Building 883 was constructed to handle the rolling and forming of uranium. Building 883 was designed with two functional areas ("sides") to prevent cross-contamination; the "B" side handled enriched uranium and the "A" side rolled and formed depleted uranium. The plant was so pressed to begin production of the new type of weapon component that operations began in Building 883 before the roof was completed. To prevent emissions from these early operations and to protect the machinery and materials from the elements, enclosures were placed around the process equipment.

Because of the single mission concept that came about in the early 1960s, Rocky Flats lost its enriched uranium work to the Oak Ridge Reservation in 1962. Building 881 laid idle for a few years until 1964, when the enriched uranium areas were decontaminated and decommissioned and conversion began to accommodate stainless steel operations when they moved to Rocky Flats in 1966. During the period of stainless steel operations, depleted uranium continued to be machined in Building 444. Another result of the enriched uranium operations moving out of Rocky Flats in 1964 was that the B side of Building 883 was converted to beryllium rolling and forming (ChemRisk, 1991; RE-891[36]).

The stainless steel operations, known as the "J Line", came to Rocky Flats from Albuquerque in 1966. The AEC curtailed its contract with the original contractor, American Car and Foundry, for economic reasons at that time, and the work became part of Rocky Flats' mission. The operations went into then-vacant Building 881. The operations have since moved to another building on-site, but remain a significant part of component manufacturing operations in modern-day times.

In 1969, a major fire in Buildings 776 and 777 resulted in some of the operations moving to other buildings in order to keep up with production demands. The machining and foundry operations which were involved in the fire-damaged areas of 776 became part of the operations in the new 707 assembly building. Those operations remained in 707 and solid waste treatment operations and size reduction moved in after 776 was restored to operation. That is why plutonium component manufacturing today seems to flow in such a circuitous route between buildings, travelling from 776 to 707 to 776/777 and back to 707 because of these fire-related changes (ChemRisk, 1991;RE-891[31,6,17,52,60,65]).

In 1984, Building 460 was completed and stainless steel operations were transferred from Building 881 along with some non-nuclear metalworking operations from Building 444. Building 460 has since been called "Consolidated Manufacturing" (ChemRisk, 1991; RE-891[35]).

Many of the manufacturing operations conducted in the various buildings are similar. Some of the components which have gone into pits have the same approximate shape and relative dimensions, and undergo similar machining and metalworking processes regardless of their elemental make-up. Many beryllium fabrication processes are essentially the same as those for uranium and stainless steel components. The same processes are regularly employed in the plutonium operations as well.

As mentioned earlier, the plant also manufactures components for other portions of the weapons, including some for ultimate installation outside of the pit. These operations often employ the same machining applications as those used for pit production, but also involve some unique operations. One example is the reservoir product manufactured at Rocky Flats to hold a supply of tritium outside the pit in another part of the finished weapon. Just prior to use of the weapon, the tritium is introduced into the first stage to "boost" it, increasing the explosive yield. These tritium reservoirs have a limited shelf life, and need to be replaced periodically.

The reservoirs are manufactured in greater numbers than the pits because of this limited shelf life, so they represent an important portion of the work (and revenue) at the plant. The reservoirs are difficult to manufacture, requiring additional equipment beyond that used in pit production because of their complexity. Because Rocky Flats had proven capabilities for high quality machining work and had stainless steel facilities in place, the contract for reservoir production went to the plant. Apparently similar circumstances resulted in Rocky Flats being chosen to perform beryllium and uranium operations.

Today, the flow of all the components that go into the pit is to Building 707, where they are assembled into the finished Rocky Flats product. As described earlier, final assembly operations were at one time in Building 991, and later were housed in Building 777. Weapons components not involved with production of pits go to Shipping, and eventually on to the Pantex Plant in Texas for incorporation into the finished weapon.

Beryllium Component Manufacturing

Beryllium operations were not part of the manufacturing process in the first years of plant operation, but were part of Production Engineering (Phase 4 of weapon development) of the new, sealed hollow core concept which was soon to be integrated into the nation's nuclear arsenal. Originally, beryllium material was received from Brush Industries in the shape of bowls which had been "chevron-cut" from "logs" of pressed-powder beryllium. These bowls were heat-treated and then machined to the required dimensions in the southeast corner of Building 444, in a room only big enough for six to eight lathes. For

some time, the plant experimented with casting beryllium components into "near-net-shapes" which went directly from the foundry to the machine shop for finish machining. When beryllium operations became part of the primary production line in 1958, the process had changed to eliminate the near-net-shape casting, and components were shaped from blanks that were supplied by an outside vendor. These blanks were pressed into shapes and then machined into final forms. The plant soon thereafter began conducting its own casting of beryllium ingots for economic reasons. These ingots were cut up into puck-like billets around which an airtight steel casing was welded. The "canned" billet could then be heated and rolled to the desired thickness, the can cut away, and the remaining blank machined as before. Machining operations include milling, turning, drilling, and polishing (USDOE, 1986; Barrick, 1982; Campbell, 1986; ChemRisk, 1991: RE-891 [56, 71, 72, 78, 81, 82]).

During the mid 1970s, the design agencies (Lawrence Livermore and Los Alamos) made the decision to change over from the wrought process described above to molding of parts from sintered (pressed powder) blanks. The plant then began receiving blanks from outside suppliers, and beryllium foundry operations ceased in 1975. By 1980, the foundry had been cleaned up of all beryllium and only depleted uranium casting was being conducted in Building 444 (Campbell, 1986; ChemRisk, 1991; RE-891[56]).

Over the course of operations, the beryllium area has undergone three ventilation changes. When manufacturing started in 1958, the ventilation system consisted of "Aero-Tech" cyclone separator units placed at each machine to filter the air at the point of operation. The Aero-Tech units exhausted to the main building exhaust serving the uranium operations. This system was updated in 1964 by installing a central Aero-Tech unit in the basement of the building that connected to the main building exhaust. The new system was arranged so that each machine's local ventilation went down through the floor and to a drop box which collected the heavier debris. The air then went on through the central plenum to a cyclone separator and then through a single bank of HEPA filters prior to reaching the building's filter units (USDOE, 1984).

In 1974, this system was taken out of service and replaced by an overhead duct system which led to an external chip cyclone and HEPA filtration unit. This system operated until 1986 when the building's ventilation system was again upgraded.

In 1986, the HEPA filters serving Buildings 444, 447, and 865 were upgraded to include two stages of HEPA filtration. Prior to this, the systems contained only one stage in conjunction with oil-impingement pre-filters. The new system in Building 444 included two types of conveyance systems - a "low vacuum" local exhaust system to carry the fine particulates and a "high vacuum" local exhaust to carry the heavier particulates. Each

subsystem had its own cyclone separator, which was then connected to its own HEPA filtration unit.

Depleted Uranium Component Manufacturing

Depleted uranium is by definition uranium which has less of the fissionable U-235 isotope than the approximate 0.7 percent by weight found in natural uranium. Depleted uranium is rich in the U-238 isotope, and is often called D-38 or Tuballoy. The term Tuballoy originated from the name of a British wartime atomic energy project called Tube Alloys Limited. Depleted uranium was originally received from Paducah, Kentucky in the form of derby-shaped parts. Later, feed material was received from the Feed Materials Production Center in Fernald, Ohio as ingots in sealed cans. Depleted uranium operations were a significant part of the original manufacturing performed at the plant. They were located entirely within the A Plant, now Building 444. Operations included casting and machining of the components from the uranium rich in the U-238 isotope. Adoption of the implosion weapon concept brought about changes in fabrication operations that required additional processing of components. Building 883 was built to fill the need for additional rolling and forming operations. Depleted uranium was still cast in Building 444, but was shipped to 883 to be heated and rolled into sheets, from which blanks were cut and then formed to the required shape. The shaped pieces were shipped back to Building 444 to be turned, trimmed, and polished as necessary. In some cases, the component was coated with other materials. From there, the component was shipped on-site to final assembly. The operations have remained basically the same for the last 34 years (Rockwell, 1981b).

One of the changes in the depleted uranium operations came when an arc furnace was installed in the mid-1970s, providing the capability to produce depleted uranium-niobium alloys. Elements such as zirconium and niobium could be melted more effectively than was possible with the induction casting furnaces, thereby creating a more homogenous alloy casting. Prior to use of the arc furnace, research and development of depleted uranium-niobium alloys involved an electron beam furnace. This alloying work began in 1966, although full-scale production didn't occur until the early 1970s (Brekken, 1965 and ChemRisk, 1991; RE-891[56]).

Enriched Uranium Component Manufacturing

As discussed earlier, enriched uranium is defined as uranium having a larger fraction of the fissile U-235 isotope than the approximate 0.7% found in naturally-occurring uranium. Enriched uranium is often called Oralloy, a term derived from Oak Ridge Alloy. The enriched uranium processed at Rocky Flats has typically contained about 93% U-235 by weight. Originally located in Building 881, enriched uranium operations included production chemistry, foundry operations, fabrication, and scrap material recycling. Building 881 now primarily houses support laboratories, offices, data processing, and record keeping.

The original concept for the nation's nuclear weapons incorporated, by today's standards, a large amount of enriched uranium. When the plant first opened, Building 881 had a very heavy workload of enriched uranium component production and enriched uranium recovery. At first, the components were solid pieces of uranium, machined to certain shapes, which were then assembled with plutonium, stainless steel, and depleted uranium components in D Plant, now known as Building 991 (Putzier, 1982).

The change in the weapon concept which came about in the late 1950s resulted in a significant downturn in the amount of uranium required in the pit, but actually increased the amount of machining which went into making the new, hollow components. The basic operations for the original components involved casting and machining. The hollow design involved the same, but added rolling, forming, and turning operations as well. The processes used in the latter design remained basically the same throughout the life of enriched uranium operations at Rocky Flats. Many other components involving beryllium, stainless steel, aluminum, plutonium, and depleted uranium employ the same processes.

Enriched uranium (oralloy) component operations left the plant in 1964, along with the uranium recovery operations. The Oak Ridge Reservation took over all enriched uranium operations, supplying Rocky Flats with the finished uranium components which were incorporated into the final pit assembly. After Oak Ridge took over the enriched uranium operations, Rocky Flats still received site returns which contained enriched uranium components. The plant processed those components with a spray leaching process to remove any external plutonium contamination, and returned the oralloy parts back to Oak Ridge for reprocessing. Oralloy leaching operations were originally conducted in Building 881, but were relocated to Building 771 a few years after Oak Ridge acquired the enriched uranium contract. Oralloy leaching remained in Building 771 through 1989.

Plutonium Component Manufacturing

In the early years, plutonium metal was reportedly machined in a "dry" state (i.e., without any oils, using only carbon tetrachloride as a coolant), with as little machining taking place as possible. Handling the material dry required extra care to prevent spontaneous combustion. Plutonium components were cast, pressed into shapes, minimally machined to "true" them, and then plated with cadmium to allow for easier handling. Cadmium was often used to coat the plutonium so that it could be handled out in the open with reduced personnel exposure to neutrons and alpha particles. The first weapons were designed such that they were armed (final assembled) on the way to the target, and so certain parts of the weapon were coated to allow them to be handled without containment. The protective coating also served to ground the parts against static electricity that might be generated while handling them in the field. The protective coating was changed to nickel within a few years time, using a process that employed nickel carbonyl. The use of nickel carbonyl lasted at least into the late 1960s, although its use in the later years was significantly less than in the 1950s, due in part to design changes in the weapons which allowed for remote arming of the warhead prior to delivery (ChemRisk, 1991; RE-891[3,31,50,63,67,40,48]).

By 1958, because of the change in the weapon concept that demanded a greater amount of plutonium and different shapes with closer dimensional tolerances, plutonium was no longer cast to a near-net shape. It was rolled, formed, and machined considerably more than under the previous weapon concept. Production demand and increases in the machinery required for manufacturing plutonium components necessitated increasing the associated manufacturing space. Buildings 776 and 777 were built by 1957 for casting, fabrication, assembly and quality assurance testing. Some of these processes came from Building 771, but many were new functions.

It was a natural progression for lubricating oil to be added to the machining operations to facilitate speeding up plutonium machining. The first really significant machining of plutonium began in 1958 with the new operations in Building 776 using Shell Vitrea cutting oil, followed by a washing with carbon tetrachloride (CCL_4). Building 776 housed a centralized oil collection and separation point, with the solid and liquid fractions sent separately to Building 771. In Building 771, the Ccl_4 was distilled out of the oil, and the plutonium recovered from the solids. Building 777 at that time was the focal point for assembly operations. The practice of using oil coolant during plutonium machining still exists today. Parts which have been in contact with the coolant are subsequently degreased using carbon tetrachloride. During those early years, however, the plant did not have a satisfactory method for handling the spent oils and solvents, and they became

one of the biggest environmental issues for the plant. Now, the spent organic liquids are filtered and then solidified for disposal (Joshel, 1970; Crisler, 1991).

In 1969, a major fire in Building 776/777 resulted in relocation of some of the foundry, fabrication, and assembly operations into Building 707 as soon as it was completed. Some of the operations remained behind, and after Building 776/777 was repaired, other operations moved in, most notably waste size reduction operations. The general processes involved in manufacturing of plutonium components are very similar to those employed in other portions of the plant using other metals. The plutonium is cast into ingots which are rolled to the desired thickness. A blank is stamped out of the sheet. The blank is then formed to the desired rough shape, turned, and then polished. Components are often joined with other components, polished, and tested for integrity (Rockwell, 1987a; Rockwell, 1981a).

Stainless Steel Component Manufacturing

Stainless steel operations, known as the "J Line", went into Building 881 in 1966 and remained there until the completion of Building 460 in 1985. Stainless steel operations from 881 and some of the operations from 444 were consolidated into Building 460, which is often referred to as "Consolidated Manufacturing".

A significant portion of the stainless steel work is the fabrication of the reservoirs for the tritium used in the weapon external to the pit. These containers hold a certain amount of tritium gas which is introduced into the pit just prior to detonation to boost the yield of the explosion. Other stainless steel work includes the tubes and fasteners associated with the tritium reservoir-to-pit delivery system (Rockwell, 1981a).

Finished Machine (FM) Components

Some of the components which go into the pit are supplied by vendors or from other plants in the weapons manufacturing complex. These components are verified in number and quality and typically go on to final assembly with little or no further machining (Rockwell, 1981a).

Final Product Assembly

The original final assembly building was the "D Plant", now known as Building 991. The final assembly operations at that time are reported to have used a small amount of solvent for one last wipe-down of the components and finished product. Final assembly of the early concept design products was apparently a relatively simple operation. Later, the hollow-core design required more operations to assemble the pit and greater controls for safety. As a result, Building 777 came on-line to provide the requisite facilities. The operations involved in final assembly of the hollow-core design include drilling, welding, brazing, turning and polishing. Instead of a few components, the hollow design may have many, in an arrangement which requires more complex fabrication. Building 707 received the final assembly operations shortly after the 1969 fire, which shut down Building 776/777. Final assembly operations remain in Building 707 today.

3.3.3 Waste Processing

Waste processing at Rocky Flats has included both liquid and solid process wastes as well as sanitary wastes. Processing of each of these waste types is discussed in this section.

Liquid Process Wastes

Perhaps the primary function at Rocky Flats which has involved the fewest process changes over the years is the area of liquid waste treatment operations. The processes involved are relatively simple and have been proven effective in industry and at Rocky Flats.

When Building 774 was built in 1952, its primary purpose was to support Building 771 by treating its radioactive aqueous waste. The general mission of the waste operations was to reduce the volume of wastes and put them in a form acceptable for transportation to off-site burial grounds. The processing of liquid wastes has involved relatively consistent technology over the years, with some refinements to achieve greater treatment capacity and eliminate off-site discharges (Crisler, 1991).

Liquids transferred to Building 774 are subjected to any necessary Ph adjustment and then go through a precipitation step to remove radionuclides. The resulting slurry is sent to vacuum filters. The solids removed from the filters are combined with cement or another solidifying agent and then shipped to long term storage as transuranic (TRU) mixed (chemically and radioactively hazardous) waste. The aqueous waste from this first stage

goes through a second stage, which is essentially a repeat of the first. Prior to establishment in 1973 of the policy that Rocky Flats would attempt to discharge no process waste to off-site surface waters (a "zero discharge" policy), the aqueous wastes from this process went to either the solar evaporation ponds or to the "B" series of holding ponds, depending upon the concentrations of radioactivity present. Below a specified level, waste water could be discharged to the ponds. The water in the "B" ponds went on to Great Western Reservoir.

Around 1965, an evaporator was installed in 774 to treat the liquids that had accumulated in the solar evaporation ponds. Its limited capacity was not able to eliminate the need for the solar ponds. Water and any volatiles evolved from the evaporation process were untreated and discharged to the atmosphere. The concentrate from the evaporator was fed to a double drum dryer, on which the salt solution dried and was removed by a scraping blade. Water vapor and volatiles evolved from the dryer went through a scrubber and demister before venting to the stack, with the liquids from the scrubber and demister returning to the aqueous treatment process. The evaporator was taken out in 1979, and the liquids from the second stage of treatment and the solar ponds have since been transferred to Building 374 (ChemRisk, 1991; RE-891[42,13,61]).

Building 774 also processes organic liquid wastes. When Building 776 went into service in 1957, the plant experimented unsuccessfully with a centrifuge in an attempt to process the plutonium-contaminated organic liquids from machining operations. In 1958, the pace of plutonium machining and the volume of associated waste oils increased significantly. Building 776 became the central collection point for the oils where the liquids and solids were separated and sent on to Building 771. In Building 771, carbon tetrachloride was distilled out of the oil, and plutonium was recovered from the solids. The still bottoms then became a problem. The spent oil and carbon tetrachloride were put into drums for storage until a satisfactory method of treatment of the contaminated material could be found. Those drums were at first buried, and then later were stored at a location now known as the 903 Pad. The drums that were buried were later unearthed and disposed of under observation of the Colorado Department of Health (Seed et al., 1971; Joshel, 1970).

There was a considerable effort over several years to find an effective method to treat the oil so that it could be re-used or disposed of as non-radioactive waste. Attempts to separate the carbon tetrachloride from the oil for re-use were unsuccessful and, eventually, the organic liquids were simply treated by filtration and solidification and sent on to long-term storage as transuranic (TRU) mixed wastes (Biles, 1970).

The method finally developed involved filtering the spent liquids to remove particulate matter larger than one micron and then mixing it with calcium silicate to create a gel. In addition, the oil coolant and carbon tetrachloride were continuously recirculated at the point of use through 30 micron filters. When the liquids are no longer suitable for continued use, they are filtered through a one micron filter and then mixed with the solidifying agent. The mixer-extruder operation was sometimes referred to as the "Jelly Factory" or the "Grease Plant". The process is essentially the same today, a one-step process in which the organic liquids are mixed with Envirostone® and allowed to set up before shipment (ChemRisk, 1991; RE-891[44,61]; Seed et al., 1971).

Two other small waste streams are treated by Building 774. One is silver recovery from spent photo solutions and the other is a variety of miscellaneous wastes, primarily from laboratory operations. The latter is simply mixed with cement to solidify it for long-term storage.

Building 374 went into operation in 1980 as an integral part of the new plutonium recovery facility, Building 371. It was designed to handle primarily the wastes which would be generated by Building 371, but would also help to relieve the demand on 774 and eventually eliminate the need to use the solar evaporation ponds as part of the waste operations (Navratil and Miner, 1984).

The processes in Building 374 are essentially the same as those used in Building 774, but newer, more efficient equipment is used. For example, a four-stage forced evaporation unit is used. As a result, Building 374 can process more liquid wastes in less time than what was possible with the old operations in 774. The new facilities were also designed to provide greater safety of operation through improved containment, control systems, and separation of workers from the operations. Two of the processes in operation in 774 have not been performed in Building 374. Those are silver recovery and organic liquid treatment operations.

The chemicals used in liquid waste treatment processes are primarily caustics for Ph adjustment, reagents such as ferric and magnesium sulfate, and flocculating agents. They are typically mixed with water and then added to the wastes. No organic solvents are used, but they do treat organic liquid waste streams.

Depending upon the amount of contamination in the waste product, the resulting sludges or solids are packaged in drums or large wooden boxes and shipped as TRU waste or low specific activity (LSA) wastes to approved national storage sites (Navratil and Miner, 1984).

Solid Wastes

Radioactive solid wastes generated at Rocky Flats can be placed into two categories; retrievable and non-retrievable. The retrievable wastes are those which contain greater than 10 nanocuries (0.00000001 Ci) of radioactivity per gram of material. These wastes are packaged and stored to enable them to be repackaged if necessary, or if technology warrants, to enable their retrieval and the subsequent recovery or treatment of the contained radioactive and/or chemical toxins. The kinds of waste which typically fall into this category are the solidified sludges and salts generated by the liquid waste treatment operations, line-generated wastes such as gloves, clothing, and other small items, and plutonium-contaminated wastes such as decommissioned glove-boxes, HEPA filters, or machine tools (Crisler, 1991).

Line generated wastes are placed in a drum until it is full. It is then assayed to determine the amount of radioactivity within the drum. If the drum content exceeds preestablished criteria, the drum is unpacked, the items with recoverable plutonium removed, and then the drum is re-packed with waste of a lower radioactivity. Plutonium-contaminated wastes first go through the size reduction facilities in Building 776, where attempts are made to remove surface contamination, and the waste is then cut up or crushed to reduce its volume and packaged in sealed, reinforced boxes which are about four feet square.

Non-retrievable wastes are non-line-generated wastes which have less than 10 nanocuries per gram contamination, and can include chairs, tables, and cabinets. These items are also reduced in volume in the size reduction facilities and packaged in 55-gallon drums or wooden boxes.

In almost every case, radioactive solid wastes have been shipped off-site to a federally approved storage or disposal facility. However, as documented in Section 5 of this report, there have been some cases in which on-site disposal of solid waste was practiced. Up until 1970, sanitary waste sludges were buried on-site, usually in the plant landfill. Since then, sanitary sludge has been shipped to a federally approved facility for disposal as radioactive waste. There were other instances of on-site burial of contaminated materials, most notably soils which were contaminated as a result of the 1969 fire and other soils excavated during cleanup of the laundry waste outfall formerly located on the north side of Building 771 (USDOE, 1986; Yoder, 1984).

Non-radioactive solid wastes generated at Rocky Flats include the typical types of materials found in municipal garbage: paper, food items, office waste, lumber, and so on. This material is disposed in the plant's on-site landfill. The original Plant landfill, located on the south side of the plant, opened in 1952 and closed in August, 1968 (see Figure

5-4). An incinerator was also in operation at that time, in Facility 219 on the west access road. With a few exceptions, non-radioactive combustible waste was burned in the incinerator and the resultant ashes were dumped on the ground adjacent to it and covered with dirt (Seastone, 1973; Owen and Steward, 1974). It has been estimated that less than 100 grams of slightly radioactive depleted uranium contaminated combustibles were burned along with the general plant waste during the period from 1952 to 1968 (Piltingsrud, 1973).

The second landfill, which is in operation today, opened in August, 1968, and is on the north side of the plant. In 1971, the plant instituted a program which required that all ordinary wastes originating in plutonium areas be monitored for radioactivity prior to placement in the dumpsters destined for the landfill (Rockwell, 1988; Yoder, 1984).

Sanitary Wastes

Liquid sanitary wastes at the Rocky Flats Plant are comprised of the sewage resulting from treatment of wastes from rest rooms, showers and sinks, food service areas, and cooling tower blowdown. The liquid sanitary waste operations are kept separate from the liquid process waste operations to prevent contamination of the sanitary waste streams. In addition, the sanitary wastes which originate from plutonium areas are kept separate from those from other areas until they reach two holding tanks upstream from the treatment plant. At that point, they can be retained and sampled to check for contamination. From those holding tanks, the sewage is processed as in many other municipal wastewater treatment facilities, through a series of clarifiers, aerators, and digesters, with the sludges becoming a waste and the liquids going through a final disinfection step before release. This basic process has remained essentially the same throughout the operation of the plant (Rockwell, 1981a).

The final disposition of the sludges has changed over the years. In the early years, the sanitary sludges were disposed on-site in trenches constructed for their disposal. These were trenches T-2 through T-8 (see Figure 5-4). At that time, some of the floor drains in the manufacturing buildings were not isolated from the sewage treatment plant, and the sanitary sludge became contaminated with uranium and plutonium. From 1954 to 1968, trenches T-2 through T-8 received approximately 100 tons of sewage sludge. When the second landfill opened in 1968, it began receiving the sludges, and continued to receive them until 1969. At that time, the sludges were declared to be low-level radioactive waste and have since been shipped off-site for disposal at federally approved disposal sites (Facer, 1970; Putzier, 1970; Hazle, 1985; Steward, 1973).

The final disposition of treated sanitary liquid effluent has also undergone some changes since the plant first opened. As discussed in Section 5, in the early years of plant operation, low-level process waste, specifically laundry waste, was discharged directly to Walnut Creek. While the water released was reported as not exceeding applicable radioactivity concentration guides, it did contain some low-level concentrations of plutonium and uranium. The Building 771 outfall became contaminated from this practice. Later, it was decided to send laundry waste to the sewage treatment plant. As a result, sewage treatment plant sludge became contaminated. On December 21, 1973, the release of laundry waste into Walnut Creek was stopped. The plant has attempted to comply with a "zero-discharge" policy, wherein all liquids are evaporated or solidified for off-site disposal (ChemRisk, 1991; RE-891[5,7,32] and USERDA, 1975).

3.3.4 Research and Development

Under the general heading of Research and Development, this section discusses some activities which have taken place at the Rocky Flats facility which are not directly related to the plant's main mission, the production of nuclear weapon triggers. A significant fraction of the historical investigation was devoted to studying the research, development, "Special Order", and "cash sales" activities which have been a part of Rocky Flats history by way of extensive document reviews and interviews. Such activities were reviewed in search of any associated processes, practices, or events which could have potentially affected the off-site public, and might not have received the usual level of scrutiny because they were not associated with primary plant production. This investigation has revealed several projects which have involved large quantities of some of the materials of concern in production of products other than weapon triggers. These projects are described in this section.

Funds available within the weapons complex in the early years for research and development were very limited and the subject of intense competition. Most of the money went to Los Alamos and Lawrence Livermore, and even these two laboratories were in tough competition with each other. At Rocky Flats, some activities that were actually research and development in nature were incorporated as an extension of production engineering. Since these expenditures weren't specifically identified as R&D, they were not as likely to be questioned or taken away by the other AEC/ERDA contractors who had R&D as a primary role. One area that Rocky Flats was encouraged to pursue R&D activities in was plutonium science. Plutonium was still such a new and relatively unfamiliar element that much research was needed to fully identify its properties, limitations, and interactions with other materials (ChemRisk, 1991; RE-891[31]).

An example of research and development work as an extension of production engineering is the early beryllium work. From 1953 to 1958, beryllium operations were in the developmental stages. The work was geared toward developing and refining production techniques and tooling requirements. Beryllium has a number of qualities which can make it difficult to tool, and considerable effort went into understanding how to best machine it into the required shape and dimensions. This was the pre-production work associated with Phase 4 of weapon programs. The work involved a lot of R&D to develop and fine-tune the manufacturing processes which were to be used, but was not weapon R & D in the strictest sense (Campbell, 1986).

Another example of production related R&D work occurred in the northeast part of Building 331, which was for some time a uranium R&D area. Rolling of enriched uranium foil was conducted in 1964 in the northeast corner of the plant garage, Building 331 (Putzier, 1982). Interviews have also suggested that this area was used for the development of depleted uranium and uranium alloy casting techniques, using electron beam energy, and uranium coating studies. The area was later converted for the development of remote handling techniques such as robotics and remote manipulator arms after Building 865 came on-line in 1970. Interviewees noted that exhaust from the area was filtered (Putzier, 1982; ChemRisk, 1991; RE-891[31, 71, 72, 78, 83]).

In the mid-1960s, more money was made available and R&D work became a larger part of the activities at the plant. As a result, Buildings 779, 559, and 865 were constructed. Much of the R&D work became focused on examining the site returns to determine what effects time and field conditions were having on the weapons. Studies on corrosion and other forms of deterioration were vital to making improvements in the reliability and shelf-life of the weapon materials (USDOE, 1980).

Today there are two main groups conducting research and developmental activities at Rocky Flats. One is geared toward improving current manufacturing techniques and methods and the development of new ones. Areas of study include metallurgy, coatings development, joining of materials, machining and gaging, and non-destructive and destructive testing. The other group focuses on chemistry-related matters such as corrosion and surface chemistry, effects of radiation on materials, actinide recovery and purification, waste treatment, and environmental detection systems (Rockwell, 1981a).

"Special Orders"

The plant has conducted "Special Order" work for other facilities in the weapons complex, the Department of Defense, or to fulfill needs of other Federal departments or agencies.

Most of the Special Order work at Rocky Flats has not involved materials outside those used in regular production activities. The tracer work is one of the few exceptions. Radionuclide tracers were introduced into manufactured components and/or pits destined for off-site test shots. These materials, for example neptunium, curium, and cerium, were blended in with the regular component materials so that scientists could study performance of the different weapon components based on post-test distribution of the rare tracers. For example, neptunium might be added to one component of the pit and cerium added to another. After the test shot, the scientists could then core through the site and find out how each tracer reacted, enabling them to calculate how each of the components acted in the detonation. Neptunium tracer was associated with both uranium and plutonium components, so its manufacture took place in Buildings 771 and 881. There was considerable effort devoted to keeping these tracer materials separate from the regular production material streams, and Special Recovery operations specialized in recovering these more exotic materials (ChemRisk, 1991; RE-891[31,9,43,52]).

Most of the Special Order work has also been relatively short-lived. Perhaps the biggest exception to this would be the Zero Power Plutonium Reactor (ZPPR or "zipper") project, in which Rocky Flats manufactured approximately 4,000 stainless-steel-clad fuel elements consisting of plutonium, molybdenum, and uranium from 1967 to 1968. The plant manufactured the fuel rods for installation in the reactor at Argonne National Laboratory (Knighton, 1983; Willging, 1970; ChemRisk, 1991; RE-891[48,31,50,63]). The ZPPR fuel elements were made by first alloying the uranium and molybdenum in Building 444. The U-Mo alloy was then sent to Building 771, where it was alloyed with plutonium by casting into plates of various sizes. The ternary alloy plates were clad in stainless steel envelopes in Buildings 776/777 and sealed by welding. The plutonium used in this project originated in the United Kingdom and contained a higher percentage of Pu-240 than most Rocky Flats plutonium, so great care was taken to keep the material separate from other plutonium recovery and waste streams (Knighton, 1983; Patterson, 1982; Leebl and Patterson, 1982).

There was also a series of projects in the late 1970s and the first half of the 1980s in which the plant manufactured thousands of calorimeter plates out of depleted uranium for Sweden, Harvard University, and Brookhaven National Laboratory. In a project that involved processing hundreds of tons of depleted uranium in Building 883 in the mid-to-late 1980s, the plant also made armor plates for the M1A1 tank (ChemRisk, 1991; RE-891[36,13,31,69]). In the mid-1980s, the U.S. Army developed an advanced type of layered "Burlington" armor that incorporates a depleted uranium mesh in its still-secret inner configuration. The new armor on the M1A1 gives the tank protection equivalent to about 24 inches of steel armor (Zaloga and Green, 1991).

Rocky Flats was also involved in "Project Plowshare", the effort to develop technology for using nuclear explosives for peaceful applications, such as excavation and uncovering of deep mineral deposits. Example applications envisioned for the technology included excavation of a sea-level alternative to the Panama Canal and west coast harbors for Africa, Australia, and South America (Seaborg et al., 1966). Rocky Flats' involvement in making components for Project Plowshare lasted from around 1959 to the mid-1970s. No detonations of Plowshare devices occurred on the plant site. The portion of the program designed for large-scale excavation saw Rocky Flats involvement from about 1962 or 1963 to the mid-1970s. An objective of the Plowshare project was to use as little fissionable material, e.g. plutonium, as necessary so as to limit the amount of fission products produced by the detonation and thereby minimize environmental impacts (Hoffman, 1992).

Plutonium R&D (Building 779)

In the mid-1960s, research and development activities were escalated in the U.S. nuclear weapons complex. At Rocky Flats, the escalation included construction of Building 779, a plutonium R & D facility. The purpose of the facility was to gain more knowledge of the chemistry and metallurgy of plutonium and its interactions with other materials which might be used in the manufacturing processes. Building 779 also housed efforts to develop improvements to the manufacturing processes and find new ways to recover plutonium and associated actinides. Yet another function has been to better understand the aging and shelf-life limitations of Rocky Flats products. Some of the processes which have been in the building have changed over the years, but the primary purpose of the activities has not. Most of the materials used in this facility are the same as those in the manufacturing buildings, as much of the work conducted involves improvement of existing processes and understanding of the materials employed.

Building 779 has nearly doubled in size since it was built in 1965, with two major additions coming in 1968 and 1973. The first addition was the larger of the two, and provided office, laboratory, and mechanical equipment space. The second addition supplied more office and laboratory space plus an environmental storage facility for studies of aging under various environmental extremes and a storage vault. A filter plenum facility (Building 729) was also constructed in 1973 next to Building 779 and linked by a second-story bridge for the ducting. The new plenum facility serves the second addition to the main building and houses an emergency generator. A year later, a new filter plenum facility was added on to the east end of 779 to serve the original building and that portion added in 1968 (Rockwell, 1987b).

The primary activities conducted in Building 779 include (Kneale, 1989):

- Product Physical Chemistry, which involves testing of various material compatibilities, stockpile reliability, and plutonium aging under various environmental conditions.
- Physical Metallurgy, which includes tensile testing, study of casting dynamics, electron microscopy, X-ray analyses, hardness testing, and dimensional dynamics.
- Joining, which involves methods such as welding and brazing.
- Pyrochemistry, the study of molten salt extraction and electrorefining processes.
- Hydriding, the nondestructive recovery of plutonium from substrates using hydrogen.
- Chemical Technology, which is concerned with improvement of aqueous material recovery techniques.
- Coatings, which involves various methods to coat substrates, such as vapor deposition.
- Machining and Gaging, which involves manufacturing of special order parts, tools, and test components.

Building 865 R&D

Building 865 began operations in 1970. It serves as a research and development facility primarily for the manufacturing processes using uranium and beryllium. The work involves metalworking and metallurgy techniques. The metallurgical operations involve the development of alloys, alloying processes, and fabrication of prototype hardware. Some of the metals employed in the alloying development include aluminum, copper, magnesium, molybdenum, niobium, platinum, stainless steel, tantalum, titanium, and vanadium.

Metalworking operations include melting and casting, forging, press forming, extrusion, drawing, rolling, diffusion bonding, hydrospinning, swaging, cutting and shearing, and heat treating. In addition, there are glove-box operations involving high-purity beryllium powder and machining operations which typically involve the materials listed above (Rockwell, 1982).

Building 881 R&D

No longer used for enriched uranium operations or stainless steel manufacturing as it had been in the past, Building 881 now is a multipurpose research and development, analytical, plant support, and administrative facility (EG&G, 1991). Operations conducted in Building 881 include analytical laboratories devoted to atomic absorption spectroscopy, inductively coupled plasma and direct current plasma emission spectroscopy, various chemical analyses, x-ray spectroscopy, furnace combustion analyses, semivolatile chemical analyses, ion chromatography, gas chromatography/mass spectrometry, radiochemistry, various organic chemical analyses, ion chromatography, anion and cation analyses, water analyses, and waste stream characterization analyses.

Other functions supported in Building 881 include generation of chemical standards and "inertial fusion" activities to machine small parts for weapons and energy generation research, gold plate the parts, assemble microscopic parts, along with some large machining operations. The Special Weapons Projects group is involved in development of engineering prototypes and full-scale models for military training.

Recovery Technology activities in Building 881 include materials development, process instrumentation and control, and equipment design and development. The Waste Chemistry group supports engineering and development of on-site waste treatment processes, and Joining Technology conducts operations to join non-nuclear metals including beryllium, in some cases using brazing alloys including nickel.

Other operations housed in Building 881 include Nondestructive Testing, Records Management and Storage, and various maintenance shops and activities.

Explosive Bonding

Explosive bonding experiments were conducted at the explosive forming area near Building 993 from 1965 until approximately 1968. The experiments were designed to explosively bond together flat plates of stainless steel and uranium alloy. The explosive consisted of 192 grams of 40% dynamite. The energy released from the dynamite drove the stainless steel plate into the radioactive material to form a bonded laminate. The explosive events took place below grade. No documentation was found which detailed the characteristics of any releases to the environment from this activity (HRR, 1992).

3.3.5 Plant Support

Plant Support activities of potential relevance to off-site exposures include Criticality Safety, the various service Laboratories, Filter Testing, and Laundry Services.

Criticality Safety

Nuclear criticality safety can be defined as practices associated with avoiding an accidental nuclear criticality event. A criticality is a spontaneous nuclear fission chain reaction caused when a sufficient quantity of fissile material is placed within a given area. The presence of large quantities of fissile materials in numerous forms on the Rocky Flats site makes it necessary to maintain an active criticality safety program. The criticality safety group at Rocky Flats performs experiments and calculations to identify container or vessel geometries or arrays of nuclear material which have the potential to spontaneously fission. Experiments and calculations are conducted to evaluate the potential for criticality under varying conditions and to validate computer programs used for criticality safety analysis (EG&G, 1991a). A criticality event would not result in a nuclear explosion, but could liberate a tremendous amount of energy and high levels of radiation. While criticality events can vary widely in power level and duration, the amount of radiation which could be generated in a criticality could be fatal to nearby personnel, and the intense forces liberated could cause severe property damage. From the beginning of the atomic energy industry to 1967, there were no less than 34 incidents where the power level of fissionable materials became uncontrollable because of unplanned or unexpected changes in the reactivity of the assembled materials (Stratton, 1967). These extensively-studied incidents, none of which occurred at the Rocky Flats Plant, caused eight deaths and in some cases resulted in significant property damage.

The Nuclear Safety Group has been in existence at the plant since 1953. At that time, however, the group did not have its own facility. In those early years, the group performed its work in the areas in which the materials were actually handled, using the actual materials which went into the production of the product. Investigators would set up the production materials in various arrays to perform multiplication-type experiments and make predictions with respect to safe geometries for various kinds of production vessels, spacing parameters, shipping containers, and other items (Putzier, 1982). These "in situ" experiments conducted outside of Building 886 were always subcritical; neutron count rates were observed as criticality was approached but not reached (Rothe, 1992).

In more recent years, the Nuclear Safety Group conducts its work in Building 886, which was commissioned in 1965. Since that time, the Nuclear Safety Group has conducted

about 1600 critical mass experiments using uranium and plutonium in solutions (800 tests), compacted powder (300), and metallic forms (500) (Rothe, 1992). Since 1983, criticality experiments have not been conducted with solid materials. They are now conducted primarily with uranyl nitrate solutions, which are re-used (ChemRisk, 1991; RE-891[53]). In 1969, the critical mass program at Lawrence Radiation Laboratories (LRL) was shut down, and Rocky Flats was notified that criticality studies that LRL considered necessary for their purposes would be performed at Rocky Flats (Schuske, 1969). While LRL materials were transferred to Rocky Flats, no significant increase in work load resulted (Rothe, 1992).

Building 886 houses the Critical Mass Laboratory, some offices, and a small electronics and machine shop. Building 875, which was constructed in 1974, is connected to Building 886 by an underground passageway containing air ducts and houses two exhaust filter plenums handling air from Building 886. Building 886 laboratory space includes a "test cell" area where experiments are conducted and two rooms for storage of radioactive materials. One of the radioactive material storage rooms houses nine tanks which contain the solutions of uranyl nitrate in dilute nitric acid that are used for criticality experiments. These tanks contain borosilicate-glass raschig rings that absorb neutrons and prevent criticality events. To conduct experiments, solution is transferred to the test cell. The solution is not heated (EG&G, 1991a). The uranyl nitrate solutions from these tests are not discarded; they are pumped back to the storage tanks for reuse in future tests. Therefore, these testing activities do not contribute to the plants liquid waste stream.

Approximately half of the 1600 criticality experiments conducted in Building 886 actually achieved criticality. The experiments were conducted in a manner to control the level of fissioning, for example by varying distance between pieces of metals and depths of solutions, and only very rarely were the radiation levels and the associated heat generated such that it was not possible to directly touch the reaction vessels immediately after the experiments. The experiments conducted in the RFP laboratory generally involved power levels and the associated heat generated of no more than 10 milliwatts for no more than one hour (ChemRisk, 1991; RE-891[53]). There were approximately six "high power" experiments that were taken to between 10 and 100 times the power of typical tests (Rothe, 1992). Using a conversion factor of $3x10^{16}$ fissions per megawatt second (Thomas, 1978), this power level and duration corresponds to a maximum of $1.08x10^{12}$ fissions from a typical RFP criticality experiment and a maximum of 1×10^{14} fissions from a high power experiment.

Prior to the addition of four stages of HEPA filtration in Building 875, exhaust from Building 886 passed through a two-stage filter plenum before release. Since the addition of the Building 875 filters, exhausted air, which includes off-gas from the test cell reaction

vessel vents, passes through a HEPA filter in Building 886 and the 4 stages of HEPA filtration in Building 875 prior to release via the "stack" (ChemRisk, 1991; RE-891[53]). The vent "stack" is rectangular (24" x 48") and extends 1.5 feet above the Building 875 roof (Los Alamos, 1991). The vessels vents are always open; they are not controlled by valves or pressure relief valves, and hold-up of off-gases was not practiced (Rothe, 1992). Airborne effluents from Building 886 have been sampled for radioactive particulates since 1965. Over the period from 1971 through 1989, reported plutonium effluents from Building 886 were at most 5% of the site total (in 1978) and enriched uranium emissions were at most 10% of the site total (in 1976) (EG&G, 1991b).

Potential pathways for release of waterborne radioactivity from the Critical Mass Laboratory appear to be limited to several incidents involving spills of uranyl nitrate solution and disposal of waste water from activities such as mopping of floors. There reportedly have been between two and five incidents where uranyl nitrate was spilled onto the floor outside the tanks in the Critical Mass Laboratory (ChemRisk, 1991; RE-891[53]). The largest spill involved between 50 and 60 gallons of solution. The Laboratory floors are sealed and bermed to contain such spills, and in no case did solution escape the building. Except for small quantities absorbed on paper used in clean-up and disposed of as radioactive waste, the solution was recovered for further use (Rothe, 1992). In one incident in the late 1960s, an accumulation of uranyl nitrate salt was found inside the base of the ventilation system filter plenum outside of building 886 (ChemRisk, 1992; RE-891[53]. This accumulation (about one foot square and one-quarter inch thick) is thought to have most likely resulted from an incident in which some solution overflowed into a vent line and dried, with subsequent air flow over the vent carrying the salt to the filter plenum (Rothe, 1992). Over the period from the late 1960s to the late 1970s, waste water from activities such as mopping was collected and periodically transferred to the solar evaporation ponds. A raschig ring filled tank was used ten or fewer times to transfer batches of less than 1000 liters of waste water to the ponds after sampling and analysis indicated that the uranium content of the water was much less than one gram per liter (ChemRisk, 1991; RE-891[53]). These waste water solutions contained concentrations of uranium far below those that would have made raschig rings necessary in the transfer tank (Rothe, 1992).

Radioactivity potentially released from the Critical Mass Laboratory would include enriched uranium and plutonium and fission products formed in fission of these materials. Fission products in the RFP solutions have been nearly unmeasurable; there has been no need for monitoring of fission product levels, administrative limitation of concentrations, or purification treatment of the solutions because fission products build-up has been insignificant (Rothe, 1992). While fission products are generally liberated from test solutions, they largely remain trapped in metal and compacted powder test specimens.

The power levels of the RFP experiments have been much less than those required to vaporize metals (Rothe, 1992). Releases from Building 886 will be included in the assessment of routine effluents from the Rocky Flats site.

Laboratories in Buildings 123, 125, 559, and 881

There are four main service laboratories at Rocky Flats; the Health Physics Laboratory, the Standards Laboratory, the Plutonium Laboratory, and the General Laboratories (Rockwell, 1981).

The Health Physics Laboratories are located in Building 123. They perform analyses of personnel dosimeters and all airborne sample analyses, including stack samples and general room air samples. Originally, these labs were in Building 441.

The Standards Laboratory is located in Building 125. It prepares analytical stock solutions for the other labs and performs analyses on incoming radiological sources for quality assurance/quality control purposes. It also performs calibration and standardization of equipment to assure it is operating according to the manufacturer's specifications. One section of the Standard Lab certifies dimensional measurements such as length, angles, and roundness.

The Building 559 Lab is the Plutonium Analytical Laboratory. The lab conducts analyses to determine the purity of plutonium, what the impurities are and in what concentrations, and the concentrations of plutonium alloys, whether in metal, liquid, or oxide form. The lab can also analyze gases and organics. The primary purpose of the lab is to sample incoming plutonium site returns and feed material, and that which is recovered/purified and cast at the plant site for the production of weapons.

The Building 881 Labs are also called the General Labs. They went in as part of initial construction of the building in 1952. A number of analyses on a variety of materials are performed here. Waste water and National Pollutant Discharge Elimination System (NPDES) permit sample analyses are performed here, as well as sludge, surface water, and groundwater sample analyses. Production control samples from Buildings 460 and 444 are analyzed by the General Labs. When the enriched uranium processes were in operation in 881, the laboratories also performed analyses of the materials generated on that line (ChemRisk, 1991; RE-891[7,46,12,34,32]).

Filter Testing

The Filter Testing Group was formed in 1979 after an audit identified the need for a group to perform in-place leak testing of HEPA filters; a group separate from the group that installs the filters. In-place testing of the filters reportedly has always been conducted at the plant site, but prior to the formation of the Filter Testing Group, in-place leak testing of filters was performed by the same group that installed the filters (ChemRisk, 1991; RE-891[24]).

In-place testing of filters is not only initiated in response to a filter change. Testing may also be required when there is visible damage to the filter or the supporting framework, when plenum monitoring indicates there may be a problem, and when the routine testing schedule for that particular bank of filters dictates. Filter changes are initiated by an increase in the pressure differential across the filter, visible damage to the filter, or when they become visibly overloaded.

The Filter Testing Group also conducts quality assurance testing on the filters (out of place testing). When a new lot of filters is received from the supplier, the Filter Testing Group conducts a series of tests on a percentage of the filters to determine that they are of acceptable quality. The tests include pressure resistance trials, in which filters are placed under a pressure of 10 inches of water for one hour, high temperature resistance testing at 750° F for 5 minutes, a drop test (180 cycles per minute for 15 minutes), and high humidity resistance. Before the filters are shipped to the plant, the manufacturer also tests each filter for efficiency and resistance. Filter Testing also conducts testing of each of the HEPA filters which go into the respirators worn by site personnel (Rockwell, 1981a).

Laundry Services

Laundry Services provides cleaning, sorting, and distribution of the coveralls and other reusable garments that are required in the manufacturing areas containing potential contamination. The clothing includes coveralls, shirts, shorts, undergarments, socks, caps, and booties. Laundry services also launders respirators and bath towels. Exhaust air from the dryers and washers is vented through HEPA filter plenums. Laundry water is sent to the forced evaporation operations in Building 374 (Rockwell, 1981). Prior to Building 374 becoming operational in 1980, laundry waters were sent to the second stage of Building 774's aqueous waste operations and then through the evaporator located there if the radioactivity of the water was above 1667 pCi/l. Below this level, it was sent on to Pond

B-2. When the plant first began operations, laundry wastes were discharged directly to North Walnut Creek.

In the very early days, Buildings 881, 771, and 991 had their own laundry facilities, while Building 444's laundry went to Building 442. Around 1958, Building 778 became the laundry facility for all plutonium-related buildings. When enriched uranium moved away from Rocky Flats in the mid-1960s, all laundry remaining from those operations went to the Building 778 laundry. In 1976, Building 442 was turned over to the Filter Installation group, and since that time all laundry from the plant site has been processed in Building 778 (ChemRisk, 1991; RE-891 [75, 78, 79]).

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4.0 USES OF MATERIALS OF CONCERN

As described in Section 1, the materials of concern for this project (listed in Table 1-1) were selected as a result of Task 2 and Task 6 activities based on known toxicologic properties of materials used by the plant, the environmental fate and transport characteristics of the materials, and preliminary knowledge of the ways in which the materials have historically been stored, used, and disposed of at the Rocky Flats Plant. A number of the materials of concern were retained for further study because no information on their storage, use, or disposal could be found.

Section 2 describes the extensive campaign of document reviews and personnel interviews that was conducted and focussed on the materials of concern to gather information on how these materials have been used throughout the history of the Rocky Flats Plant. The following pages will describe the key information sources utilized to document uses of the materials of concern at Rocky Flats, and present the material use profiles and air emission source maps that have been generated to summarize the significant points about historical uses of each material.

4.1 Key Information Sources

Information regarding the historical uses of each material of concern has been obtained primarily from plant document reviews and plant personnel interviews. The most important documents for material usage information have been the Air Pollution Emission Notices (APENs) and Waste Stream and Residue Identification and Characterization Reports (WSRIC). Other relevant documents have been obtained from searches performed on the legal/environmental index, the legal database, the integrated research file, the Building 706 Technical Library, and the Building 881 Archives. Although the APENs and WSRIC documents reflect material usage and emissions only during the late 1980s, they provided a starting point for our investigation prior to interviews. Consequently, interview time was optimized as a result of the project team's knowledge of current day operations. As stated in Section 3.0 of this report, many processes have remained fairly constant over the years. Interviews and historical correspondence were used to identify differences between current day and historical operations. Two examples of these differences are the enriched uranium operations of the 1950s and solvent substitutions occurring in the 1970s.

The personnel interview process was focussed on the materials of concern. ChemRisk verified with the interviewees the modern-day uses of the materials, if any, as described in the APENs and/or WSRIC reports. Information was then requested on any historical changes to processes, buildings, and effluent treatment or handling systems that would have

affected associated air emissions. Knowledge of any major material additions, substitutions, or eliminations was also requested. Each interviewee was asked for suggestions on how to best reconstruct the changes in chemical use rates and emissions over the years, since emissions of other materials have not historically been monitored to the extent that radionuclides and beryllium have. Information on historical waste generation, treatment, and disposal practices was elicited, along with information about any of the major accidents and incidents of interest to the project. Members of the ChemRisk team identified the list of materials of concern for each interviewee, and asked for information pertaining to any materials that came to mind that have been used in significant quantities but were not among the materials of concern. See Appendix C for a listing of the actual interview questions.

4.2 Emission Source Maps and Material Use Profiles

The following pages present emission source maps and material use profiles for each material of concern. The material use profiles present qualitative historical information on use of the materials of concern obtained in Task 3 and 4 activities. Source maps show qualitative historical information regarding building locations of potential emissions of the materials of concern. The maps also present quantitative current day air emissions as percentages of site emission totals. Quantitative data on historical emissions is being developed as part of Task 5 and will be presented in the Task 5 Source Terms Report. The following fields of information are provided to describe the uses of each material at Rocky Flats and the spatial distribution of emission sources on the site:

Emission Sources - *Significant airborne emission sources for each material of concern are indicated on a plant map. The source information is, for the most part, based on modern-day APENs estimates, and EIS database radionuclide releases for 1988.*

Synonyms - *Many materials of concern have multiple names in popular use, and in practice, trade names and slang terms are common.*

Chemical Forms and Properties - *Several of the materials of concern are elements or isotopes of elements. As such, they can exist as various compounds and in different physical states. Indications are given in this field of the physical*

	forms that have been used at Rocky Flats and their associated physical and chemical properties.
Uses by Man and Presence in Nature-	*Some of the materials of concern are found in nature. Others may be detectable in the environment due to man's activities. Where applicable, this field indicates typical natural abundances, or ranges of typical background concentrations.*
Toxicologic Highlights -	*Known toxicologic properties of the materials are presented, for example known or suspected animal or human carcinogens, reproductive toxins, or irritants. Known patterns of distribution in the body are described.*
Uses at Rocky Flats -	*Results of the historical investigation are presented for each material- the "who, what, when, where, and why" of use of the material at Rocky Flats. Inventory quantities from 1974 (Barrick, 1974) and 1988/89 (Setlock, 1990) are presented when available.*
Modern-Day Emission Estimates -	*Expected emission rates of the material are presented based on Air Pollution Emission Notices submitted by EG&G Rocky Flats or, for radionuclides, DOE Effluent Information System data for 1988.*
Monitoring Data Availability -	*The availability of emission monitoring data is described, be it routine or as special-studies of building or process emissions. Ambient monitoring, if any, is also listed.*
Period(s) of Use at Rocky Flats -	*To the extent possible, the time period(s) of use of the material at Rocky Flats are indicated.*

The following convention is used for indicating periods of material presence or use:

filled circles	●	indicate points in time where use is documented, for example hazardous material inventories in 1974 and 1988/89, or dates of correspondence describing uses.
empty circles	○	indicate points in time where inventories or summaries were prepared, and use of the material was *not* indicated.
solid lines	▬	indicate periods of documented use
dashed lines	▬	indicate periods of possible use

4.3 Grouping of the Material Use Profiles

The material use profiles presented in this report are placed in two groups. The first group contains those twelve materials for which investigations have conclusively demonstrated that the material has been used at Rocky Flats in significant quantity, and in forms and processes that are associated with a reasonable potential for off-site release. The materials presented in this group are those which warrant further quantitative evaluation from the standpoint of potential off-site releases, and will be the focus of Task 5 source term estimation efforts.

The thirteen materials in the second group of material use profiles are those for which extensive investigation has indicated that uses of the material at Rocky Flats have been extremely limited in scope or duration, associated with insignificant quantities of the material, or have involved processes or forms of the material which were not expected to have any significant off-site releases. These materials therefore do not warrant further quantitative evaluation of potential off-site impacts.

A number of materials on the initial list of materials of concern generated as part of project Task 2 were included because no information was immediately available with regards to the nature of their use and potential for release. For four of the materials in the second group, even after the extensive searches and interviews performed as part of this Task 3 and 4

effort, no information could be found with regards to a use at the plant which supports the recorded inventory quantity or a potential for off-site release. These materials are:

Benzidine
1,3-Butadiene
Ethylene Oxide
Propylene Oxide

In addition, information obtained on the other nine materials of concern in the second group has indicated that based on the nature of their use they do not warrant further quantitative evaluation of potential off-site impacts. These include:

Benzene
Cadmium Compounds
Chromium Compounds
Formaldehyde
Hydrazine
Lead Compounds
Mercury
Nickel Compounds
Nitric Acid

A comparison of the emission source maps with inventory quantities presented in the Building Summaries (Appendix B) indicates that in some cases, buildings or processes which use a given material are not identified as emission sources of that material. This is because the manner in which the material is stored, processed, or handled is not expected to lead to significant emissions. Lead is an example of such a case. On a number of the emission source maps, the waste treatment buildings are identified as air emission sources for chemicals which are not expected to be released in significant quantities in their primary areas of use as indicated by inventory quantities. Cadmium is an example of such a difference between the source maps and inventory quantities.

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MATERIALS OF CONCERN
EMISSION SOURCE DIAGRAMS
AND
MATERIAL USE PROFILES

GROUP NUMBER 1

The twelve materials presented in this group are those which warrant further quantitative evaluation from the standpoint of potential off-site health impacts, and will be the focus of Task 5 source term estimation efforts.

Building No. 371

Plutonium recovery facility conducted pilot americium recovery operations in the early to mid 1980s. Salts for molten salt extraction are made here. Some waste handling and repackaging is done.

3% of Site Emission Total

Building No. 374

Process wastewater treatment facility receives wastes from over 15 buildings and the solar ponds. Some wastes contain americium. Processes include neutralization, radioactive decontamination, sludge and salt solidification, and evaporation.

3% of Site Emission Total

Building No. 771

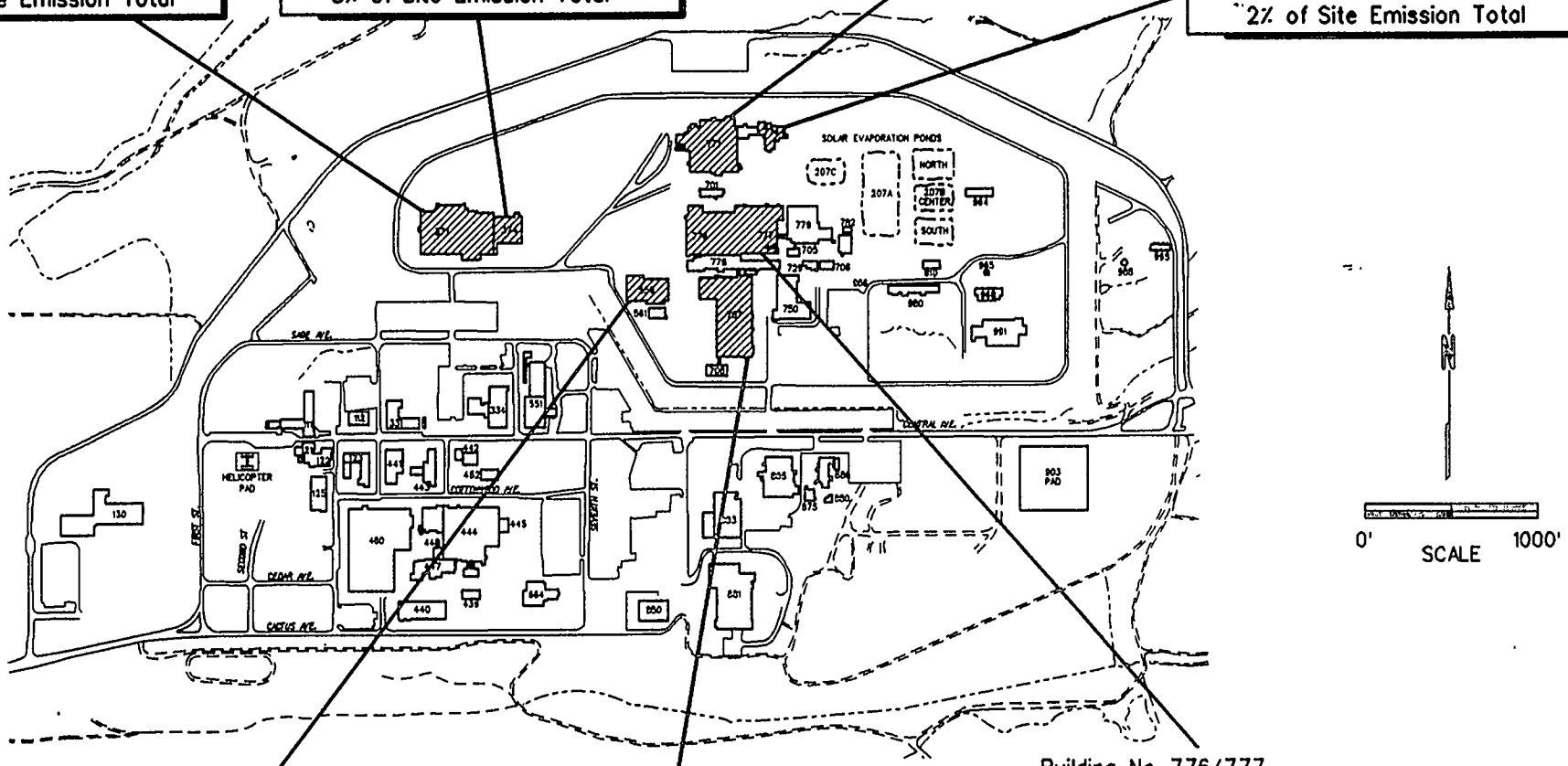
Plutonium purification operations include chemical separation of americium contamination. Past operations have included Am purification.

78% of Site Emission Total

Building No. 774

The aqueous and organic waste treatment facility treats transuranic wastes from Building 771 plutonium recovery operations. Some wastes contain americium. Processes include neutralization, precipitation, filtration, and solidification.

2% of Site Emission Total



Building No. 776/777

Weapons components are disassembled, and some parts are processed via molten salt extraction to remove americium. Salt scrub process recovers Am and Pu from associated salts.

3% of Site Emission Total

Building No. 559

Some Plutonium Analytical Laboratory samples contain americium.

4% of Site Emission Total

Building No. 707

Plutonium involved in fabrication operations includes some of the Pu-241 decay product Am-241.

3% of Site Emission Total

Source Of Emission Data: Effluent Information System Totals For 1988

ChemRisk
A Division of McLaren/Hart

FIGURE 4-1
AMERICIUM AIR EMISSION SOURCES

RokyFlts/Hstry 3-4/04-01 REV: 01-06-92

SYNONYMS: None. Americium is named after the Americas.

CHEMICAL FORMS AND PROPERTIES:

- Americium is more white and silvery than plutonium. It is more malleable than uranium, and tarnishes slowly in dry room-temperature air.
- Am-241, a decay product of Pu-241, is associated with plutonium handling and processing.

USES BY MAN AND PRESENCE IN NATURE:

- Am-241 is used as a radiation source for static eliminators, smoke detectors, and as a medical diagnostic tracer.
- Am-241 has been used as a gamma radiography source and in thickness gages in the glass industry.

TOXICOLOGICAL HIGHLIGHTS:

- Americium most commonly enters the body by inhalation.
- It deposits primarily in the liver and skeleton with elimination half-times of 20 and 50 years, respectively.
- The main concern at low exposures is the probability of increased risk of cancer from irradiation of cells. Heavy metal poisoning from ingestion or inhalation occurs with exposure to large amounts.

USES AT ROCKY FLATS:

- Am-241 is associated with the plutonium used at Rocky Flats, at levels depending on the length of time that has passed since the Pu was produced. In general, the average age of the Pu at Rocky Flats is about 10 years, and Am ranges from 10 to 20% of the Pu activity (USDOE, 1980).

- Am-241 is separated from plutonium as a contaminant. At times in history, americium has also been purified at Rocky Flats for sale for commercial applications such as use as a medical diagnostic tracer and for smoke detector ionization sources. In the early 1980s, about a kilogram of >95% americium oxide was shipped to Oak Ridge National Laboratory each year (Knighton, 1981). Now americium is considered a waste product.

- Retired weapons components ("site returns") are disassembled, and some parts are processed via molten salt extraction to remove americium. A "salt scrub" process recovers Am and Pu from associated salts.

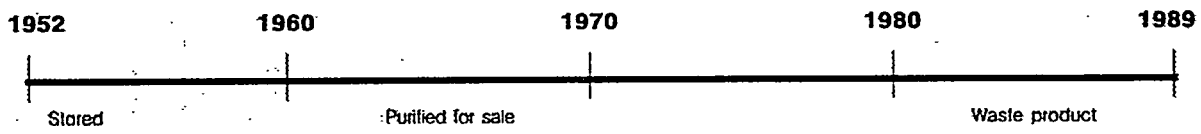
MODERN-DAY EMISSION ESTIMATE FROM EG&G REPORTS:

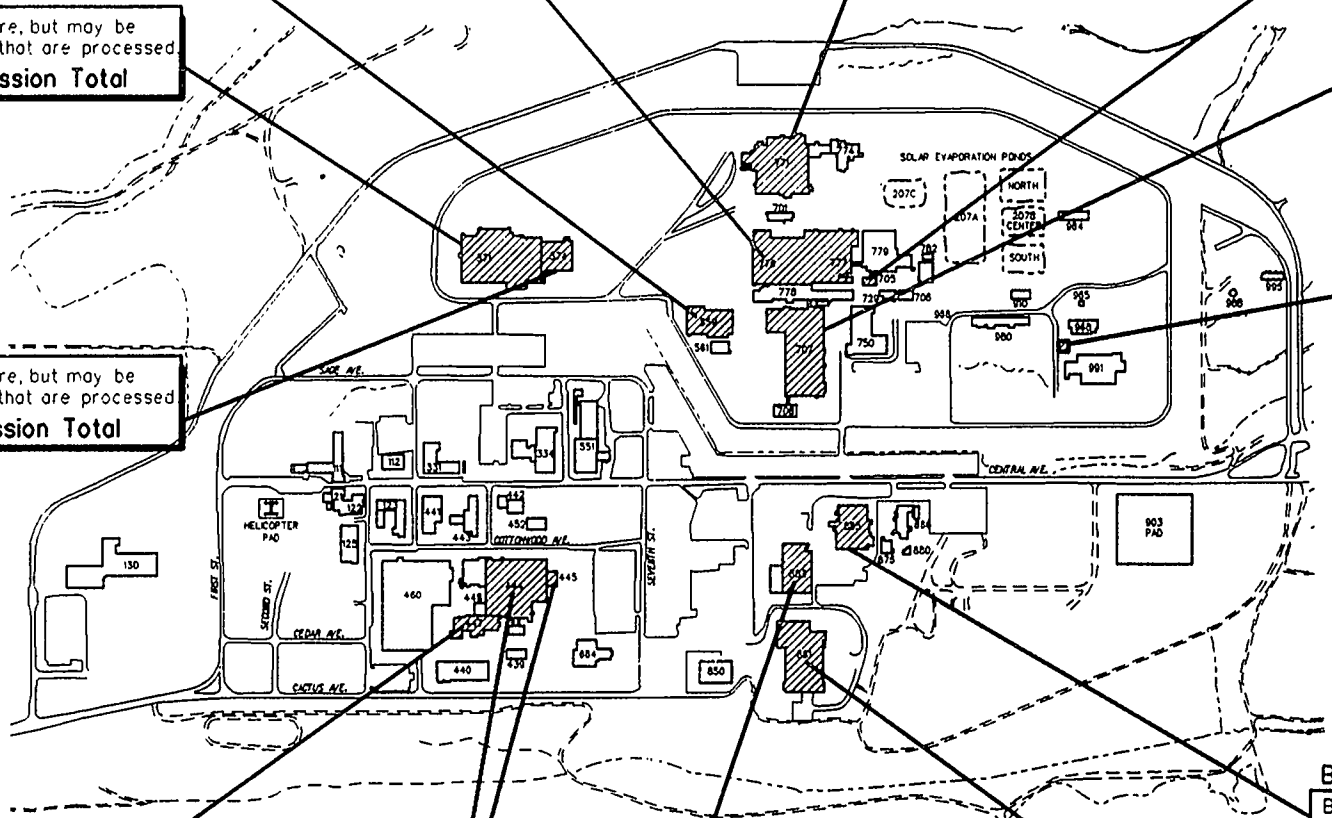
For 1988, reported americium-241 emissions were 2.02 microcuries airborne and 115 microcuries from waterborne surface runoff (Rockwell, 1989).

MONITORING DATA AVAILABILITY:

Americium has been monitored in Rocky Flats airborne effluents since 1985 and in waterborne effluents since at least 1971.

PERIOD(S) OF USE AT ROCKY FLATS:





Building No. 559
Be not processed here, but may be present in materials that are processed
7% of Site Emission Total

Building No. 776
Be not processed here, but may be present in materials that are processed
19% of Site Emission Total

Building No. 771
Be not processed here, but may be present in materials that are processed
Under 1% of Site Emission Total

Building No. 705
Be vapor deposition: Be is vaporized and used to coat metal parts.
Under 1% of Site Emission Total

Building No. 371
Be not processed here, but may be present in materials that are processed
19% of Site Emission Total

Building No. 707
Be not processed here, but may be present in materials that are processed
7% of Site Emission Total

Building No. 985
Be not processed here, but may be present in materials that are stored in the associated underground vaults
2% of Site Emission Total

Building No. 374
Be not processed here, but may be present in materials that are processed
1% of Site Emission Total

Building No. 865
Be powder is mixed with other metals, molded, and pressed into shapes. Metal working R & D is conducted. Be is cast, heat treated, and electrorefined to high purity.
Under 1% of Site Emission Total

Building No. 447
Electron beam welding of parts including Be components Electrochemical milling of metals including Be Some Be parts are vacuum heat treated to drive out impurities and relieve internal stresses.
7% of Site Emission Total

Building No. 883
Be fabrication (rolling and forming) was conducted on the "A side" from around 1966 to mid-1970s. The building has since undergone Be decontamination
9% of Site Emission Total

Building No. 881
Be not processed here, but may be present in materials that are processed.
3% of Site Emission Total

Building No. 444 & 445
Machining of Be castings, sintered forms, and bar stock includes sawing, milling, drilling, lathe operations, polishing, and abrading Be foundry active 1958 to 1980
25% of Site Emission Total

Source Of Emision Data:
Air Pollution Emission Notice Reports

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RckyFlts/Hstry 3-4/04-02 REV 01-08-92

FIGURE 4-2
BERYLLIUM AIR EMISSION SOURCES

SYNONYMS: Glucinium or Glucinum

CHEMICAL FORMS AND PROPERTIES:

- Beryllium is a hard, brittle, gray-white solid metallic element.
- Beryllium is useful in nuclear weapons because it is light-weight, strong, and reflects neutrons but is transparent to X rays.

USES BY MAN AND PRESENCE IN NATURE:

- Beryllium is found in some 30 mineral species, including beryl, chrysoberyl, and phenacite. Aquamarine and emerald are precious forms of beryl.
- Beryllium is used in ceramics, electron tubes, and high temperature reaction systems

TOXICOLOGICAL HIGHLIGHTS:

- Beryllium is a probable inhalation carcinogen (evidence in animals, inadequate evidence in humans).
- Chronic and acute Be inhalation exposure can result in pulmonary disease, termed berylliosis.
- Allergic contact dermatitis can result from dermal exposure.

USES AT ROCKY FLATS:

- Beryllium has been used to make weapons parts since 1958, based on R&D work that began at the plant in 1953 (Campbell, 1986). Early "wrought" process operations involved casting Be ingots, sawing the ingots into "billets", "canning" the billets with a stainless steel cladding to protect the Be from the atmosphere, heating and rolling into sheets, and removing the "cans". The Be sheets were then etched, rolled again, annealed, cut and pressed into shapes, and machined (USDOE, 1984).

- The wrought process ended in 1975, and since that time sintered blanks have been purchased from Brush Wellman, Inc. Machining is done on-site or by a subcontractor. Machining includes turning, milling, sawing, deburring, and polishing (Campbell, 1986).

- Be powder is mixed with other metals and pressed into shapes in Building 865 (EG&G, 1991c). Beryllium is vapor deposited to coat metal parts in Building 705 (EG&G, 1991d).

- Early Be machining operations were not enclosed (ChemRisk, 1991;RE-891[36]). There were "elephant trunks" for ventilation near Be machines and open hoods. Now, hoods are enclosed and machines have high & low vacuum systems to collect grit and fines (ChemRisk, 1991; RE-891[37]).

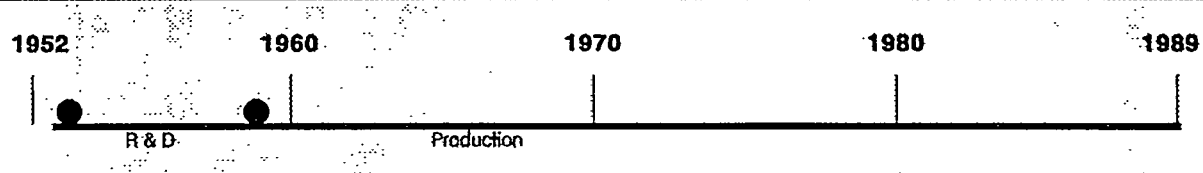
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

2.23×10^{-5} ton per year, which equals 0.07 ounces.

MONITORING DATA AVAILABILITY:

Be has been monitored in plant exhaust systems since at least 1963 (Hammond, 1963). It is currently monitored in 50 vents, although Be is actually processed in only six of the associated areas (EG&G, 1990a). Be is among 11 elements analyzed by atomic absorption in waterborne effluents since at least 1980 (USDOE, 1980).

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 707

CCL_4 is used to clean glove-box walls, furnaces, and rollers. Plutonium parts are cleaned in CCL_4 and turnings are dipped in CCL_4 baths for cleaning.

80% of Site Emission Total

Building No. 776

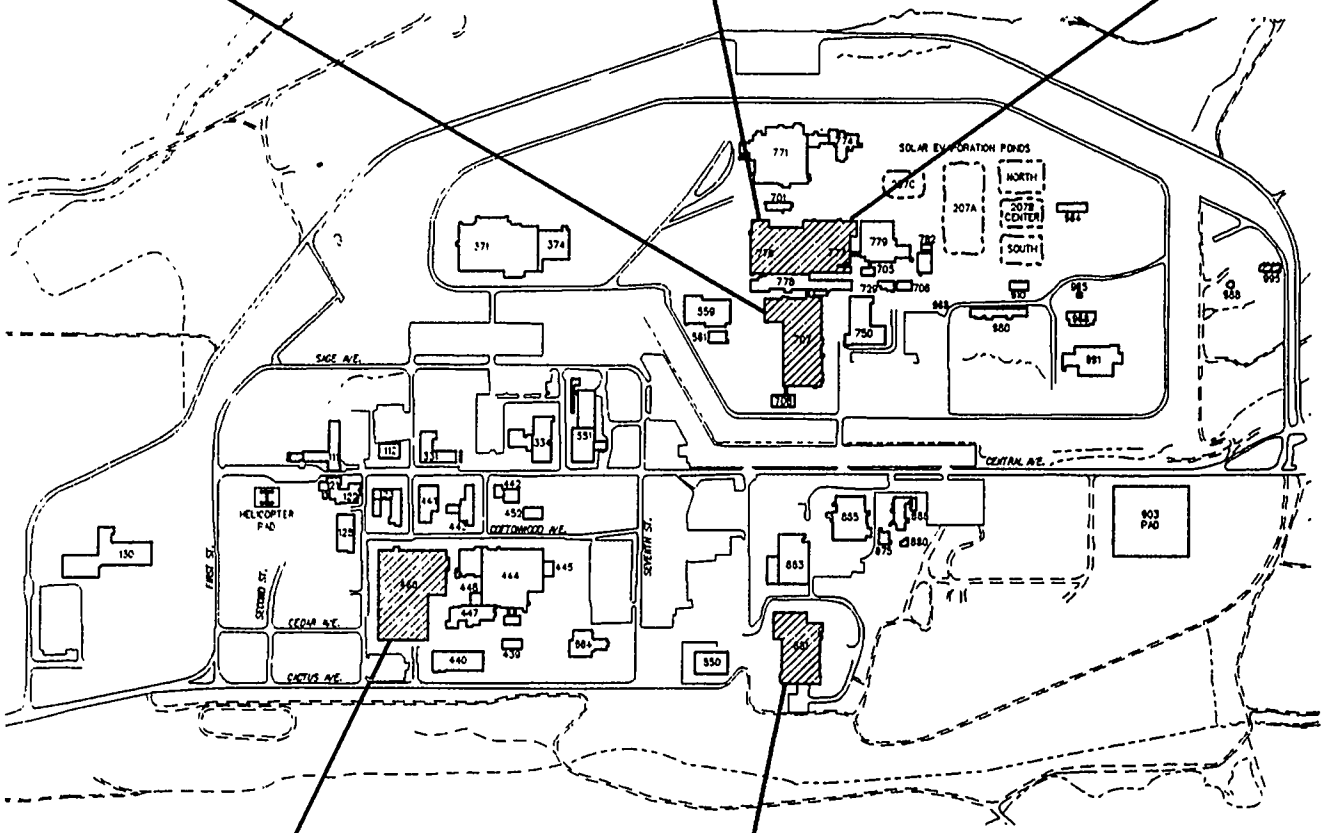
A baler is used to reduce the volume of low-level combustible wastes. CCL_4 is present in some wet wastes.

6% of Site Emission Total

Building No. 777

Parts are cleaned with CCL_4 prior to machining and for inspection. Plutonium metal turnings are placed in baskets and dipped in CCL_4 baths for cleaning.

14% of Site Emission Total



N

0' SCALE 1000'

Building No. 460

CCL_4 is used to clean metal parts

Under 1% of Site Emission Total

Building No. 881

CCL_4 is used in several laboratories and processes. It is used in small quantities, most commonly as a room-temperature rinse.

Under 1% of Site Emission Total

ChemRisk
A Division of McGraw-Hill

Source Of Emission Data:
Air Pollution Emission Notice Reports

FIGURE 4-3
CARBON TETRACHLORIDE
AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-03 REV: 01-06-92

SYNONYMS: carbon chloride, carbon tet, perchloromethane, tetrachloromethane, Freon 10, Halon 104

CHEMICAL FORMS AND PROPERTIES:

- Carbon tetrachloride is a clear, colorless, nonflammable liquid with a distinctive ether-like odor.
- Carbon tetrachloride is present in the environment due to human activities; the EPA national database of atmospheric concentrations indicates a median urban carbon tetrachloride concentration of about 110 parts per trillion by volume (Sturges and Taylor, 1990).
- Carbon tetrachloride works well with Pu because it contains no hydrogen atoms. Hydrogenated solvents are more likely to leave behind harmful solvent residue (ChemRisk, 1991; RE-891[46]).

USES BY MAN AND PRESENCE IN NATURE:

- Carbon tetrachloride has seen a wide range of industrial and chemical applications.

TOXICOLOGICAL HIGHLIGHTS:

- Carbon tetrachloride is a probable inhalation carcinogen (evidence in animals only).
- Inhalation of large quantities can damage liver, kidneys, lungs, or central nervous system.
- Chronic ingestion exposure may produce liver toxicity.
- Chronic dermal exposure may cause skin irritations.

USES AT ROCKY FLATS:

- Rocky Flats was formerly the largest volume U.S. user of carbon tetrachloride (EG&G, 1990b). Carbon tetrachloride has been used to clean glove-box walls, furnaces, product components, metal chips, machinery, and instruments. Prior to 5-6 years ago, it was used "like a bucket of soap and water." (ChemRisk, 1991; RE-891[16]).

- Briquetting and chip degreasing emissions have the highest carbon tetrachloride concentrations- up to approximately 13% by volume (ChemRisk, 1991; RE-891[5,7,32]).

- Carbon tetrachloride was present on the 1974 Harmful Materials Inventory in the amount of 12,500 kg. The quantity indicated on the 1988/89 Chemical Inventory was 7,060 kg.

- Carbon tetrachloride was used as a diluent in solvent extraction operations on a laboratory scale (ChemRisk, 1991; RE-891[43]).

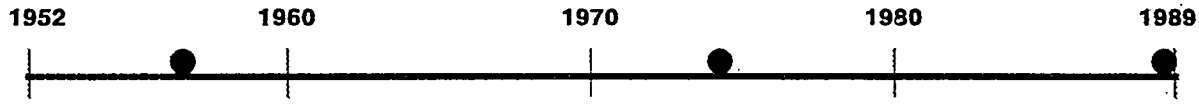
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

40.4 tons per year, which equals 80,800 pounds.

MONITORING DATA AVAILABILITY:

Carbon tetrachloride has not been routinely monitored in airborne or waterborne effluents. There have been several special studies involving short-term monitoring of carbon tetrachloride emissions in the work-place or in airborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 374

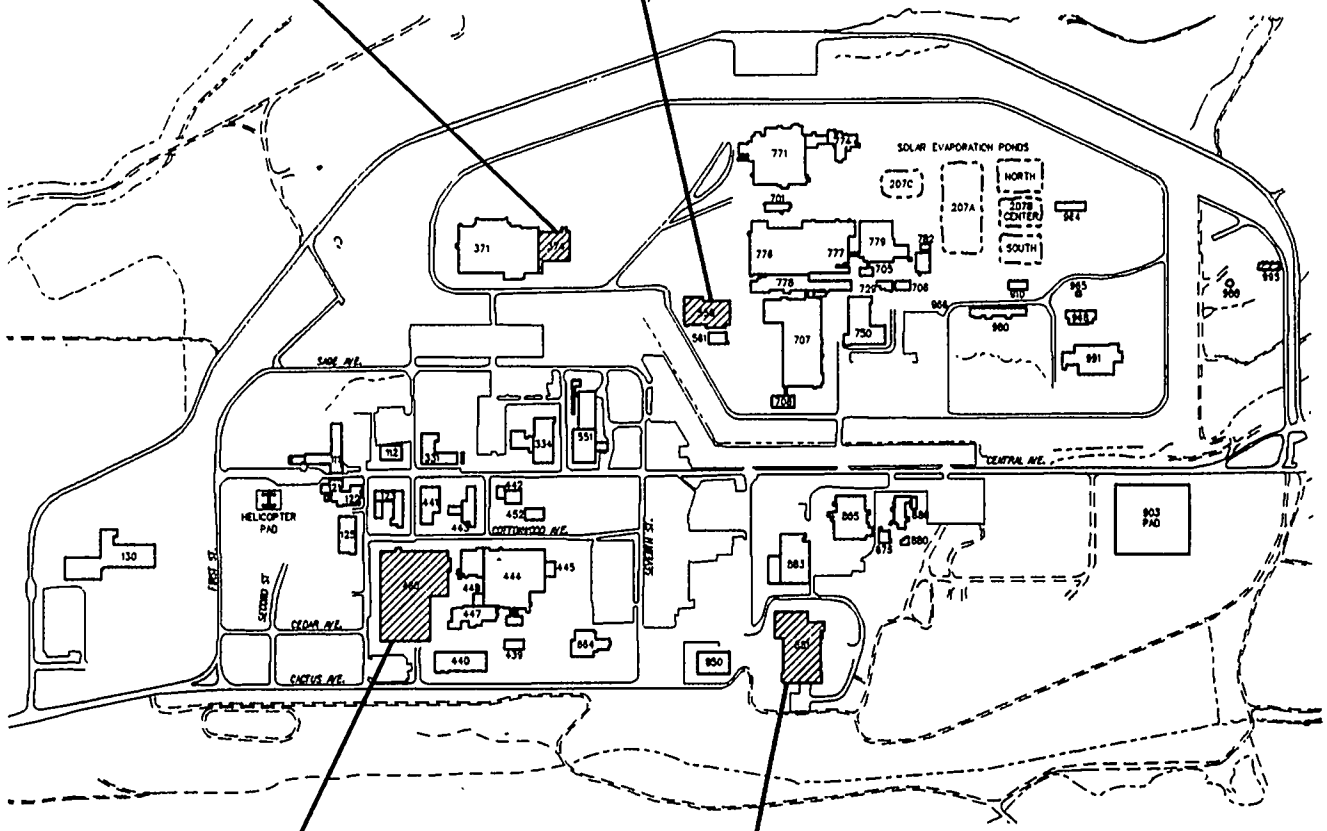
Chloroform is released from process liquid waste neutralization processes

Under 1% of Site Emission Total

Building No. 559

Chloroform is used in analyses of plutonium samples for determination of gallium content. Chloroform extracts the gallium oxide complex.

88% of Site Emission Total



Building No. 460

Chloroform is used in high bay, central manufacturing areas.

Under 1% of Site Emission Total

Building No. 881

Chloroform listed as used in Building 881. No specific use is identified The building currently houses laboratories, maintenance shops, and plant support activities.

11% of Site Emission Total

N

0' SCALE 1000'

Source Of Emission Data:
Air Pollution Emission Notice Reports

ChemRisk
A Division of McLaren/Hart

FIGURE 4-4
CHLOROFORM AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-04 REV: 01-08-92

SYNONYMS: methane trichloride, trichloromethane

CHEMICAL FORMS AND PROPERTIES:

- Chloroform is a dense, colorless, volatile liquid with a pleasant odor.
- When heated to decomposition, forms phosgene gas.

USES BY MAN AND PRESENCE IN NATURE:

- Chloroform is used in manufacturing of floor polishes, resins, vitamins, penicillin, as a dry cleaning agent, and in production of chlorodifluoromethane.
- Chloroform is a by-product in chlorinated drinking water and municipal sewage
- It is ubiquitous in the environment; the EPA national database of atmospheric concentrations indicates a median urban chloroform concentration of about 58 parts per trillion by volume (Sturges and Taylor, 1990).

TOXICOLOGICAL HIGHLIGHTS:

- Chloroform is a probable carcinogen (evidence in animals, but inadequate evidence in humans).
- It is considered a potential developmental toxicant based on animal studies.
- Dermal exposure to chloroform may cause skin irritation.
- Acute inhalation exposure may cause liver and kidney toxicity.

USES AT ROCKY FLATS:

- Chloroform is used in analyses of plutonium samples for determination of gallium content. Chloroform extracts the gallium oxide complex (EG&G, 1990c).
- Chloroform is released from process liquid waste neutralization processes (EG&G, 1991b).
- Chloroform has reportedly been used by carpenters to join plastics, but is no longer used in that manner (ChemRisk, 1991; RE-891[35,56]).
- The 1974 Harmful Materials Inventory listed chloroform with a quantity of 5513 liters. The 1988/89 Chemical Inventory Quantity was 500 kg, with uses including as an adhesive/solvent in Building 334, a glue for plexiglass in Building 460, and dissolving of plastics and photo resists in Building 881.

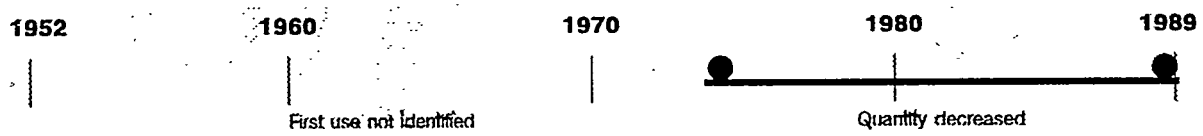
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

0.844 tons per year, which equals 1,688 pounds per year.

MONITORING DATA AVAILABILITY:

Chloroform has not been routinely monitored in airborne or waterborne effluents, but has been the subject of some special, short-term monitoring studies.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 374

Methylene chloride is emitted during treatment of process liquid wastes, most significantly in wastes from Building 738/732, 444, and 881/887

Under 1% of Site Emission Total

Building No. 776

A baler is used to reduce the volume of low-level combustible wastes. Methylene chloride is present in some wet wastes

70% of Site Emission Total

Building No. 771

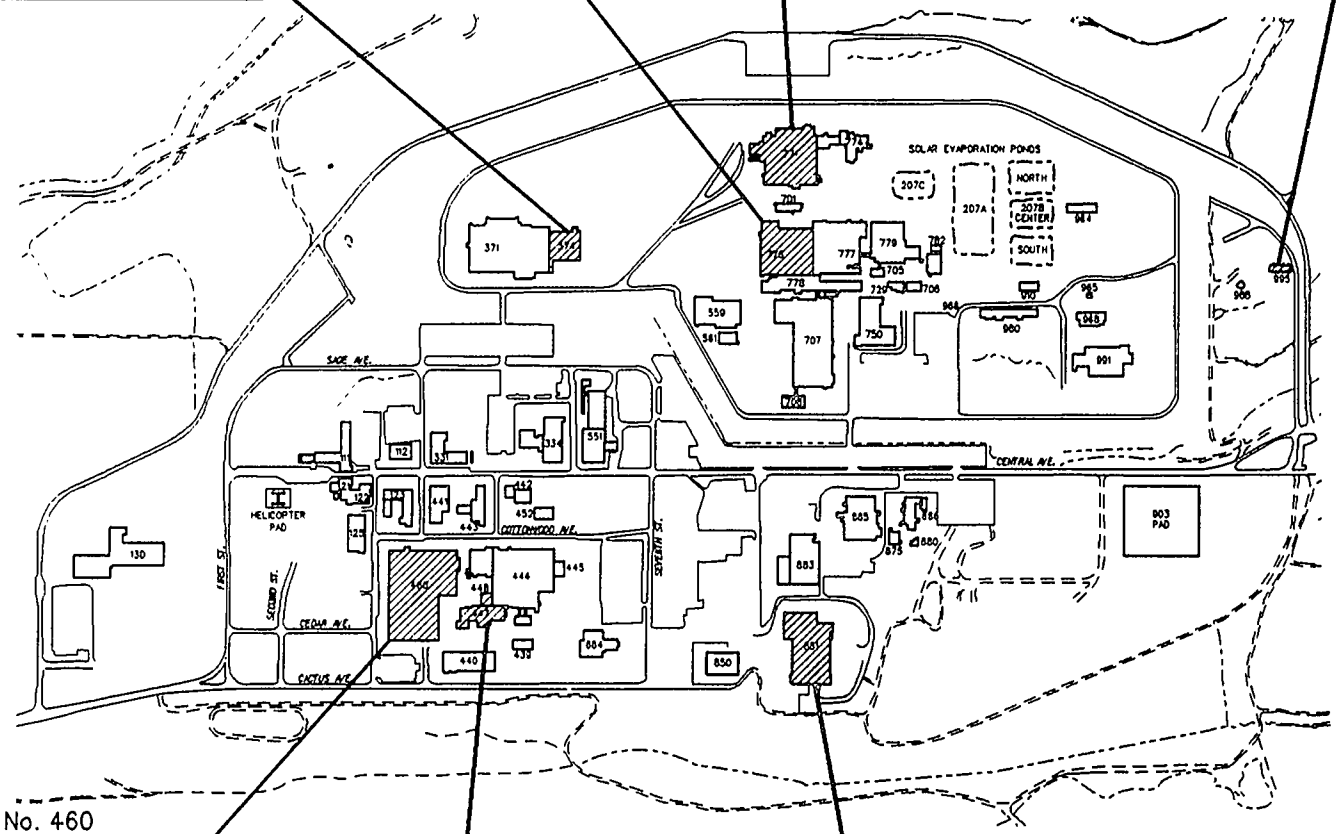
Methylene chloride is present in paints and paint strippers used here.

21% of Site Emission Total

Building No. 995

Methylene chloride has been detected in samples of the sludge contained in the sanitary sewege treatment plant drying beds

Under 1% of Site Emission Total



Building No. 460

Methylene chloride is present in the "Cee Bee" solution used in the aqueous component cleaning line

Under 1% of Site Emission Total

Building No. 881

Methylene chloride is used in several laboratories and process areas for sample preparation and analysis.

8% of Site Emission Total

Building No. 447/8, 451

Methylene chloride is emitted during painting and paint stripping operations.

Under 1% of Site Emission Total

Source Of Emission Data:
Air Pollution Emission Notice Reports

ChemRisk
A Division of McLaren/Hart

FIGURE 4-5
METHYLENE CHLORIDE AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-05 REV 01-08-92

ROCKY FLATS MATERIAL USE PROFILE; METHYLENE CHLORIDE

SYNONYMS: dichloromethane, DCM, methylene dichloride

CHEMICAL FORMS AND PROPERTIES:

- Methylene chloride is a colorless liquid with a pleasant, chloroform-like odor.
- Methylene chloride is moderately soluble in water and highly volatile in air.

USES BY MAN AND PRESENCE IN NATURE:

- Because it is an excellent solvent with low flammability, methylene chloride is used in paint removers, aerosol products, production of urethane foams and pharmaceutical products, and as a cleaning agent for metal parts and electronic components.
- It is also produced at low levels by chlorination of drinking water.

TOXICOLOGICAL HIGHLIGHTS:

- Methylene chloride is one of the least toxic chlorinated hydrocarbons.
- The primary route of exposure is by inhalation.
- Methylene chloride is a probable carcinogen (evidence in animals only).
- Inhalation of high levels of methylene chloride causes irritation to the eyes, nose, and throat.

USES AT ROCKY FLATS:

- Methylene chloride is present in paints and paint strippers used at Rocky Flats. Use was significant in Building 889, particularly in the 1960s and 1970s (e.g. clean-up of oralloy line equipment from Building 881).
- Methylene chloride is an ingredient of the "Cee Bee" solution used in aqueous component cleaning (EG&G, 1991f).
- It is used in several laboratories and process areas for sample preparation and analysis.
- Methylene chloride has been detected in samples of the sludge contained in the sanitary sewage treatment plant drying beds (EG&G, 1991e).

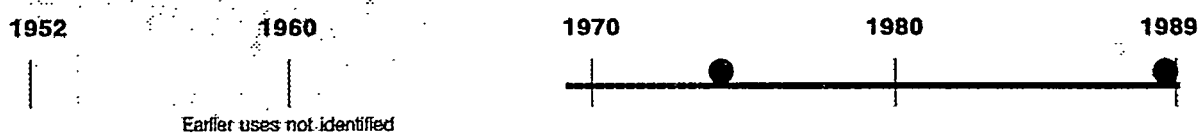
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

3.33 tons per year, which equals 6,660 pounds per year.

MONITORING DATA AVAILABILITY:

Methylene chloride has not been routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 371

Plutonium recovery facility conducted pilot operations in the early to mid 1980s. Salts are made for molten salt extraction. Plutonium Analytical Support Laboratory does analyses to support process control. Chemical Standards Lab provides standards Some waste handling and repackaging is done.

2% of Site Emission Total

Building No. 374

Process waste water treatment facility receives wastes from over 15 buildings and the solar ponds. Some wastes contain plutonium. Processes include neutralization, radioactive decontamination, sludge and salt solidification, and evaporation.

1% of Site Emission Total

Building No. 771

Plutonium recovery operations include dissolution of Pu metal and Pu bearing residues, purification, and conversion to metal. An incinerator was used for Pu recovery from 1958 through 1988.

82% of Site Emission Total

Building No. 774

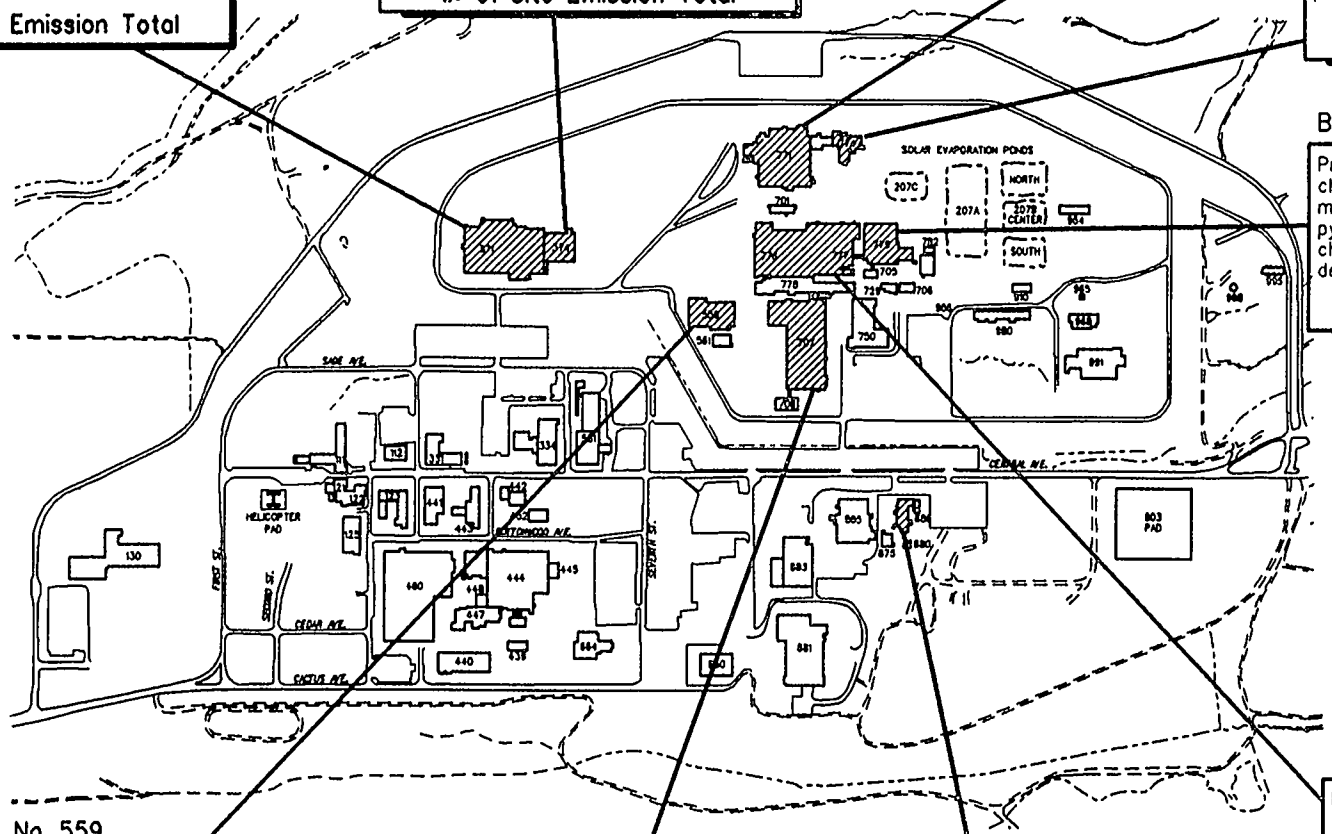
The aqueous and organic waste treatment facility treats transuranic wastes from Building 771 plutonium recovery operations. Organic wastes from Buildings 707 and 776/777 are also treated and stored here. Wastes from other buildings are received in drums. Processes include neutralization, precipitation, filtration, and solidification.

2% of Site Emission Total

Building No. 779

Production Support involves Pu in physical chemistry research and product testing, metallurgical support, nuclear joining, pyrochemical technology, hydride operations, chemical technology, coatings & metal film deposition, and machining and gaging support.

4% of Site Emission Total



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0' SCALE 1000'

Building No. 559

Plutonium Analytical Laboratory conducts spectrochemical, chemical, and mass spectrometric analyses of gaseous, liquid, and solid samples from process areas. Samples include plutonium metal, sludges, precipitates, and solutions. Building 561 houses the ventilation plenum for Building 559.

3% of Site Emission Total

Building No. 707

Plutonium fabrication operations include casting, rolling and forming, machining, and final product assembly. Machining, foundry, and assembly operations moved here after the 1969 fire in Building 776

1% of Site Emission Total

Building No. 886

Since 1965, about 1600 critical mass experiments have been conducted, using uranium and plutonium in liquid, powder, and metal forms. About half achieved criticality, with very low power levels and durations. Solutions were contained and re-used.

No Emission Estimate Available

Building No. 776/777

Product Support involves Pu in physical chemistry research and product testing, metallurgical support, nuclear joining, pyrochemical technology, hydride operations, chemical technology, coating & metal film deposition, and machining and gaging support.

3% of Site Emission Total

ChemRisk
A Division of McLaren/Hart

Source Of Emission Data:
Effluent Information System Totals for 1988

FIGURE 4-6
PLUTONIUM AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-06 REV: 07-21-92

SYNONYMS: None. Plutonium is named after the planet Pluto.

CHEMICAL FORMS AND PROPERTIES:

- Plutonium is a silvery, white metal that takes on a yellow tarnish when slightly oxidized.
- Pu-239 is produced when U-238 absorbs a neutron; Pu-239 can absorb more neutrons to form heavier isotopes, such as Pu-240, Pu-241, and Pu-242. Pu-239 is fissionable.
- A relatively large piece of plutonium will be warm to the touch because of the energy given off by alpha decay. Larger pieces will produce enough heat to boil water.
- Plutonium metal is attacked by all common gases at elevated temperatures; for example, nitrogen forms nitrides and hydrogen forms hydrides.

USES BY MAN AND PRESENCE IN NATURE:

- Plutonium is primarily produced and used by man in reactors and nuclear weapons.
- Plutonium is also found in trace quantities in naturally-occurring uranium ores.
- Pu-238 has been used as a power source in space, for example for equipment on the lunar surface.

TOXICOLOGICAL HIGHLIGHTS:

- Inhalation is the primary health concern because particles embedded in lungs emit alpha and some gamma rays with a half-life of 24,000 years.
- About 0.1% of ingested amount enters the bloodstream. About 80% of the resulting blood burden deposits in the liver and skeleton, with elimination half-lives of 20 and 50 years, respectively.
- The main concern at low exposures is the probability of increased risk of cancer from irradiation of cells. Heavy metal poisoning from ingestion or inhalation occurs with exposures to large amounts.

USES AT ROCKY FLATS:

- Pu fabrication involves casting, rolling and forming, machining, and final product assembly.
- Recovery involves dissolution of Pu metal and Pu bearing residues, purification, and conversion to metal. An incinerator was used for Pu recovery from 1959 (Gaskins and Martin, 1970) until 1988. Effluents were HEPA filtered.
- Production Support uses Pu in physical chemistry research and product testing, metallurgical support, nuclear joining, pyrochemical technology, hydride operations, chemical technology, coatings & metal film deposition, and machining and gaging support (Kneale, 1989).

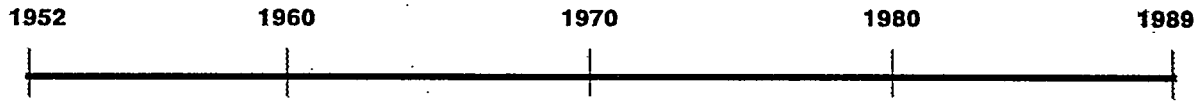
MODERN-DAY EMISSION ESTIMATE FROM EG&G REPORTS:

1988 Pu air emissions were 15.33 μCi. Surface water runoff totalled 118 μCi (Rockwell, 1989).

MONITORING DATA AVAILABILITY:

Air monitoring 1953-1973 was for total long-lived alpha. After 1973, analyses were specific for Pu (USDOE, 1980). Prior to 1961, ambient water and vegetation sample analyses were gross alpha or Pu + Th, later separations were specific for Pu and U (ChemRisk, 1991; RE-891[5,7,32]).

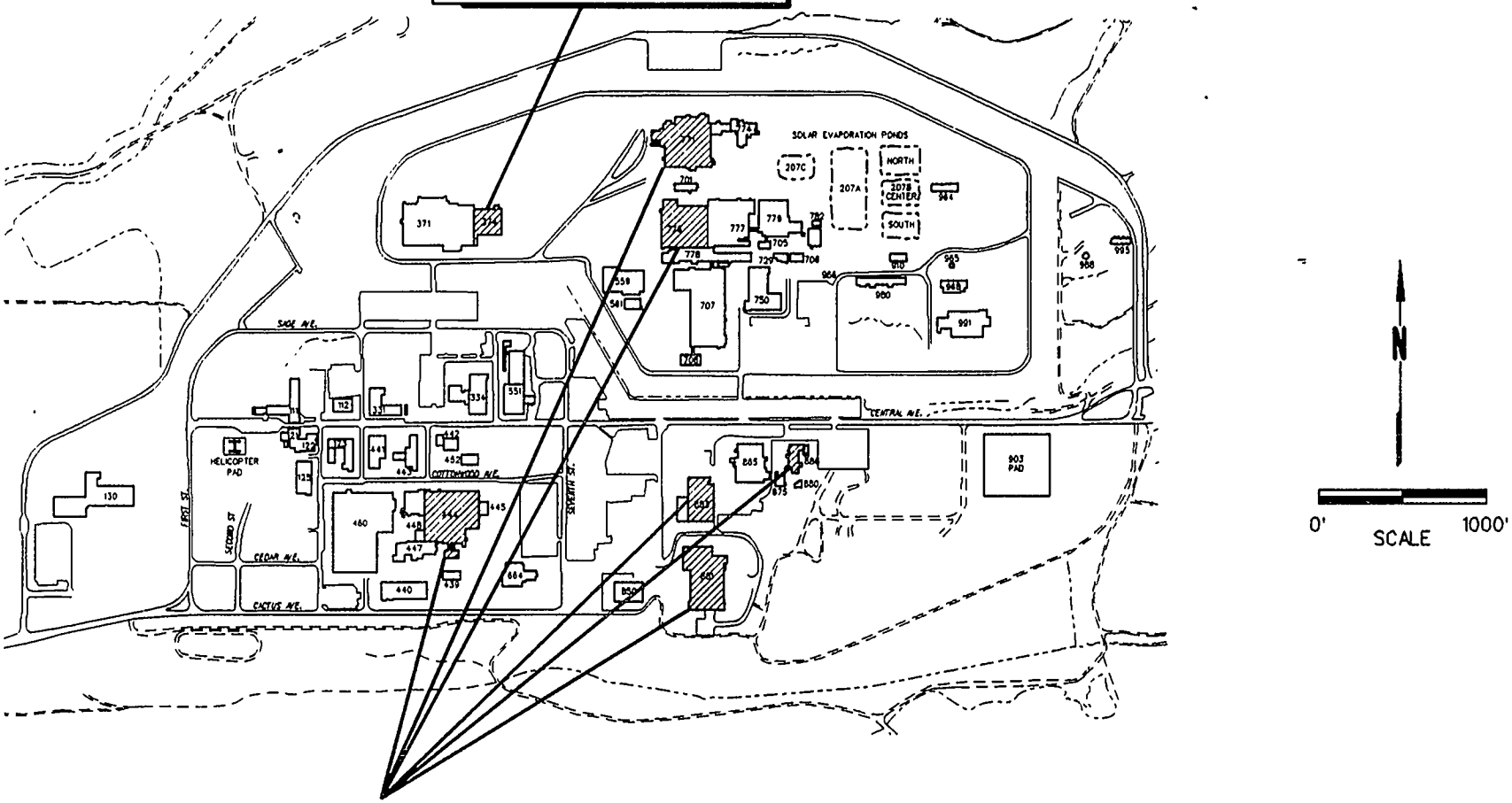
PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 374

Tetrachloroethylene is present in some process liquid wastes treated here, and is emitted during neutralization. The most significant waste source for PCE is Building 889

100% of Site Emission Total



Buildings No. 444, 771, 776, 881, 883 & 886

Tetrachloroethylene was widely used for parts cleaning and degreasing It was replaced by 1,1,1-TCA in 1970s

No Emission Estimates Available

ChemRisk
A Division of McLaren/Hart

Source Of Emission Data:
Air Pollution Emission Notice Reports

FIGURE 4-7
TETRACHLOROETHYLENE AIR EMISSION SOURCES

Rckyflts/Hstry 3-4/04-07 REV: 01-07-92

ROCKY FLATS MATERIAL USE PROFILE; TETRACHLOROETHYLENE

SYNONYMS: PCE, perchlorethylene, perchloroethylene, "perc", tetrachlorethylene

CHEMICAL FORMS AND PROPERTIES:

- PCE is a colorless liquid with a mild, chloroform-like odor.
- It is a noncombustible liquid.

USES BY MAN AND PRESENCE IN NATURE:

- PCE is used in dry cleaning and degreasing fabricated metal parts.
- It rapidly volatilizes from water to air, and rapidly migrates from soil to groundwater.

TOXICOLOGICAL HIGHLIGHTS:

- The most likely route of human exposure to PCE is inhalation.
- PCE is a probable carcinogen (evidence in animals, but limited evidence in humans).
- Chronic exposure to low levels of PCE is not likely to present a health concern.
- Acute exposure to high concentrations causes central nervous system depression and cardiovascular effects.
- PCE has been observed to cause dermal irritation.

USES AT ROCKY FLATS:

- PCE was widely used for part cleaning and degreasing in Buildings 881, 444, 883, 771, and 776 (ChemRisk, 1991; RE-891[39,48,53]).
- PCE was apparently most heavily used during the period of enriched uranium processing in Building 881 (prior to 1963); about 50 drums per month were used (ChemRisk, 1991; RE-891[39]).
- The period of PCE use in Building 886 was from about 1965 to 1975 (ChemRisk, 1991; RE-891[53]).
- Based on the 1974 Harmful Materials Inventory quantity of 4462 kg, the 1988/89 Chemical Inventory quantity of 1.5 kg, and personnel interviews, it appears that PCE was replaced by 1,1,1-trichloroethane for plutonium component cleaning and vapor degreasing in the 1970s.

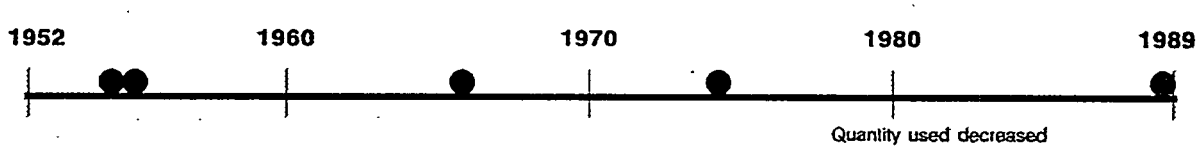
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

0.0000714 ton per year, which equals 2.28 ounces per year. Modern-day emissions are not representative of periods of much higher use in earlier years.

MONITORING DATA AVAILABILITY:

PCE has not been routinely monitored in airborne or waterborne effluents.

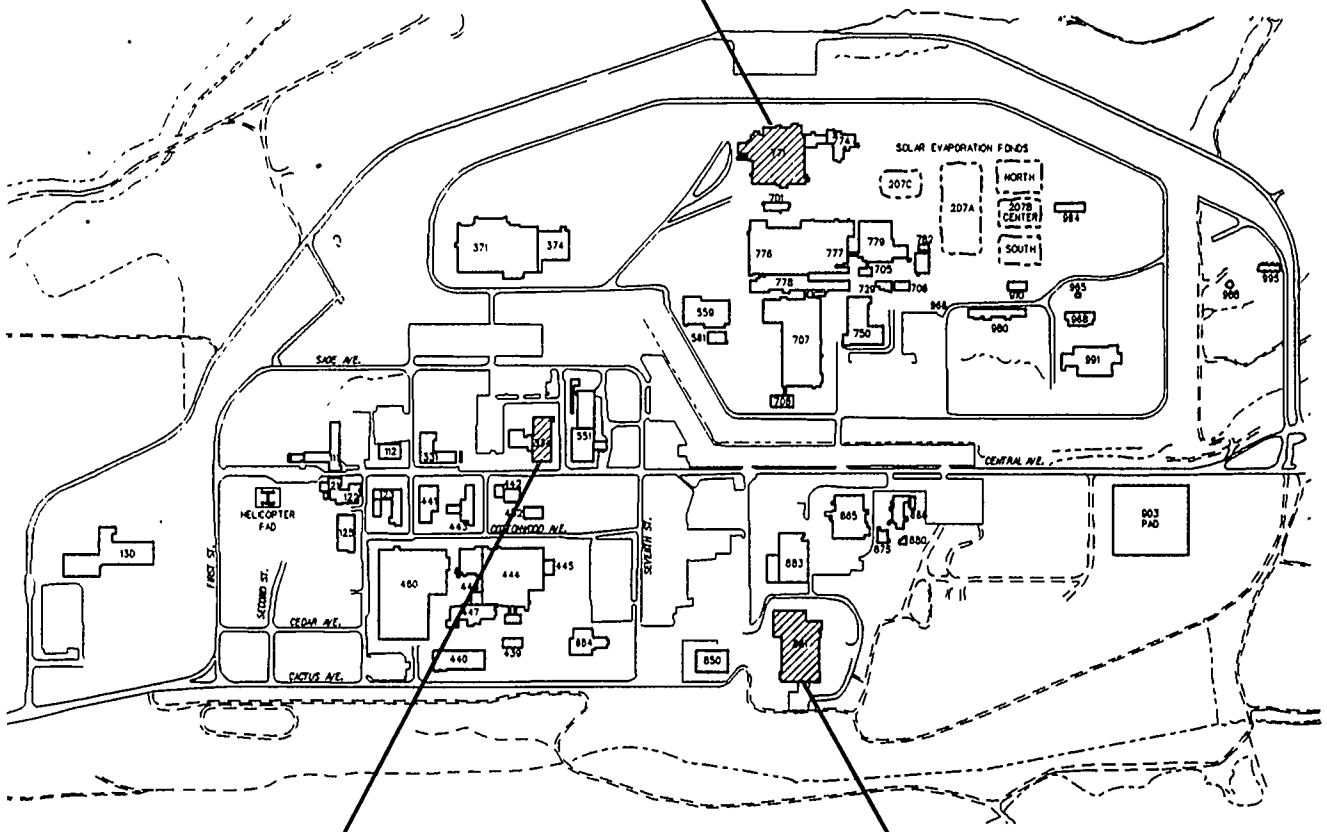
PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 771

Some small-scale thorium work of unspecified nature was conducted in the Building 771 Special Recovery laboratory. A few kilograms of natural thorium were present.

No Emission Estimate Available



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0' SCALE 1000'

Building No. 334

Small quantities of thorium and depleted uranium were sheared here

No Emission Estimate Available

Building No. 881

There was light production of thorium parts in Building 881 in the 1950s to early 1960s. "Thorium strikes" to remove impurities from U-233 were also done here.

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-8
THORIUM AIR EMISSION SOURCES

Rckyflts/Hstry 3 4/04-08 REV 01-08-92

ROCKY FLATS MATERIAL USE PROFILE; THORIUM

SYNONYMS: None. Thorium was named after Thor, the Norse god of thunder, weather, and crops.

CHEMICAL FORMS AND PROPERTIES:

- Thorium is a soft, ductile metal that can be easily scratched.
- Th-232 is a very long-lived alpha particle emitting isotope with a half-life exceeding 10 billion years.

USES BY MAN AND PRESENCE IN NATURE:

- Th is found in nature in ores such as thorite and monazite.
- Th is used in ceramic glazes, optical glass, welding electrodes, gas lantern mantles, and alloys.

TOXICOLOGICAL HIGHLIGHTS:

- 0.02% is absorbed into the blood, then 70% deposits in bone and is eliminated with a 22 y half-life.
- The main concern at low exposures is the probability of increased risk of cancer from irradiation of cells. Heavy metal poisoning from ingestion or inhalation occurs with exposures to large amounts.

USES AT ROCKY FLATS:

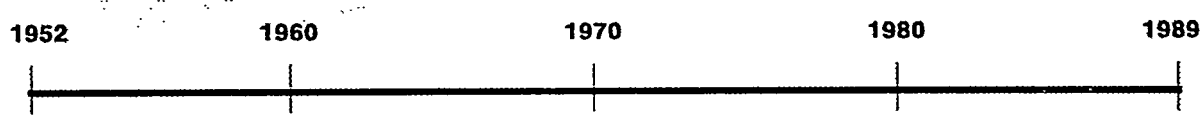
- Thorium has been used in several ways at Rocky Flats since 1952. The quantities of Th used have varied from none to about 238 kilograms in any month (Anonymous, 1976).
  - The major use has been fabrication of metal parts from natural thorium and thorium alloys.
  - Th oxide ("thoria") may have been used as a mold coating compound in limited experiments, but never on a production scale.
  - Th compounds have been used in analytical procedures and "development programs". Amounts were small, but applications "numerous".
  - Twice during 1964 to 1969, "thorium strikes" removed gamma-emitting Th-228 from U-233 metal. The strikes used natural thorium (Putzier, 1982).
  - Th has also been used as a stand-in for the more expensive U or Pu components in various phases of development programs.
- A project in B-881 involved Th production over several years in the late 1950s to early 1960s (ChemRisk, 1991; RE-891[48]). There were very tight controls, and Th went through the same processes as enriched uranium, but most was sent to Savannah River or Oak Ridge for recovery.

MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs: Not addressed in the APEN program.

MONITORING DATA AVAILABILITY:

Th contributes to total alpha, but has not been specifically analyzed routinely in effluents. Before 1961, ether extraction separated Pu + Th from environmental samples. After 1961, specific separations for Pu and U were performed (ChemRisk, 1991; RE-891[5,7,32]).

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 374

1,1,1-TCA is present in some process liquid wastes treated here, and is emitted during processing. The most significant waste sources for 1,1,1-TCA are bldgs 883/865

Under 1% of Site Emission Total

Building No. 776

1,1,1-TCA is present in some wet low-level combustible wastes and is emitted from the baler used for volume reduction.

29% of Site Emission Total

Building No. 774

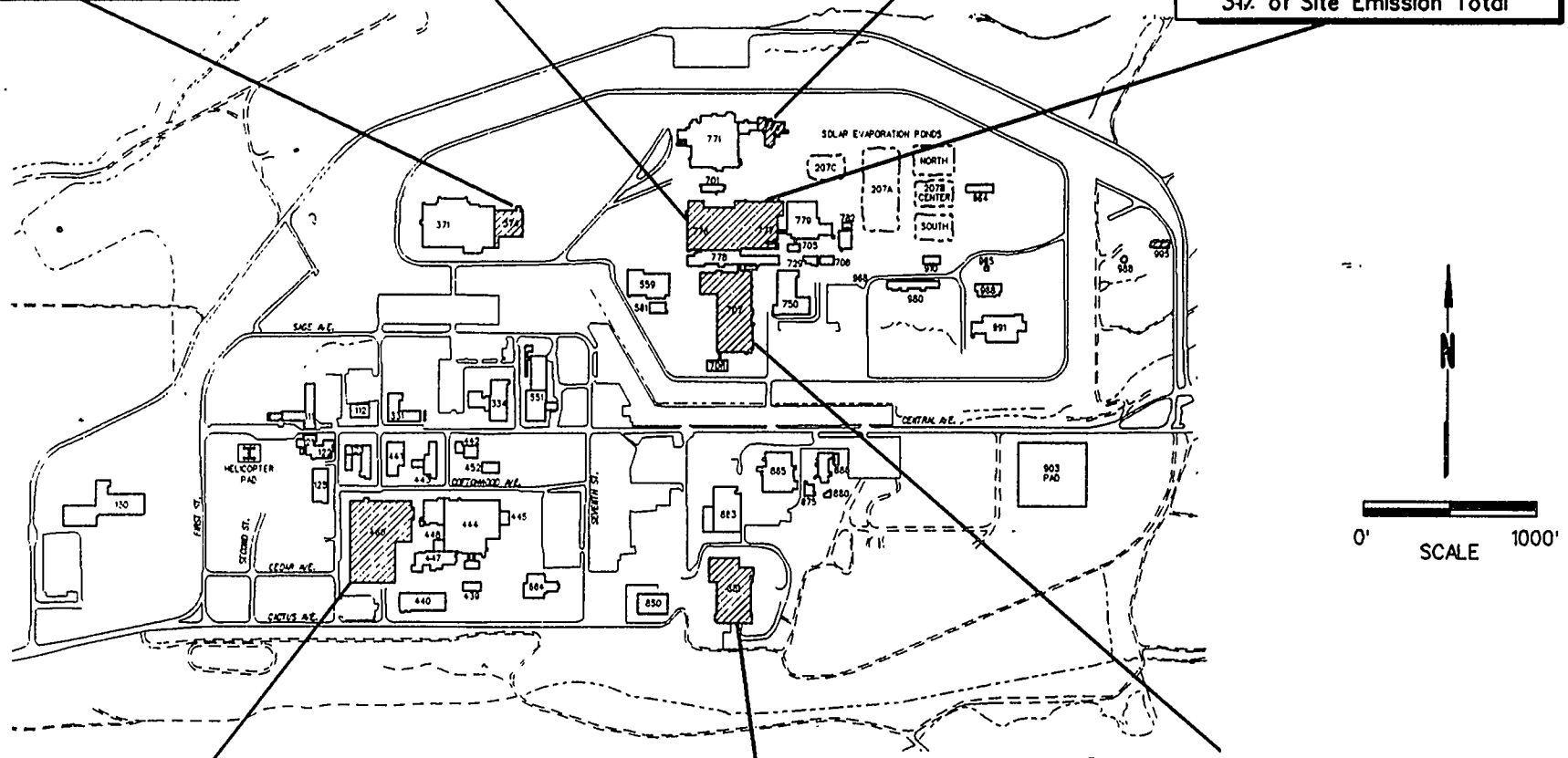
1,1,1,-TCA and oils mixed with carbon tetrachloride are solidified with gypsum cement in the Organic and Sludge Immobilization System (OASIS)

31% of Site Emission Total

Building No. 777

1,1,1-TCA is used to clean parts, substrates to be coated, filters, and instruments. It is used in ultrasonic baths, vapor degreasers, and as a cutting agent for carbide grit grinding to cut plutonium.

31% of Site Emission Total



Building No. 460

1,1,1-TCA is present in a solution used for cleaning in radiography areas, in aqueous part cleaning, and in the high-bay central manufacturing areas

Under 1% of Site Emission Total

Building No. 881

1,1,1-TCA is listed as present in Bldg 881. No specific use is identified. The building currently houses laboratories, maintenance shops, and plant support activities

Under 1% of Site Emission Total

Building No. 707

1,1,1-TCA is used in ultrasonic cleaners to clean plutonium parts and to clean gauges, gloveboxes, and bell jars used for brazing.

14% of Site Emission Total

ChemRisk
A Division of McLaren/Hart

Source Of Emission Data:
Air Pollution Emission Notice Reports

FIGURE 4-9
1,1,1-TRICHLOROETHANE AIR EMISSION SOURCES

Rckyflts/Hstry 3-4/04-09 REV. 01-08-92

ROCKY FLATS MATERIAL USE PROFILE; 1,1,1- TRICHLOROETHANE

SYNONYMS: chlorothene, methyl chloroform, "1,1,1-TCA"

CHEMICAL FORMS AND PROPERTIES:

- 1,1,1-TCA is a colorless liquid with a faint, benzene-like odor.

USES BY MAN AND PRESENCE IN NATURE:

- 1,1,1-TCA is one of the most frequently used cleaning solvents in industry.
- It is removed from water by volatilization; can migrate to groundwater.
- 1,1,1-TCA is ubiquitous in the environment; the EPA national database of atmospheric concentrations indicates a median urban 1,1,1-TCA concentration of about 365 parts per trillion (Sturges and Taylor, 1990).

TOXICOLOGICAL HIGHLIGHTS:

- There is no animal or human evidence of 1,1,1-TCA carcinogenicity.
- Toxic effects of 1,1,1-TCA exposure include central nervous system depression and lack of coordination and equilibrium at low concentrations, and at very high concentrations, anesthesia.

USES AT ROCKY FLATS:

- 1,1,1-TCA has been used to clean and degrease metal parts. It has been used in uranium cleaning operations and in plutonium component cleaning and vapor degreasing (EG&G, 1990b).
- 1,1,1-TCA replaced trichloroethylene in the 1970s in the search for a cleaning solvent with acceptable material compatibility and toxicologic qualities.
- 1,1,1-TCA was present on the 1974 Harmful Materials Inventory with a quantity of 22,763 kg. It was present on the 1988/89 Chemical Inventory with a quantity of 1,750 kg.
- As of May 1990, 1,1,1-TCA was still in use for cleaning in assembly operations, but implementation of isopropyl alcohol as a substitute for non-plutonium areas had begun. Water has been proposed as a substitute for 1,1,1-TCA for non-plutonium cleaning in plutonium areas, and non-regulated solvents such as water-based detergents, liquid carbon dioxide, and petroleum distillates have been recommended for in-process plutonium cleaning (EG&G, 1990b).

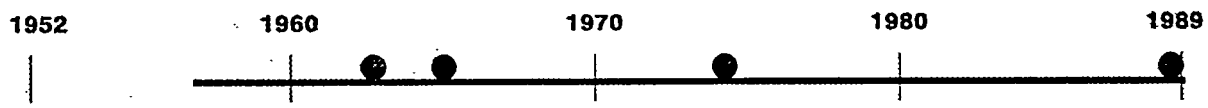
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

31.4 tons per year, which equals 62,800 pounds per year.

MONITORING DATA AVAILABILITY:

1,1,1-TCA has not been routinely monitored in airborne or waterborne effluents. It has been included in some special studies of organic solvent emissions.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 374

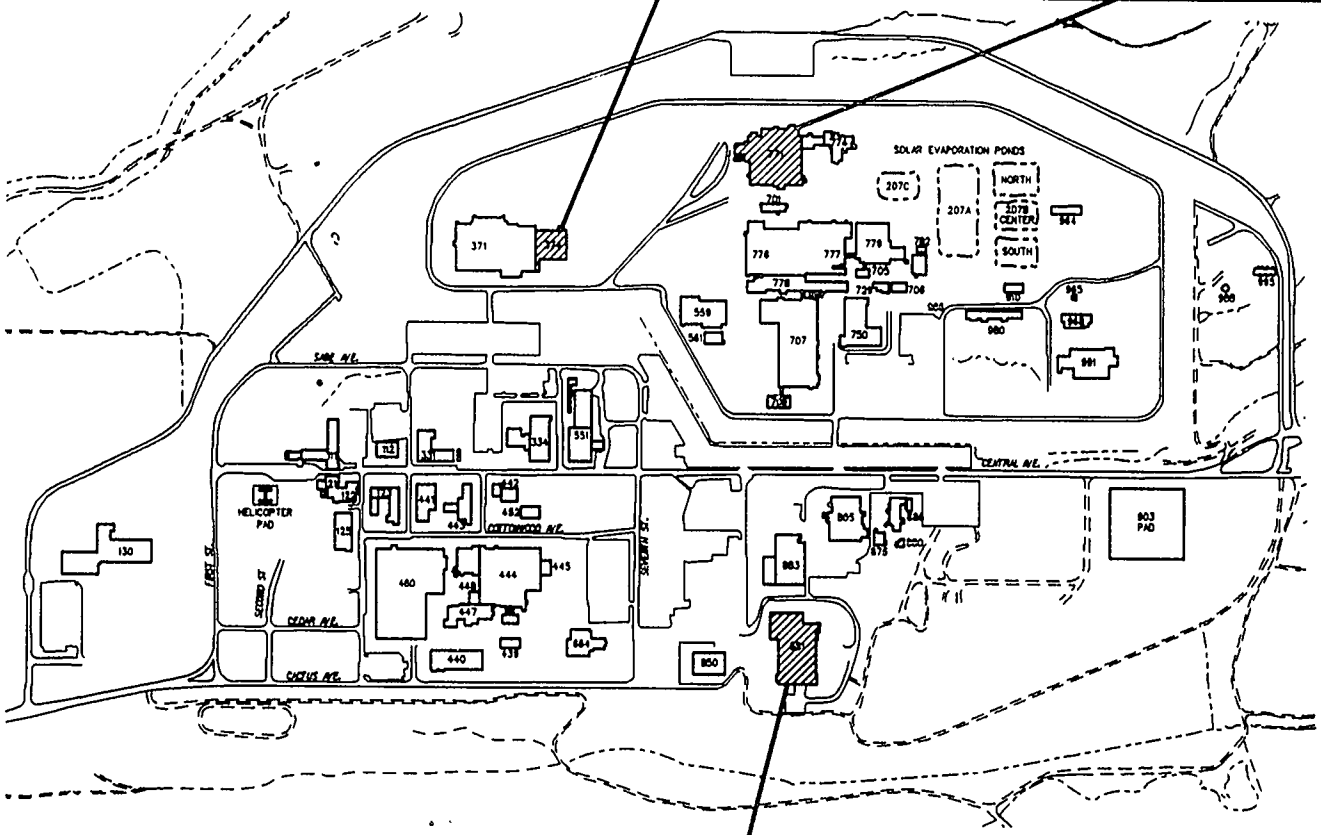
TCE is present in some process liquid wastes treated here, and is emitted during processing. The most significant waste source for TCE is Building 889.

100% of Site Emission Total

Building No. 771

TCE was used to decontaminate glove-boxes until replaced with KW soap solution in the 1960s.

No Emission Estimates Available



N

0' SCALE 1000'

Building No. 881

TCE was used to clean and degrease parts. During enriched uranium operations here (prior to 1963), large quantities of TCE were used

No Emission Estimates Available

Source Of Emission Data:
Air Pollution Emission Notice Reports

FIGURE 4-10
TRICHLOROETHYLENE AIR EMISSION SOURCES

ChemRisk
A Division of McLaren/Hart

RckyFlts/Hstry 3-4/04-10 REV: 08-06-92

ROCKY FLATS MATERIAL USE PROFILE; TRICHLOROETHYLENE

SYNONYMS: TCE, trichloroethene, ethylene trichloride, triclene, "trike"

CHEMICAL FORMS AND PROPERTIES:

- TCE is a colorless liquid (sometimes dyed blue) with a pleasant, chloroform-like odor.

USES BY MAN AND PRESENCE IN NATURE:

- TCE is a common solvent in organic chemical and pharmaceutical manufacturing.
- TCE rapidly volatilizes from water and soil; can leach into groundwater from soil.
- TCE is ubiquitous in the environment; the EPA national database of atmospheric concentrations indicates a median urban TCE concentration of 200 parts per trillion (Sturges and Taylor, 1990).

TOXICOLOGICAL HIGHLIGHTS:

- TCE is a probable inhalation and ingestion carcinogen (evidence in animals only).
- Chronic toxic effects of TCE exposure involve the kidneys, liver, nervous system, and skin.
- Acute TCE inhalation and ingestion studies indicate no toxicity.
- TCE reacts with sunlight and air to contribute to photochemical smog.

USES AT ROCKY FLATS:

- TCE was used in large quantities to clean and degrease Be, Pu, and U parts. TCE in ultrasonic vapor degreasers replaced acetone, isopropyl alcohol, and other solvents for parts cleaning in 1963. Nearly 10,000 gallons of TCE were used during 1973 (Musgrave, 1974). TCE was replaced by 1,1,1-TCA later in the 1970s in the search for a nonphotochemically reactive solvent with acceptable material compatibility. In some areas, the progression of cleaning solvents went from isopropyl alcohol to CCl_4 to TCE to 1,1,1-TCA (ChemRisk, 1991; RE-891[67]).

- TCE was present on the 1974 Harmful Materials Inventory with a quantity of 22,763 kg. The quantity present on the 1988/89 Chemical Inventory decreased to 140 kg.

- TCE was used for decontamination (e.g. of B-771 glove-boxes) before KW soap solution came into use in the 1960s (ChemRisk, 1991; RE-891[25]). It was used in significant quantities during the period of enriched uranium processing in Building 881 (prior to 1963); about 50 drums per month were used (ChemRisk, 1991; RE-891[39]).

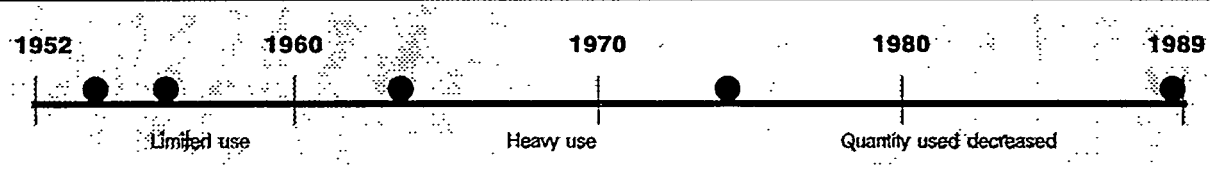
- Small quantities of TCE are used in Building 460 inspection operations to remove a putty-like substance used to make molds (ChemRisk, 1991; RE-891[35]).

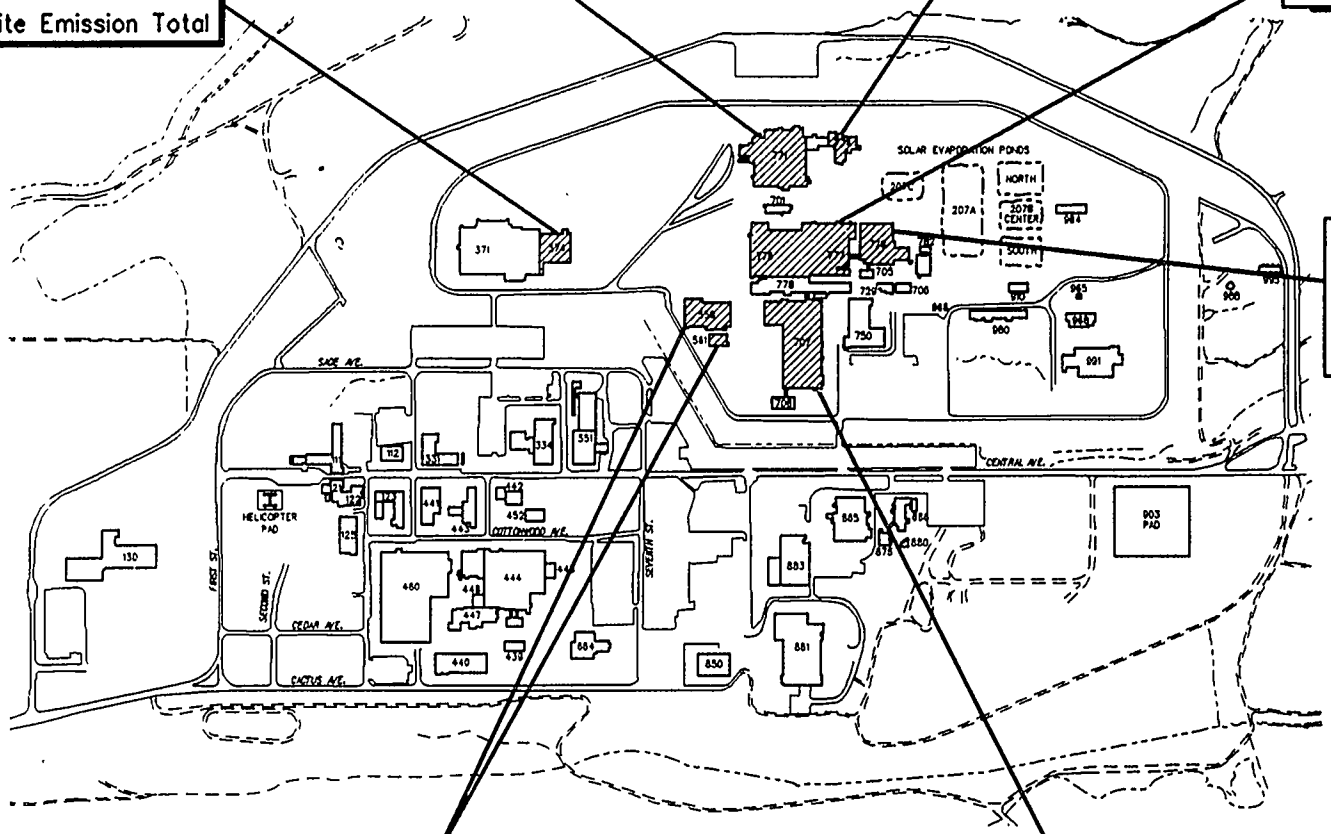
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs: 0.152 ton per year (304 pounds)

MONITORING DATA AVAILABILITY:

TCE has not been routinely monitored in airborne or waterborne effluents, but has been included in several special studies of organic solvent emissions.

PERIOD(S) OF USE AT ROCKY FLATS:





Building No. 374

Waste waters contaminated with tritium are evaporated.

Under 1% of Site Emission Total

Building No. 771

Components and residues processed for plutonium recovery may be contaminated with Tritium.

20% of Site Emission Total

Building No. 774

Waste waters contaminated with tritium are evaporated.

Under 1% of Site Emission Total

Building No. 777

Tritium is sometimes released during disassembly of contaminated site return components. The tritium gettering system is designed to capture tritium from process atmospheres

67% of Site Emission Total

Building No. 779A

Hydriding operations designed to recover plutonium resulted in tritium releases when contaminated materials were fed to the process
(See Section 6, 1973 tritium release)

2% of Site Emission Total

Building No. 559/561

Plutonium Analytical Laboratory operations in Building 559 are a possible source of tritium emissions from processing of product and waste streams containing tritium Building 561 contains exhaust filter plenums for Building 559.

3% of Site Emission Total

Building No. 707

Plutonium fabrication and product assembly occurs here

5% of Site Emission Total

ChemRisk
A Division of McLaren/Hart

Source Of Emission Data:
Effluent Information System Totals For 1988

FIGURE 4-11
TRITIUM AIR EMISSION SOURCES

Krkyflts/Hstry 3 4/04-11 KFV 01 08-92

SYNONYMS: Hydrogen-3

CHEMICAL FORMS AND PROPERTIES:

- Tritium is the sole radioactive isotope of the element hydrogen; the stable isotopes are protium (H-1, ordinary hydrogen) and deuterium (H-2 or D), which is present in "heavy water."

USES BY MAN AND PRESENCE IN NATURE:

- Tritium is found in nature at low levels as a result of cosmic ray reactions with nitrogen and spontaneous fissioning of elements in the earth's crust.
- Tritium has been used in luminous paints and as a biological tracer.
- Upon release to the environment, tritium mixes with the global pool of hydrogen atoms.

TOXICOLOGICAL HIGHLIGHTS:

- Tritiated water vapor or tritium gas can penetrate the skin, lungs, or GI tract.
- Tritiated water is completely absorbed and excreted with a half-life of 10 days; some becomes bound to organic molecules and half-life may vary.
- Tritiated water vapor is, relatively speaking, much more hazardous radiologically than is tritium gas (as HT or T_2).

USES AT ROCKY FLATS:

- Tritium has been present at Rocky Flats since 1964 as trans-shipments, Special Order work, standards, and nondestructive testing sources (Hoffman, 1992).
- Tritium is also sometimes released during disassembly of contaminated weapon components. The H-3 environmental control system is designed to capture H-3 from process atmospheres (EG&G, 1990d).
- Hydriding operations designed to recover plutonium resulted in tritium releases when contaminated materials were fed to the process (See Section 6, 1973 tritium release). Plutonium Analytical Laboratory operations in Building 559 are a possible source of tritium emissions from processing of product and waste streams containing tritium (EG&G, 1990c).

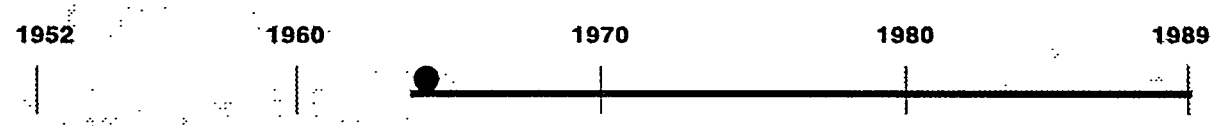
MODERN-DAY EMISSION ESTIMATE FROM EG&G REPORTS:

Releases of airborne tritium totalling 0.015 Ci were reported for 1988 (Rockwell, 1989). A 1988 waterborne H-3 release total of 0.23 Ci was reported in the USDOE Effluent Information System.

MONITORING DATA AVAILABILITY:

H-3 monitoring results have been published since 1973 for waterborne effluents and since 1974 for airborne effluents. Airborne tritium was monitored prior to 1973 in preparation for production work that didn't materialize at Rocky Flats (Hoffman, 1992). Results have not been located.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 371

Plutonium recovery facility conducted pilot operations in the early to mid 1980s Products and process materials could also contain uranium Plutonium Analytical Support Laboratory does some uranium analyses. Chemical Standards Lab provides standards Some waste handling and repackaging is done.

7% of Site Emission Total

Building No. 374

Process waste water treatment facility receives wastes from over 15 buildings and the solar ponds. Some wastes contain uranium Processes include neutralization, radioactive decontamination, sludge and salt solidification, and evaporation

4% of Site Emission Total

Building No. 771

Oralloy leaching removes surface impurities from enriched uranium parts. Any uranium contamination present on parts or in residues is separated from plutonium in the chemical plutonium recovery process.

8% of Site Emission Total

Buildings No. 776/777

Product assembly moved here from Building 991 in 1957 After the 1969 fire, Building 776 was converted to waste storage and size reduction. Weapons components are disassembled. Uranium components are involved in this disassembly

5% of Site Emission Total

Building No. 334

Small quantities of depleted uranium were sheared in the maintenance shop.

No Emission Estimate Available

Building No. 331

A portion of the plant garage was at one time used for a special R & D effort involving depleted and enriched uranium.

No Emission Estimate Available

Building No. 707

Final product assembly operations moved here after the 1969 fire in Building 776. Uranium components are included in the assembly operations.

4% of Site Emission Total

Building No. 865

Research and development of uranium and beryllium metalworking processes, including casting, heat treating, and grit blasting of uranium parts.

4% of Site Emission Total

Building No. 886

From 1965, uranyl nitrate solutions have been used to conduct nuclear criticality safety experiments.

1% of Site Emission Total

Building No. 883

From 1957, Building 883 housed rolling and forming operations for depleted and enriched uranium. In 1966, the enriched uranium side was converted to beryllium rolling. Current operations for depleted uranium include rolling, shearing, blanking, trepanning, and heat treating.

40% of Site Emission Total

Building No. 447

Manufacturing operations include welding, chemical milling, and heat treatment of materials including depleted uranium A vacuum arc melt furnace is used to melt metals including depleted uranium and uranium alloys to cast consumable electrodes of desired compositions A chip roaster is used to transform depleted uranium scraps to a more stable oxide form

2% of Site Emission Total

Building No. 444

Depleted uranium operations have included casting and machining since 1953.

4% of Site Emission Total

Building No. 559

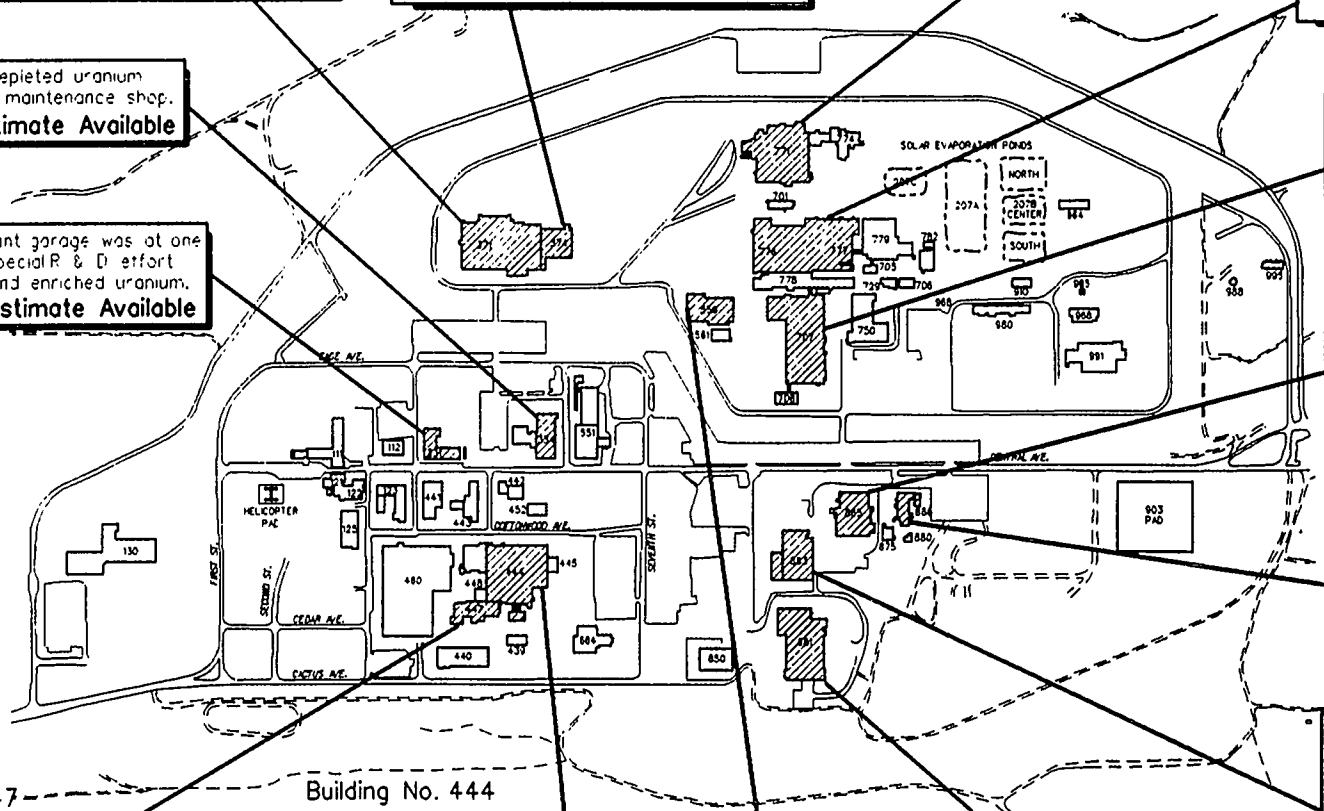
Plutonium Analytical Laboratory conducts spectrochemical, chemical, and mass spectrometric analyses of gaseous, liquid, and solid samples from process areas Samples may include uranium Building 561 houses the ventilation plenum for Building 559

2% of Site Emission Total

Building No. 881

From 1952 to around 1963, Building 881 housed enriched uranium machining, manufacturing, recovery and purification. Enriched uranium recovery was relocated to Oak Ridge in the mid 1960s. Some enriched uranium metalworking and machining continued into the 1970s.

10% of Site Emission Total



Source Of Emission Data:

Effluent Information System Totals For 1988

ChemRisk
A Division of McLaren/Hart

RckyFlts/Hstry J-4/04-12 REV: 01-08-92

FIGURE 4-12
URANIUM AIR EMISSION SOURCES

SYNONYMS: Named after the planet Uranus. Forms are called oralloy, EU, tuballoy, staballoy, and D-38.

CHEMICAL FORMS AND PROPERTIES:

- A heavy, slightly radioactive, silvery white metal; readily oxidizes to black on contact with air.
- Natural uranium consists primarily of U-234 (0.005%), U-235 (0.7%), and U-238 (99%).
- Enriched uranium, often called oralloy (from Oak Ridge alloy) or EU, has more U-235 than natural uranium (about 93% U-235 at Rocky Flats). U-235 is fissionable.
- Depleted uranium (often called tuballoy or D-38) has less U-235 than natural uranium, therefore a higher content of U-238. U-238 can absorb neutrons and become fissionable Pu-239.
- Over 95% of enriched U's alpha activity comes from the trace U-234 present. Enriched U yields about 150 dpm per microgram, compared to 0.7 for depleted U and 1.5 for natural U (Putzier, 1982).

USES BY MAN AND PRESENCE IN NATURE:

- Uranium is ubiquitous in soils and rocks, with concentrations ranging from 1 to 4 ppm.
- Enriched U is the main fissionable fuel for power reactors and is a component of nuclear weapons.
- Depleted uranium is used in armor-piercing shells due to its high density.

TOXICOLOGICAL HIGHLIGHTS:

- Exposure to soluble uranium compounds produces kidney damage. While radioactive isotopes of uranium are considered carcinogens, chemical toxicity often dominates.
- The main concern at low exposures is the probability of increased risk of cancer from irradiation of cells. Heavy metal poisoning from ingestion or inhalation occurs with exposures to large amounts.
- Insoluble U compounds are a hazard to the lungs when inhaled, and to the bone when ingested.

USES AT ROCKY FLATS:

- Uranium has been used from initial plant operation to make weapons parts. Enriched and depleted U metal have been the main forms used. Uranium has been alloyed with niobium and other metals.
- Fissile U-233 was processed over 15 years from the late 1950s to the early 1970s. U-233 was aqueously processed, cast, and machined in Buildings 771, 776/777, and 779. U-233 was machined in B-881. U-236 was processed in B-881 on special runs. U-233 and U-236 were separated on a lab scale in B-771 for Oak Ridge (ChemRisk, 1991; RE-891[9,31,48]).
- In the mid-1980s, hundreds of tons of depleted U were processed in B-883 to manufacture armor plates for the Army's M1A1 tanks (ChemRisk, 1991; RE-891[13,31,36,69]).

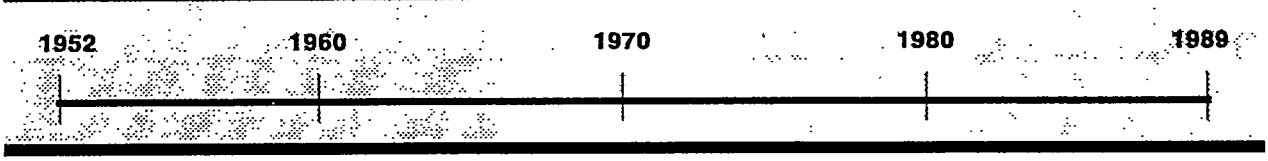
MODERN-DAY EMISSION ESTIMATE FROM EG&G REPORTS:

For 1988, an airborne release total of 11.93 microcuries of uranium was reported along with a waterborne emission total (from surface water runoff) of 24,300 microcuries (Rockwell, 1989).

MONITORING DATA AVAILABILITY:

Air effluent measurements 1953-1973 were total alpha activity, assumed to be U or Pu. From 1973 on, samples from Pu areas were analyzed specifically for Pu. From 1978 on, analyses were specific for U and Be (USDOE, 1980). Before 1961, water and vegetation analyses were gross alpha or Pu+Th. After 1961, separations were specific for Pu and U (ChemRisk, 1991; RE-891[5,7,32]).

PERIOD(S) OF USE AT ROCKY FLATS:



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MATERIALS OF CONCERN
EMISSION SOURCE DIAGRAMS
AND
MATERIAL USE PROFILES

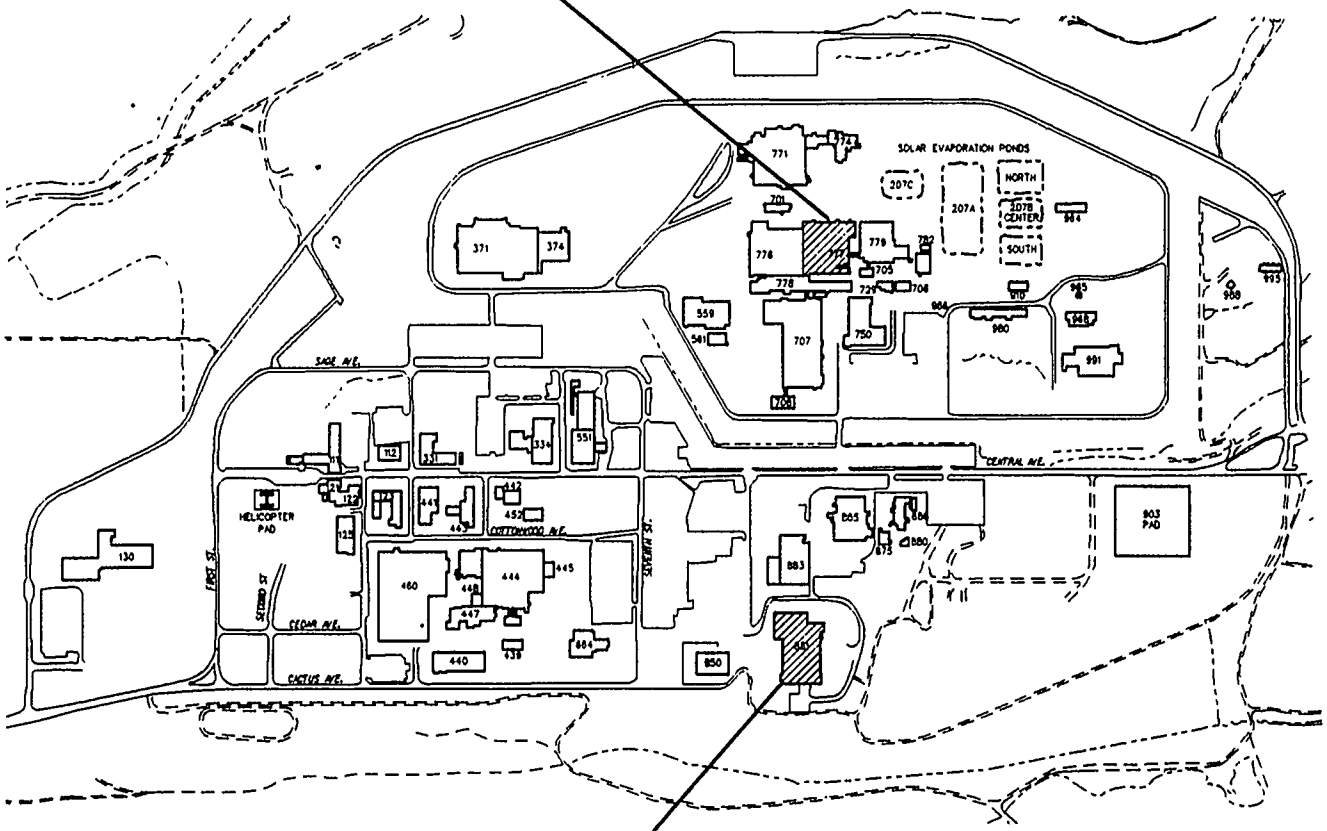
GROUP NUMBER 2

The thirteen materials in this group are those for which extensive investigation has indicated that uses of the material at Rocky Flats have been extremely limited in scope or duration, associated with insignificant quantities of the material, or have involved processes or forms of the material which were not expected to have significant off-site releases. These materials do not warrant further quantitative evaluation of potential off-site impacts.

Building No. 777

Benzene was used in the 1960's and 1970's in a tank to ultrasonically test components

No Emission Estimate Available



Building No. 881

Benzene is listed as a Building 881 process chemical. No specific use is listed. The building currently houses laboratories, maintenance shops, and plant support activities

100% of Site Emission Total

ChemRisk
A Division of McLaren/Hart

Source Of Emission Data:
Air Pollution Emission Notice Reports

FIGURE 4-13
BENZENE AIR EMISSION SOURCES

RokyFlts/Hstry 3-4/04-13 REV: 01-08-92

ROCKY FLATS MATERIAL USE PROFILE; BENZENE

SYNONYMS: benzol, benzole, coal naptha, cyclohexatriene, phene, phenyl hydride, pyrobenzol

CHEMICAL FORMS AND PROPERTIES:

- Benzene is a clear, colorless, noncorrosive, highly flammable liquid
- Benzene has a strong, rather pleasant odor.

USES BY MAN AND PRESENCE IN NATURE:

- Benzene saw widespread industrial use in the 1930s to 1960s, mostly as an intermediate in producing other organic chemicals. Other uses include manufacture of detergents and pesticides and as a solvent or paint remover.

TOXICOLOGICAL HIGHLIGHTS:

- Benzene is considered an inhalation carcinogen (evidence in both humans and animals).
- Chronic inhalation exposure is associated with blood and bone marrow disorders, such as leukemia.
- Acute toxicity effects are central nervous system depression, respiratory or cardiac arrest.

USES AT ROCKY FLATS:

- Many interviewees indicated that benzene was used in small quantities, mainly in laboratories. Its use at the plant was not widespread, and it was never used in production processes.
- Benzene is listed in the Building 881 APEN report as a process chemical. No specific use is listed. The building currently houses laboratories, maintenance shops, and plant support activities.
- Benzene was reportedly used in a tank in Building 777 for ultrasonic testing of components. The tank held a couple hundred gallons, and would periodically leak and cause evacuation of the area until a team in protective clothing could enter and make repairs. The tank was used from around 1966 to about 1975 (ChemRisk, 1991; RE-891[40])
- Benzene was present on the 1974 Harmful Materials Inventory with a quantity of 42.5 kg, and was present on the 1988/89 Chemical Inventory with a quantity of 5 kg.

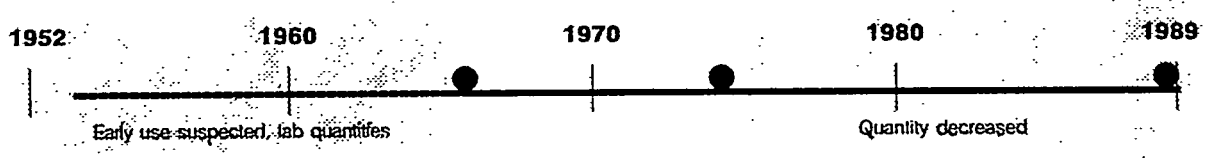
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

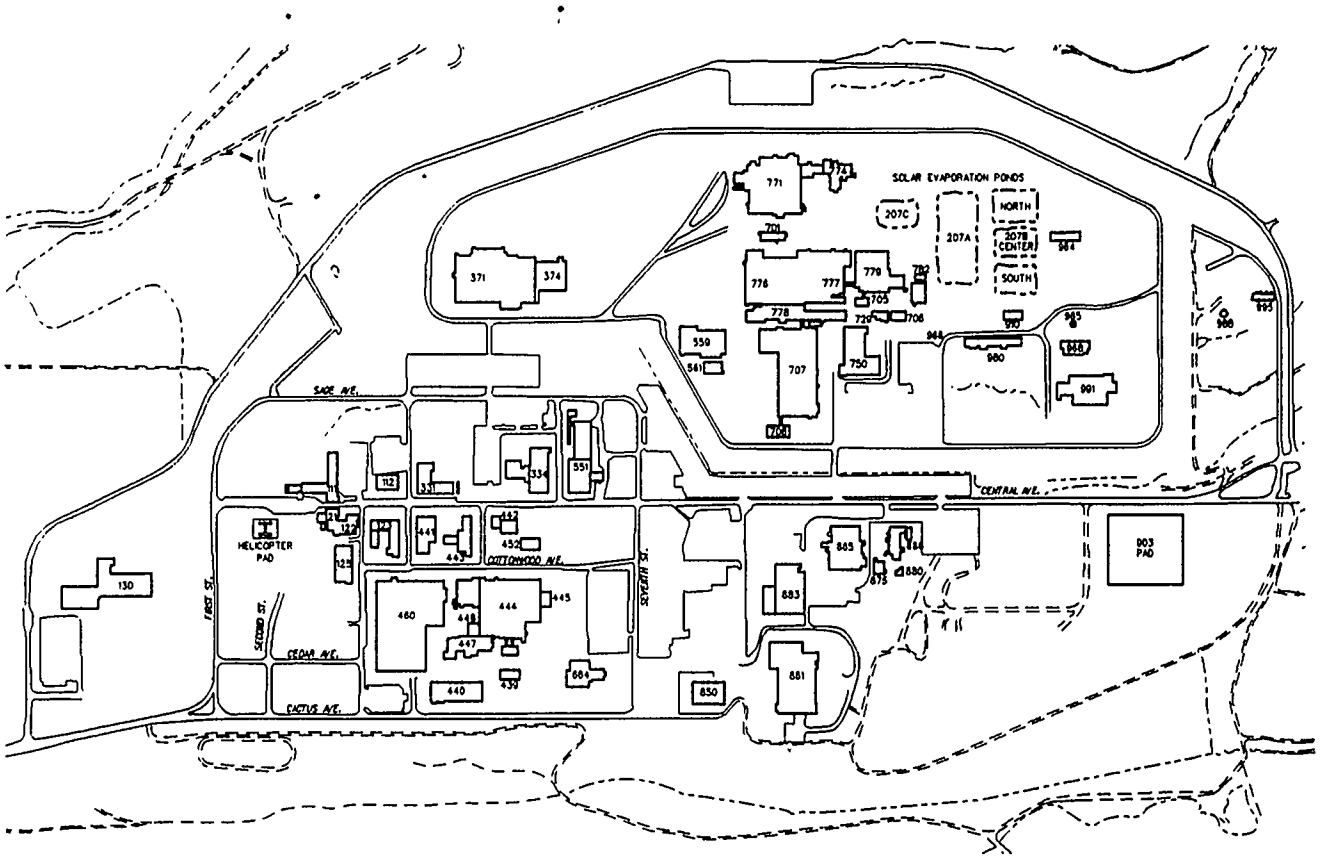
7.74 pounds per year.

MONITORING DATA AVAILABILITY:

Benzene has not been routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:





No Emission Sources Identified

May have been used as a molecular weight standard for osmosis applications. Location unknown

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-14
BENZIDINE AIR EMISSION SOURCES

Rckvflts/Hstry 3-4/04-14 REV 01-08-92

SYNONYMS: 4,4'-Bianiline, 4,4'-Biphenyldiamine, 1,1'-Biphenyl-4,4'-diamine, 4,4'-Diaminobiphenyl, p'-Diaminodiphenyl

CHEMICAL FORMS AND PROPERTIES:

- Benzidine is a grayish-yellow, reddish-gray, or white crystalline powder.

USES BY MAN AND PRESENCE IN NATURE:

- Benzidine is used in the manufacture of dyes.

TOXICOLOGICAL HIGHLIGHTS:

- Exposure to benzidine can occur through inhalation, ingestion, or dermal contact.
- There is evidence of carcinogenicity in humans.
- No information is available on effects of chronic exposure.
- Liver and kidney damage can result from acute exposure.

USES AT ROCKY FLATS:

- Benzidine was on the 1974 Harmful Materials Inventory, with a quantity of under an ounce and no location listed. Benzidine was not on the 1988/89 Chemical Inventory.
- May have been used as a molecular weight standard for osmosis applications (ChemRisk, 1991; RE-891[11]).

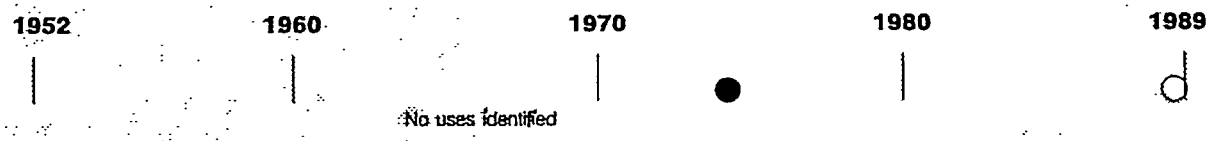
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

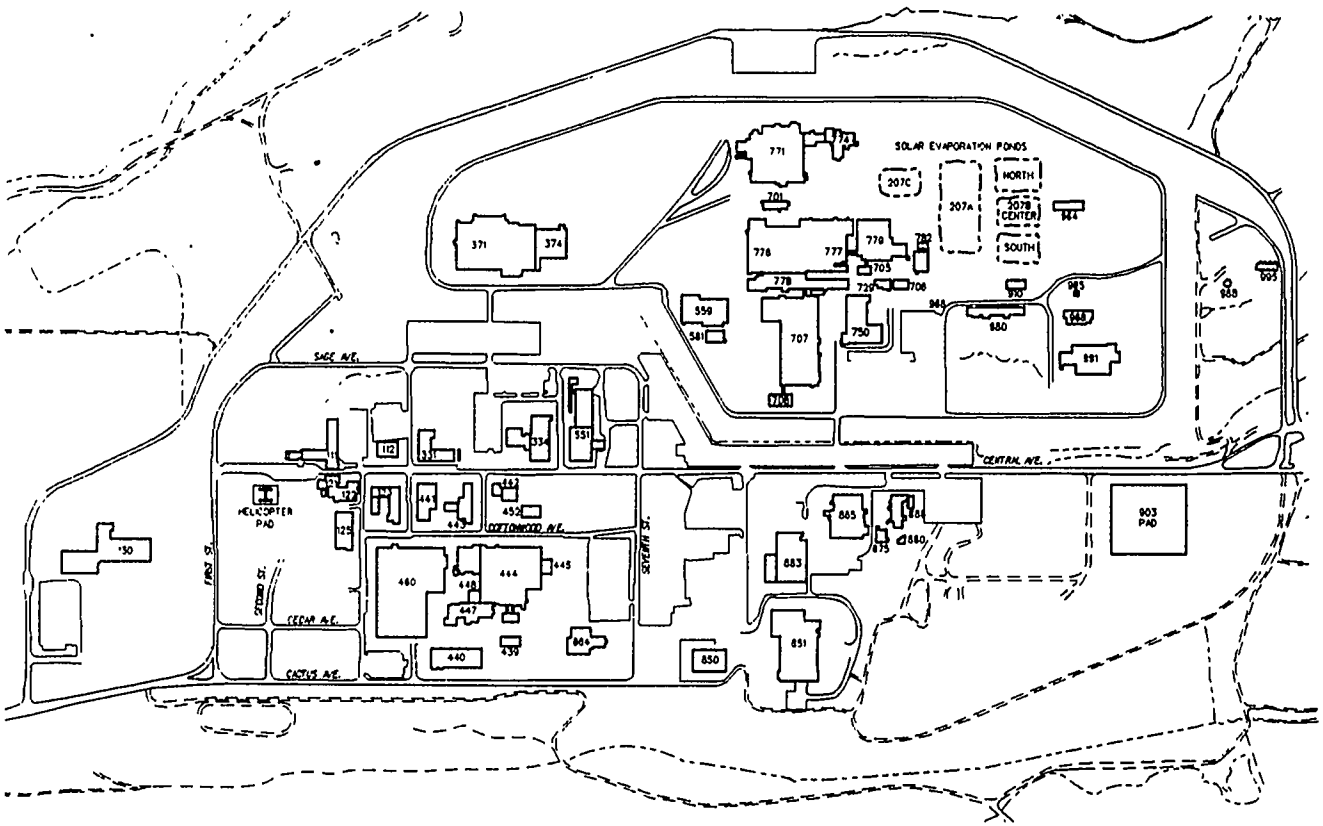
Benzidine is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

Benzidine has not been routinely monitored in airborne or waterborne effluents or the environment.

PERIOD(S) OF USE AT ROCKY FLATS:





N

0' SCALE 1000'

No Emission Sources Identified

No interviewees or records reviewed have indicated any uses for 1,3-butadiene at Rocky Flats

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-15
1,3-BUTADIENE AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-15 REV: 01-08-92

SYNONYMS: biethylene, bivinyl, butadiene, divinyl, erythrene, vinylethylene

CHEMICAL FORMS AND PROPERTIES:

- At room temperature, 1,3-butadiene is a colorless gas with a mild aromatic or gasoline-like odor.
- 1,3-butadiene can be liquified below 24 degrees F.

USES BY MAN AND PRESENCE IN NATURE:

- 1,3-butadiene is released from motor vehicles, burning of fossil fuels, and plastic and rubber manufacturing.

TOXICOLOGICAL HIGHLIGHTS:

- 1,3- butadiene is a probable inhalation carcinogen (evidence in animals, but not in humans).
- Chronic exposure to animals resulted in adverse effects to the liver, testes, and ovaries.
- The acute toxic effect is irritation of the respiratory tract, mucous membranes, and eyes.

USES AT ROCKY FLATS:

- 1,3-butadiene was on the 1974 Harmful Materials Inventory, with a quantity of about 250 pounds and no location listed. Butadiene was not on the 1988/89 Chemical Inventory.
- No interviewees or records reviewed have indicated any uses for 1,3-butadiene at Rocky Flats.
- The only mentions of butadiene located in records repositories deal with ABS (Acrylonitrile Butadiene Styrene) thermoplastic and studies to characterize its thermal stability and compatibility with organic solvents. A document has also been located which deals with identification of drums with styrene butadiene gaskets. The significance of the material is not otherwise evident.

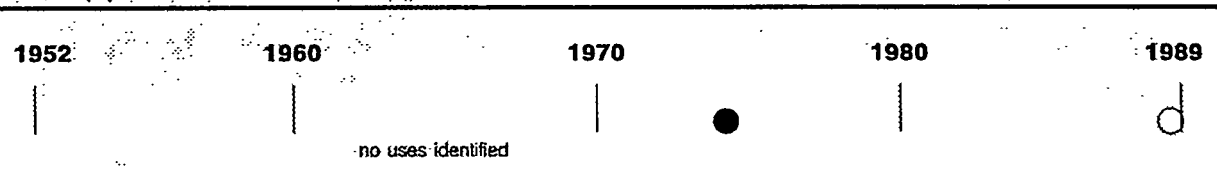
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

Butadiene is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

Butadiene has apparently not been monitored in airborne or waterborne effluents or the environment.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 374

Electroplating wastes have been treated here since the building went into operation; they were sent to the solar ponds prior to the 1980s

Emission Estimate Not Available

Building No. 771

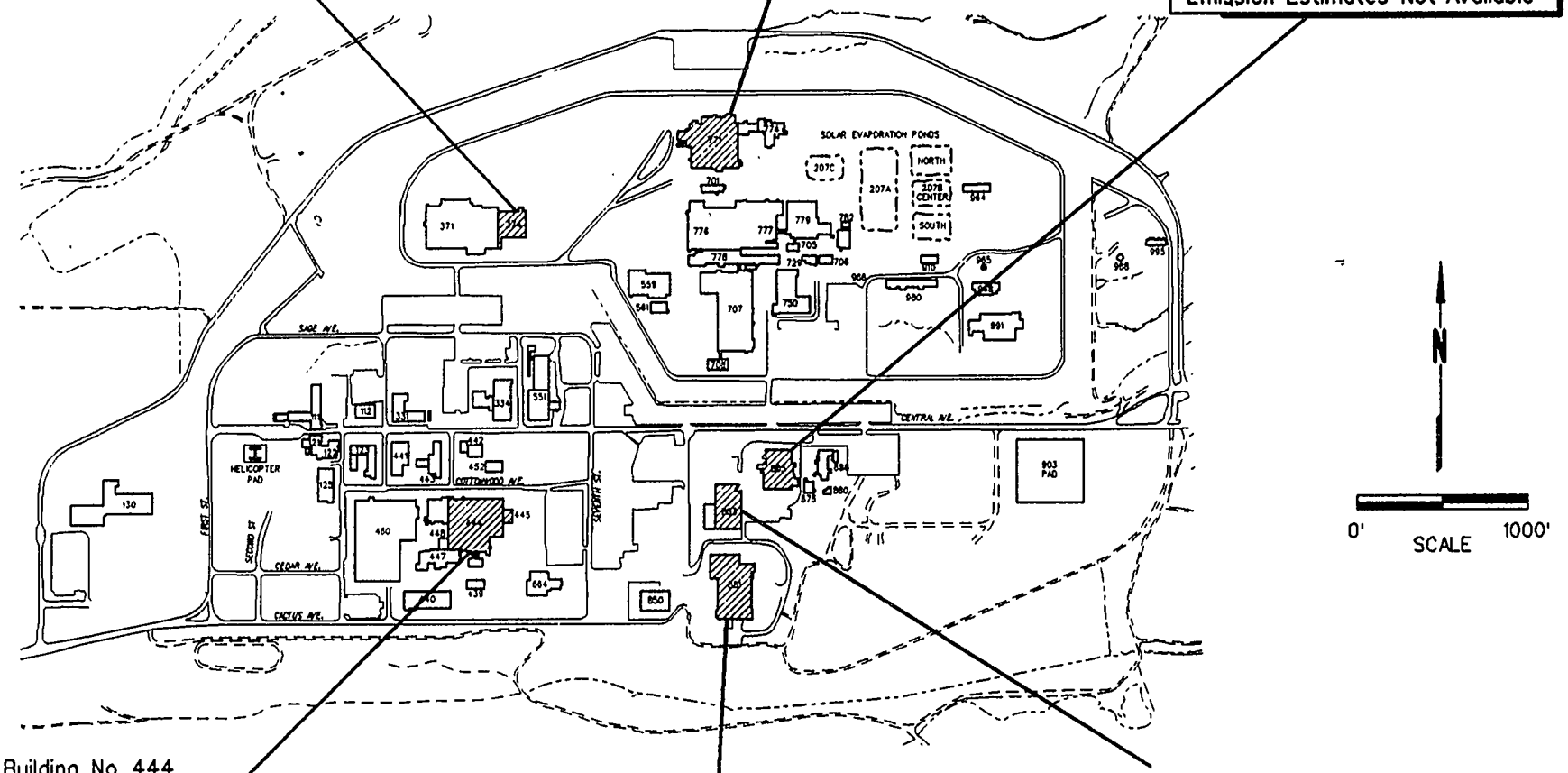
Cadmium has been used as a neutron absorber to ensure criticality safety in plutonium recovery operations that were not dimensionally safe.

Emission Estimate Not Available

Building No. 865

Cadmium was rolled and formed here when the building first became operational.

Emission Estimates Not Available



Building No. 444

Cadmium has been used for plating metal parts by immersion in cyanide baths. Cadmium was also rolled, formed, machined, and alloyed with other metals here.

Emission Estimate Not Available

Building No. 881

Cadmium has been used as a neutron absorber to ensure criticality safety in uranium recovery operations that were not dimensionally safe.

Emission Estimate Not Available

Building No. 883

Cadmium was rolled and formed here.

Emission Estimates Not Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-16
CADMIUM COMPOUNDS AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-16 REV: 01-08-92

SYNONYMS: Metal: None. Named from kadmeia, the ancient name for calamine, zinc carbonate.

CHEMICAL FORMS AND PROPERTIES:

- Cadmium compounds used include elemental or metallic cadmium oxide, cadmium chloride, and cadmium sulfate.
- Elemental cadmium is a soft, silver-white, blue-tinged, lustrous, odorless solid. It is easily cut with a knife. It is noncombustible in bulk form, but will burn in powder form.

USES BY MAN AND PRESENCE IN NATURE:

- Cadmium is used in plating, solders, pigments, batteries, plastics, and television tube phosphors.
- Cd enters the environment from discarded metal products, phosphate fertilizer, and fuel combustion.

TOXICOLOGICAL HIGHLIGHTS:

- Probable inhalation carcinogen (evidence in animals; limited evidence in humans).
- Toxic effects of chronic inhalation exposure include emphysema and painful joints and bones.
- Acute ingestion exposure produces stomach irritation and vomiting; acute inhalation exposure may result in breathing distress and pulmonary edema.

USES AT ROCKY FLATS:

- Cd has been used in plating. Some solutions are made by mixing cadmium salts with cyanide solutions, others are purchased in aqueous form. Cd plating is done at room temperature in 20-gallon tanks. Some liquid evaporates, but measurements show that the metals remain in solution (Simmons, 1992).

- Since RCRA went into effect, plating wastes were drummed and shipped off-site as hazardous waste. Before RCRA, they were treated in B-774 (Simmons, 1992) by addition of sodium hydroxide and mixing with Portland cement and an absorbent material (Anderson, et al., 1984). Dilute rinsing solutions are sent to B-374. Prior to B-374, the solar ponds were used to treat wastewater, and as a result "pondcrete" made from solar pond wastes contains Cd (Paynter, 1989).

- Cd salts have been used as neutron absorbers for criticality safety in recovery operations that take place in equipment that was not dimensionally safe; e.g. in B-771 and B-881 (Schuske, 1958). Cd has been used for thermal neutron shielding because of its high neutron capture cross-section.

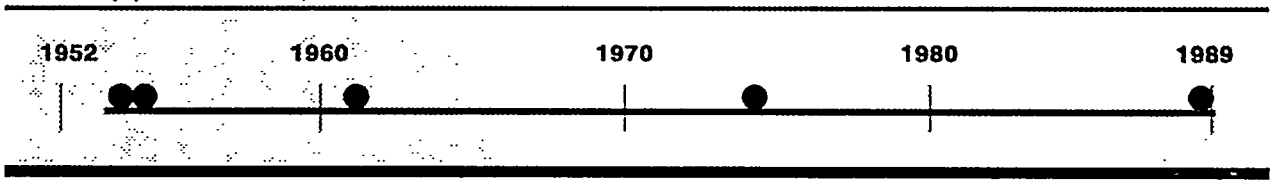
- Cd has been rolled and formed in Buildings 444, 883, and 865. Cd was used as commonly as lead for shielding from the late 1950s through the 1970s, but in smaller quantities. During welding, Cd was afforded the same protective measures as for beryllium (ChemRisk, 1991; RE-891[40]). Cd was alloyed with other metals in B-444 (Dow, 1965).

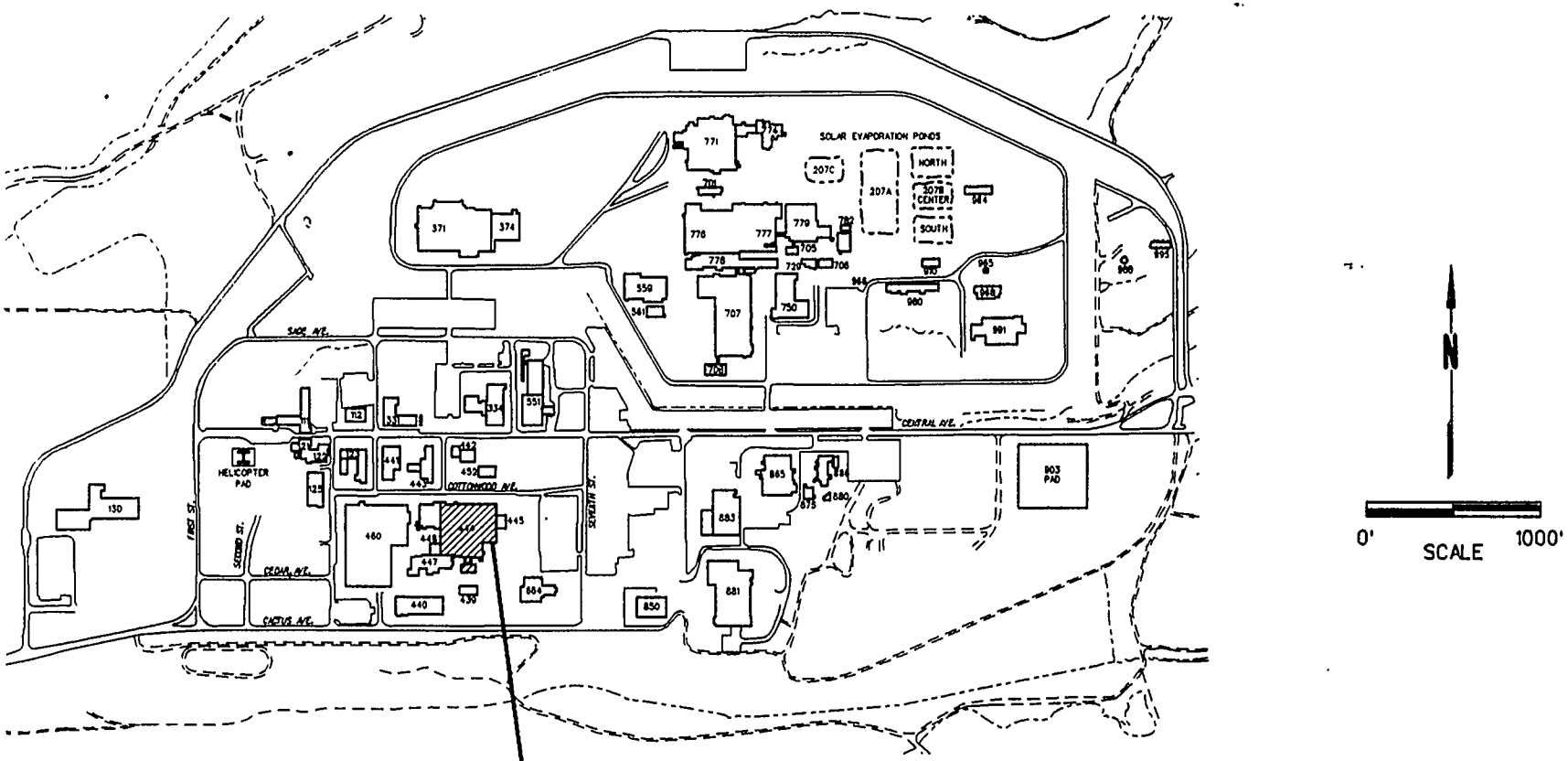
- Of the 100 kg of Cd on the 1974 Harmful Material Inventory, 57% was elemental and 34% was cadmium oxide. Of the 46 kg of Cd on the 1988/89 Chemical Inventory, 31% was elemental and 56% was oxide.

MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs: Cd is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY: Cadmium has not been routinely monitored.

PERIOD(S) OF USE AT ROCKY FLATS:





Building No. 444

Chromium compunds have been used in plating operations in the R & D plating lab. Chromium trioxide was also used (with sulfuric acid and nitric acid) to chemically mill beryllium.

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-17
CHROMIUM COMPOUNDS AIR EMISSION SOURCES

Rckyflts/Hstry 3-4/04-17 REV. 01-08-92

SYNONYMS: None. Chromium is named from chroma, Greek for color.

CHEMICAL FORMS AND PROPERTIES:

- Elemental chromium is a blue-white to steel-gray, lustrous, brittle, hard solid.
- Different forms of chromium include trivalent and hexavalent chromium.

USES BY MAN AND PRESENCE IN NATURE:

- Chromium is commonly used for plating of metals and other substrates. It is used to harden steel and make stainless steel and many useful alloys. Cr is used to give glass an emerald green color.
- Chromium occurs naturally, primarily in chromite ore.
- Trivalent chromium is the stable form found in nature. Hexavalent chromium is almost exclusively produced as the result of manufacturing activities. In nature, hexavalent chromium is more often converted to trivalent than the reverse process.

TOXICOLOGICAL HIGHLIGHTS:

- Hexavalent chromium is thought to be an inhalation carcinogen (evidence in both humans and animals). Effects of chronic chromium exposure include changes in the skin and mucous membranes. Acute exposure to high doses of chromium can result in damage to the liver, kidneys, gastrointestinal tract, and circulatory system.
- Chronic trivalent Cr inhalation and ingestion exposure appears to have minimal health effects.

USES AT ROCKY FLATS:

- Cr compounds have been used for plating in the B-444 R&D plating lab (ChemRisk, 1991; RE-891[9,56]). Some solutions are made by mixing chromium salts with acids, others are purchased in aqueous form. Cr plating solutions are heated, and are used in 75-gallon tanks. Some liquid evaporates, but measurements show that the metals remain in solution (Simmons, 1992).

- Since RCRA went into effect, plating wastes have been drummed and shipped off-site as hazardous waste. Before RCRA, they were treated in B-774 (Simmons, 1992) by addition of sodium hydroxide and mixing with Portland cement and an absorbent material. Dilute rinsing are sent to B-374. Prior to B-374, the solar ponds were used to treat wastewater (Anderson, et al., 1984).

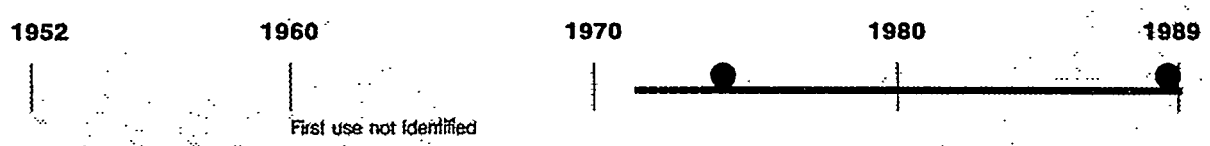
- Cr trioxide was used in B-444 (with sulfuric acid and phosphoric acid) to chemically mill Be (ChemRisk, 1991; RE-891[56]). Cr compounds were on the 1974 Harmful Materials Inventory with a quantity of 211 kg. The 1988/89 Chemical Inventory lists a quantity of 793 kg, 692 kg of which is Cr trioxide.

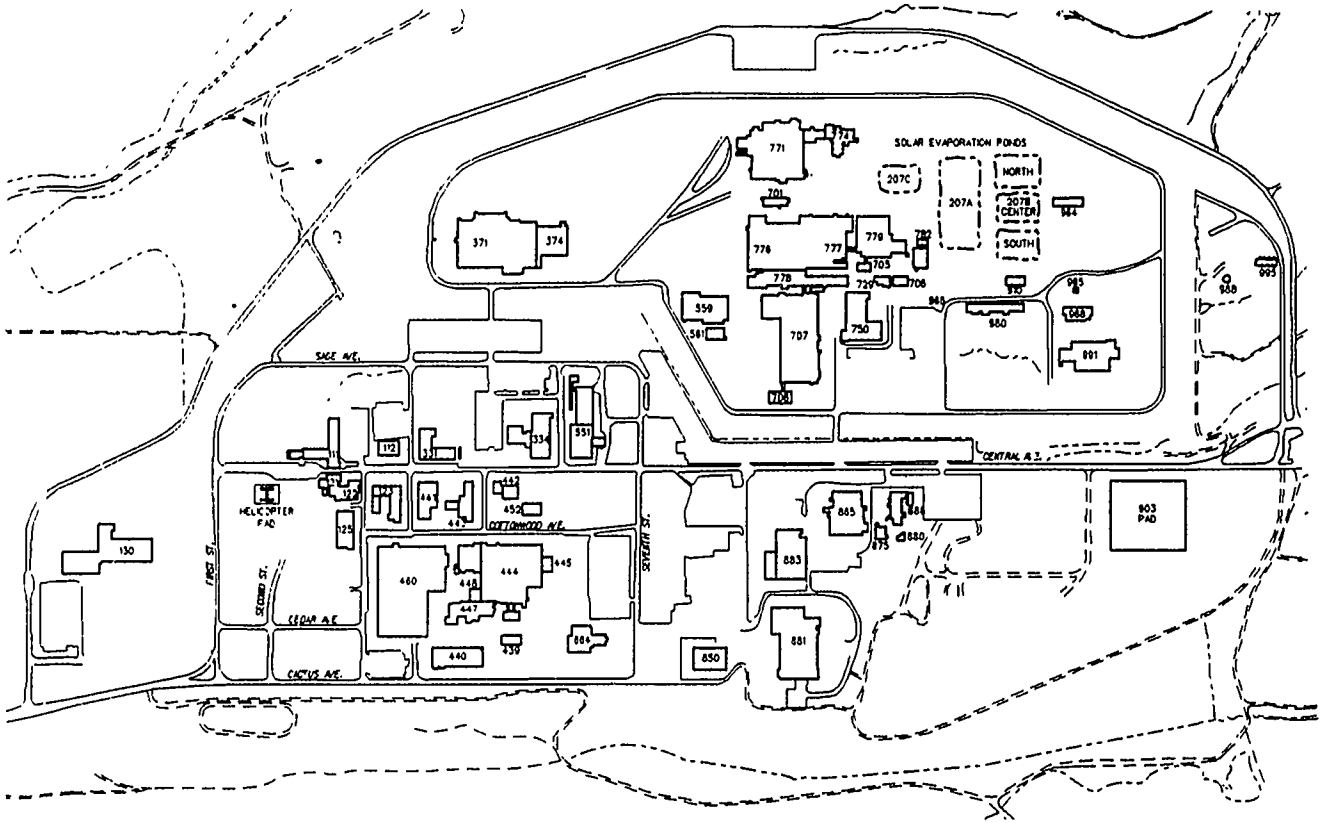
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs: Cr is not addressed in the APEN reports.

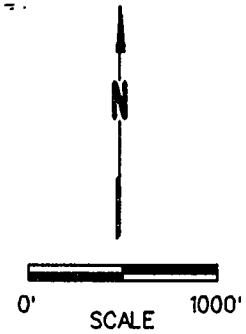
MONITORING DATA AVAILABILITY:

Total chromium (mg/l) is currently monitored in surface waterborne effluents from Rocky Flats.

PERIOD(S) OF USE AT ROCKY FLATS:







No Emission Sources Identified

Dow may have experimented with ethylene oxide as a possible substitute for carbon tetrachloride as a solvent that could be used with plutonium without the hydrogen generation problems associated with some solvents contacting plutonium.

No Emission Estimate Available

FIGURE 4-18
ETHYLENE OXIDE AIR EMISSION SOURCES

ChemRisk
A Division of McLaren/Hart

RckyFlts/Hstry 3-4/04-18 REV: 01-08-92

ROCKY FLATS MATERIAL USE PROFILE; ETHYLENE OXIDE

SYNONYMS: dimethylene oxide, 1,2-epoxy ethane, oxirane, ETO

CHEMICAL FORMS AND PROPERTIES:

- Ethylene oxide is a colorless gas or liquid (below 51° F), with an ether-like odor.
- Ethylene oxide is not persistent in the environment due to high reactivity (degradation)

USES BY MAN AND PRESENCE IN NATURE:

- Ethylene oxide is used as chemical intermediate, fumigant, and sterilizing agent

TOXICOLOGICAL HIGHLIGHTS:

- Ethylene oxide is a probable inhalation carcinogen (evidence in animals; insufficient for humans).
- Acute inhalation exposure can result in headache, nausea, and respiratory irritation.
- Acute exposure to high concentrations causes central nervous system depression.
- Aqueous solutions can be extremely irritating to the skin.

USES AT ROCKY FLATS:

- Ethylene oxide was on the 1974 Harmful Materials Inventory, with a quantity of 192,400 kg and no location listed. It was not on the 1988/89 Chemical Inventory.

- Chemical utilization checklists completed by plant managers in 1978 provided no positive responses indicating ethylene oxide use (Barrick, 1978).

- Dow may have experimented with ethylene oxide as a possible substitute for carbon tetrachloride as a solvent that could be used with plutonium without the hydrogen generation problems associated with some solvents contacting plutonium (ChemRisk, 1991; RE-891[46]).

- Reports of a possible classified use for ethylene oxide have not been supported in classified document reviews or interviews.

- Ethylene oxide was used to sterilize respirator cartridges in the Building 776 laundry for several years beginning in 1960 or 1961 (ChemRisk, 1991; RE-891 [71]).

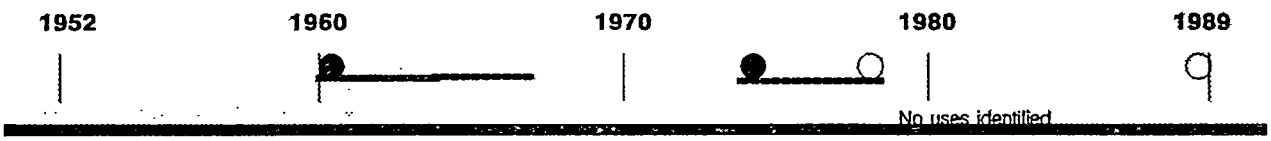
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

Ethylene oxide is not addressed in the APEN program.

MONITORING DATA AVAILABILITY:

Ethylene oxide has not been routinely monitored in airborne or waterborne effluents.

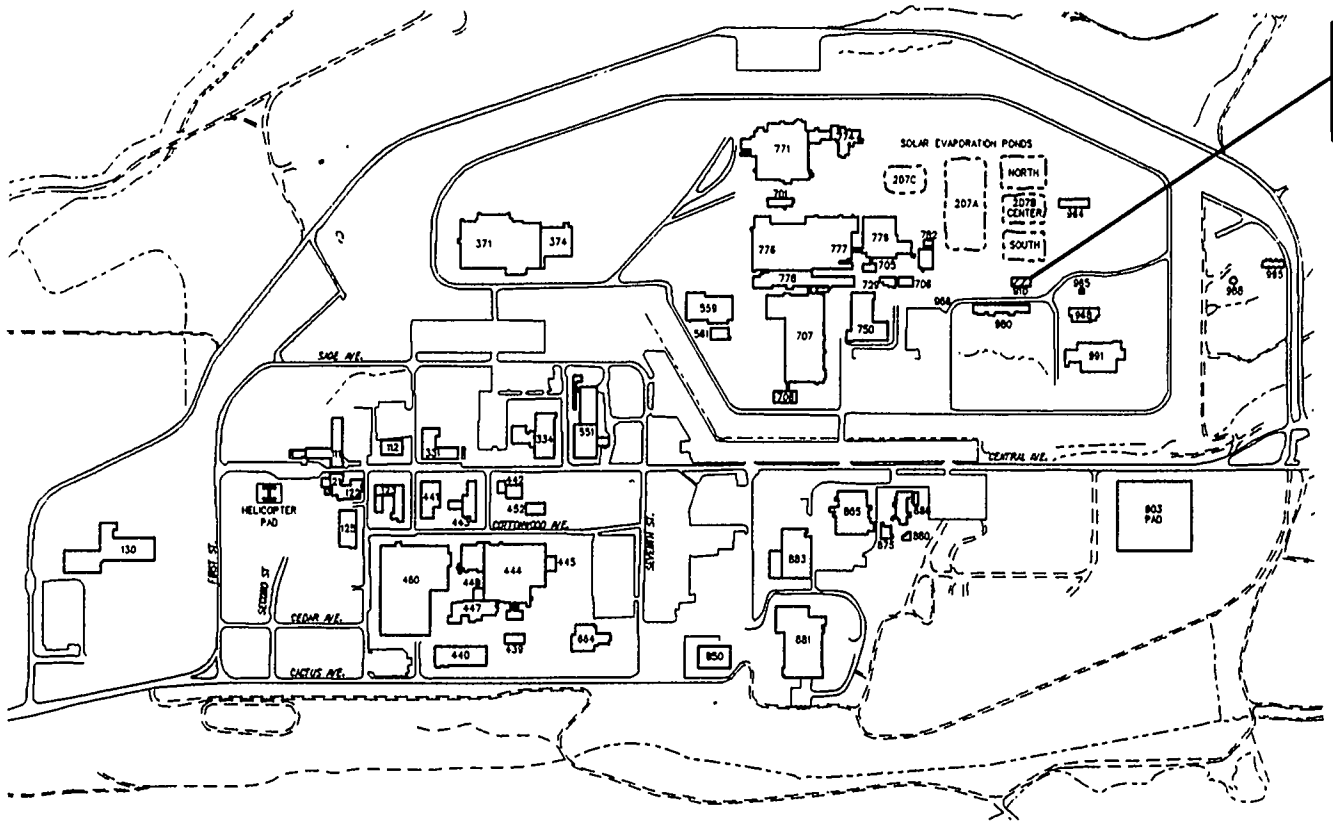
PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 910

Formaldehyde has been used for sterilization of reverse osmosis membranes.

No Emission Estimate Available



N

0' SCALE 1000'

No Emission Sources Identified

Formaldehyde may have been tested for de-nitration, but it is very violent, and was never used in large quantities.

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-19
FORMALDEHYDE AIR EMISSION SOURCES

RockyFlts/Hstry 3-4/04-19 REV: 01-08-92

SYNONYMS: gaseous forms: methanal, methyl aldehyde, methylene oxide
aqueous solutions: formalin

CHEMICAL FORMS AND PROPERTIES:

- A nearly colorless gas at room temperature, with a pungent, suffocating odor.
- Degradation occurs rapidly in air and water.

USES BY MAN AND PRESENCE IN NATURE:

- Formaldehyde is a powerful antiseptic, germicide, fungicide, and preservative used in the tanning and preservation of hides and furs and in embalming.
- Formaldehyde is also used to improve fastness of dyes, waterproofing of fabrics, processing and preserving rubber, and preserving foodstuffs.
- It is also used as a seed and soil disinfectant, in hardening paper products, in developing photographic film, and in refining gold and silver.

TOXICOLOGICAL HIGHLIGHTS:

- Formaldehyde is a probable carcinogen (evidence in animals; insufficient evidence in humans).
- Dermal contact can result in skin irritation or allergic contact dermatitis.
- Formaldehyde is a respiratory irritant.

USES AT ROCKY FLATS:

- Formaldehyde was on the 1974 chemical inventory, with a quantity of 27 kg and no location listed. A quantity of 146 kg was reflected on the 1988/89 inventory.

- Formaldehyde may have been tested for de-nitration in Building 771, but it is very violent, and was never used in large quantities (ChemRisk, 1991; RE-891[11]).

- According to the 1988/89 Chemical Inventory, a large portion of the formaldehyde used at Rocky Flats at that time was used by the Utilities Department to sterilize reverse osmosis membranes used for waste water treatment in Building 910.

MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

Formaldehyde is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

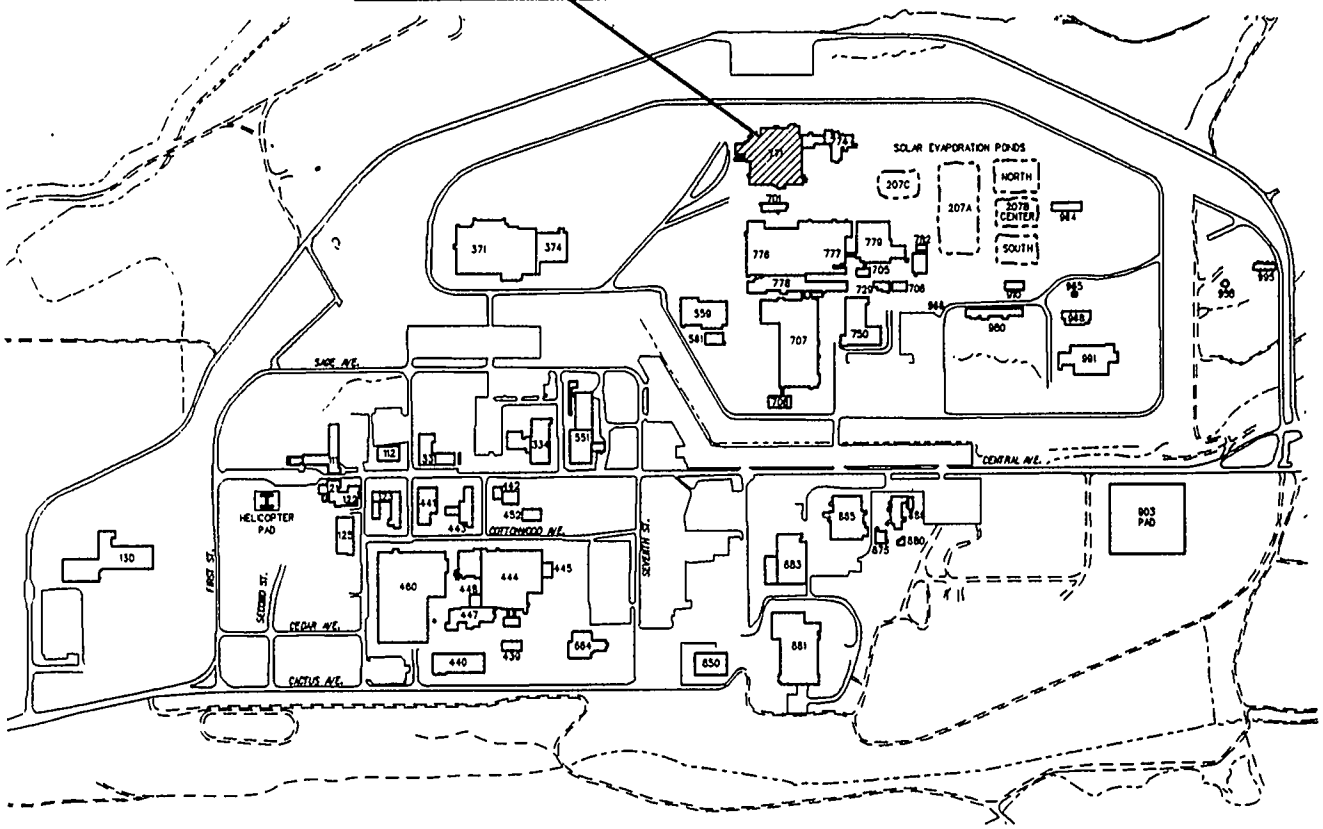
Formaldehyde has not been routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:

Building NO. 771

Hydrazine was used as a holding reductant for neptunium valency. It was also used as a nitrous acid scavenger to assist in reducing plutonium valency

No Emission Estimate Available



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0' SCALE 1000'

ChemRisk
A Division of McLaren/Hart

FIGURE 4-20
HYDRAZINE AIR EMISSION SOURCES

Rckyflts/Hstry 3 4/04-20 REV 01-03-92

SYNONYMS: diamine, diamide, hydrazine (anhydrous), hydrazine base

CHEMICAL FORMS AND PROPERTIES:

- Hydrazine is a colorless liquid with an ammonia-like odor.
- Hydrazine is a solid below 36° F.

USES BY MAN AND PRESENCE IN NATURE:

- Hydrazine is used as a reducing agent and as a rocket fuel.
- Hydrazine is used for synthesis and analysis of a wide variety of organic compounds.

TOXICOLOGICAL HIGHLIGHTS:

- Hydrazine is a probable carcinogen (evidence in animals, but not in humans).
- Chronic exposure to hydrazine may cause damage to the liver and red blood cells.
- Acute hydrazine exposure may cause corrosive damage to the eyes, skin, and mucous membranes.

USES AT ROCKY FLATS:

- Hydrazine was on the 1974 Harmful Materials Inventory with a quantity of 30 kg. The 1988/89 Chemical Inventory reflected a total of about 2 kg of hydrazine in use in laboratories.

- Hydrazine was used in very small quantities in neptunium recovery operations as a holding reductant for neptunium valency. Hydrazine was added to destroy any nitrous acid that could destroy the value of Fe(II) as a reducing agent (Conner and Baaso, 1981). Hydrazine was also used to assist in reducing plutonium valency (ChemRisk, 1991; RE-891[9,43]).

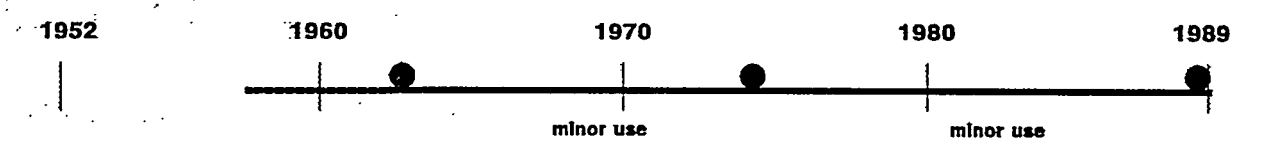
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

Hydrazine is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

Hydrazine was not routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 444

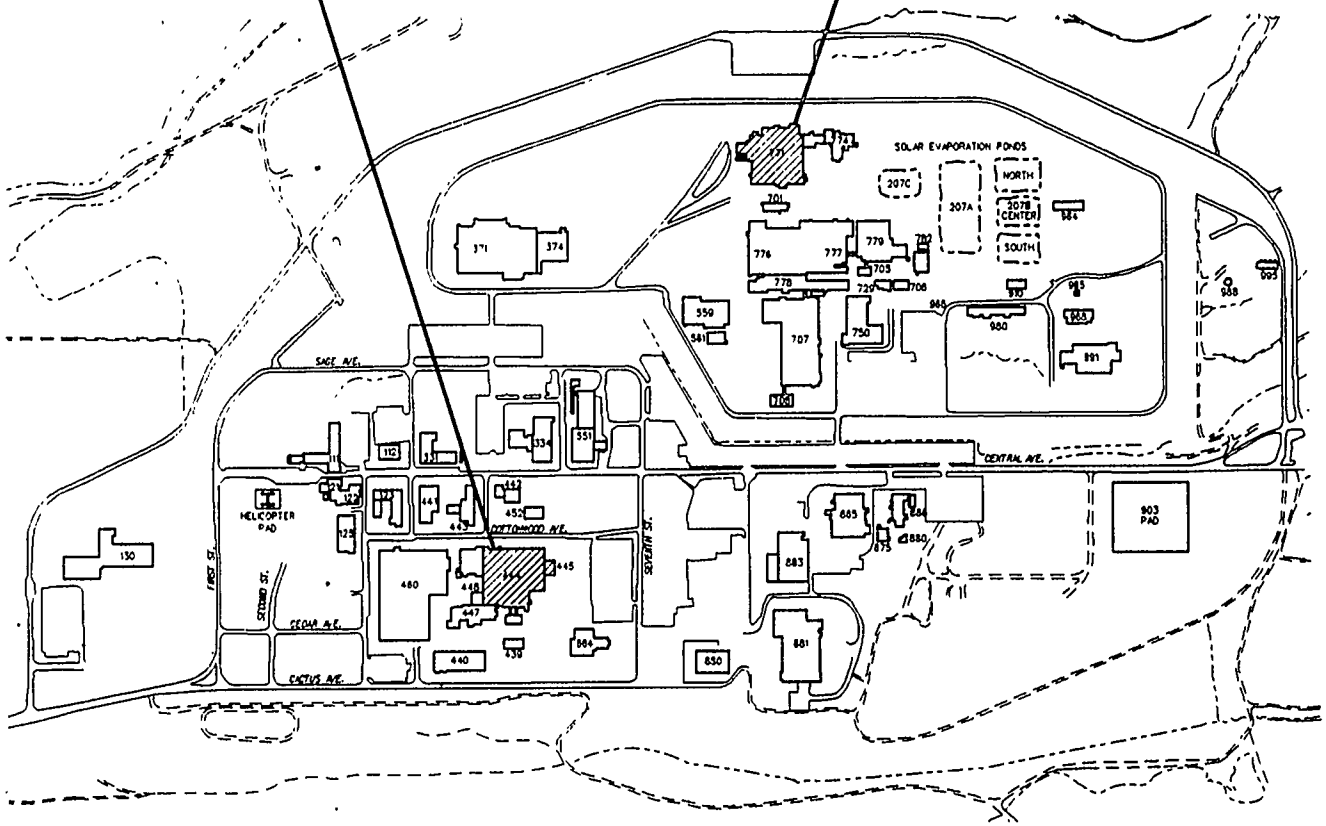
Lead fluoborate and lead oxide have been used in small quantities in plating operations

No Emission Estimates Available

Building No. 771

Lead fluoride and lead metal were used in Building 771. There were laboratory-scale attempts at lead/americium alloying.

No Emission Estimate Available



No Specific Building

Lead has been used mainly in metal form for radiation shielding throughout the plant site. The 1974 inventory quantity was over a million pounds. Lead tetroxide (red lead) was also used by maintenance machinists in rebuilding machines and leak testing fittings

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-21
LEAD COMPOUNDS AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-21 REV: 01-08-92

SYNONYMS: lead metal, plumbum

CHEMICAL FORMS AND PROPERTIES:

- Lead is a heavy, ductile, soft gray solid.
- Lead compounds include lead chloride, lead dioxide, lead tetroxide, and lead chromate.

USES BY MAN AND PRESENCE IN NATURE:

- Native lead occurs in nature, but is rare. Lead is obtained chiefly from galena ore, PbS.
- Lead is ubiquitous in the environment due to past use of leaded gasoline.
- Lead is extremely persistent in water and soil, but not easily taken up by plants.

TOXICOLOGICAL HIGHLIGHTS:

- Lead is a probable carcinogen (some evidence in animals, but no evidence in humans).
- Toxic effects from chronic exposure include learning disabilities, brain and kidney damage.
- Acute lead exposure affects the nervous system, kidneys, and blood-forming organs.

USES AT ROCKY FLATS:

- Lead has been used mainly in metal form for radiation shielding throughout the plant site. The 1974 inventory quantity was over a million pounds. The 1988/89 Chemical Inventory apparently excluded much of the lead metal, and indicated the presence of 1350 kg.

- Lead tetroxide (red lead) was also used by maintenance machinists in rebuilding machines and leak testing fittings (ChemRisk, 1991; RE-891[56]).

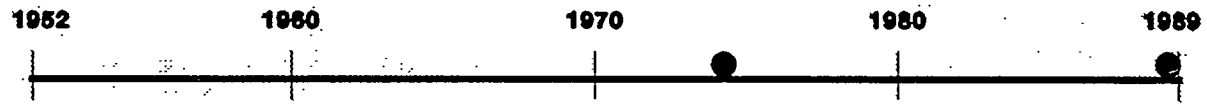
- Lead fluoroborate and lead oxide have been used in small quantities in plating operations based on the 1988/89 Chemical Inventory.

- Lead fluoride and lead metal were used in Building 771. There were laboratory-scale attempts at lead/americium alloying (ChemRisk, 1991; RE-891[9]).

MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:
Lead is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:
Lead has not been routinely monitored in airborne or waterborne effluents.

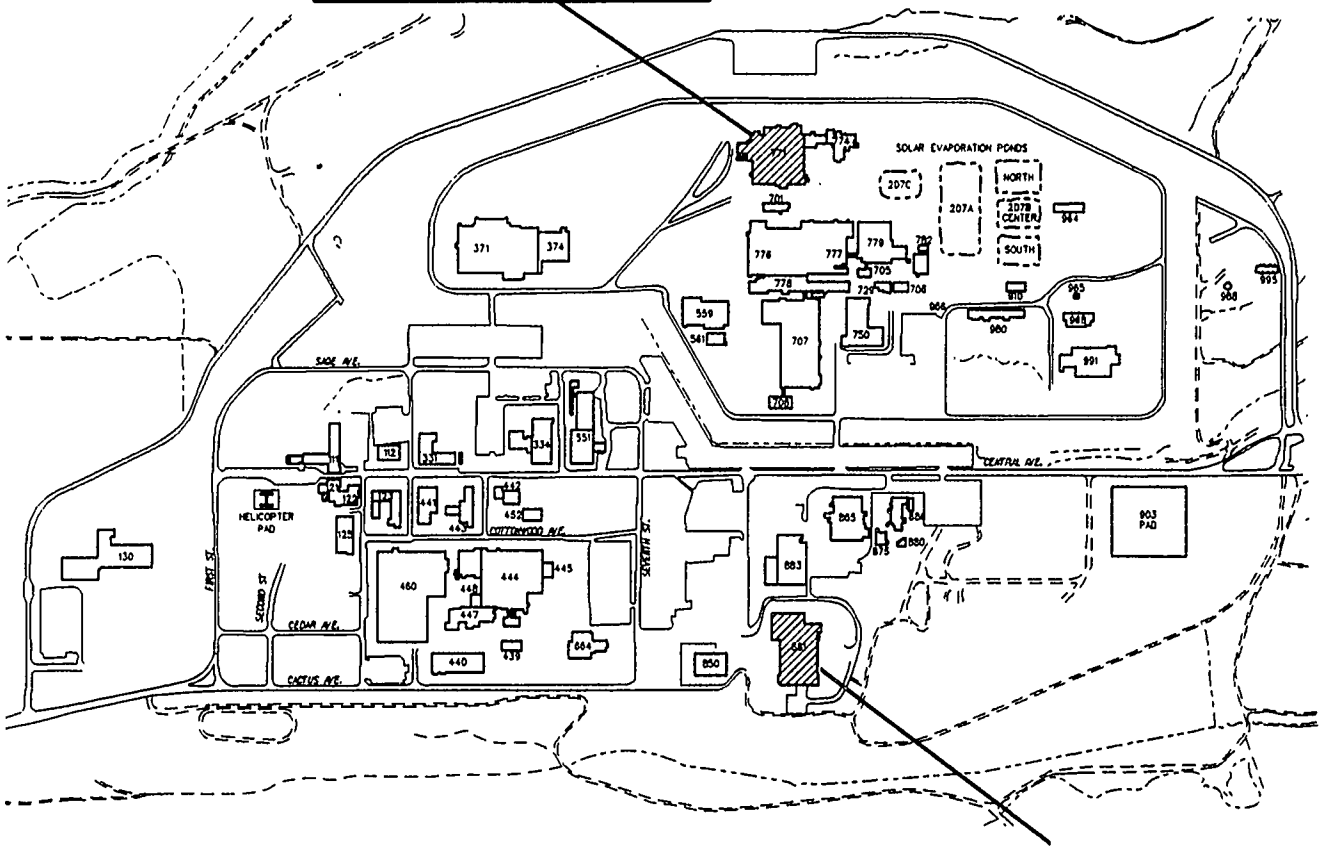
PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 777

Mercury was emitted from an unspecified joining operation.

No Emission Estimate Available



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0' SCALE 1000'

No Emission Sources Identified

Mercury used at Rocky Flats has been for the most part limited to the metallic mercury contained in instruments

No Emission Estimate Available

Building No. 881

Mercury has been collected from plant sources and purified by distillation at the Building 881 General Laboratory. After distilling, it was recycled back to the originating area in five-pound containers.

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-22
MERCURY COMPOUNDS AIR EMISSION SOURCES

RockyFlts/Hstry 3-4/04-22 REV: 01-08-92

SYNONYMS: colloidal mercury, metallic mercury, quicksilver. Named after the planet Mercury.

CHEMICAL FORMS AND PROPERTIES:

- Mercury is silvery-white, heavy, odorless, and is the only common metal liquid at ordinary temperatures.
- Mercury compounds include methyl mercury, mercuric oxide, and mercurous chloride.
- Methyl (organic) mercury is more toxic than other mercury compounds.

USES BY MAN AND PRESENCE IN NATURE:

- Mercury is used in many industries, including textile printing, photography, and the manufacture of scientific equipment and batteries.
- Mercury rarely occurs free in nature; the chief ore is cinnabar, HgS.
- Mercury compounds are fairly mobile in the environment.
- Elemental mercury volatilizes at room temperature.

TOXICOLOGICAL HIGHLIGHTS:

- Uptake in food is usually the largest source of human exposure.
- Inhalation of mercury may cause pneumonia, bronchitis, gum inflammation, or nausea.
- Inadequate evidence of carcinogenicity in animals or humans.
- Chronic exposure is associated with behavioral and neurological disturbances.
- Methyl mercury may pass into the fetus and concentrate in brain tissue.

USES AT ROCKY FLATS:

- Hg used at Rocky Flats is for the most part limited to the metallic mercury contained in instruments such as barometers and thermometers, plant machinery, mercury switches, and experimental apparatus (EG&G, 1986). Hg has been collected from plant sources and purified by distillation at the B-881 General Laboratory. It was recycled back to the originating area in 5 lb. containers (EG&G, 1986). There are no large sources of mercury like those found at Oak Ridge or Savannah River Laboratories (ChemRisk, 1991; RE-891[11]).

- Materials present in 1971 included mercuric chloride, mercuric oxide, mercury/thallium, batteries, electrodes, fluorescent lamps, and rectifiers (Willging, 1972).

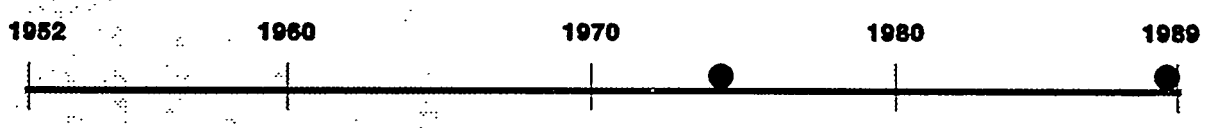
- A reference to mercury emissions from an unspecified joining operation in the Building 777 "modulab" has been located and reviewed (Putzier, 1975). A welding operation used mercury to make contact with spinning parts during the welding (ChemRisk, 1991; RE-891 [71]).

MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs: Hg is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

Mercury has not been routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 444

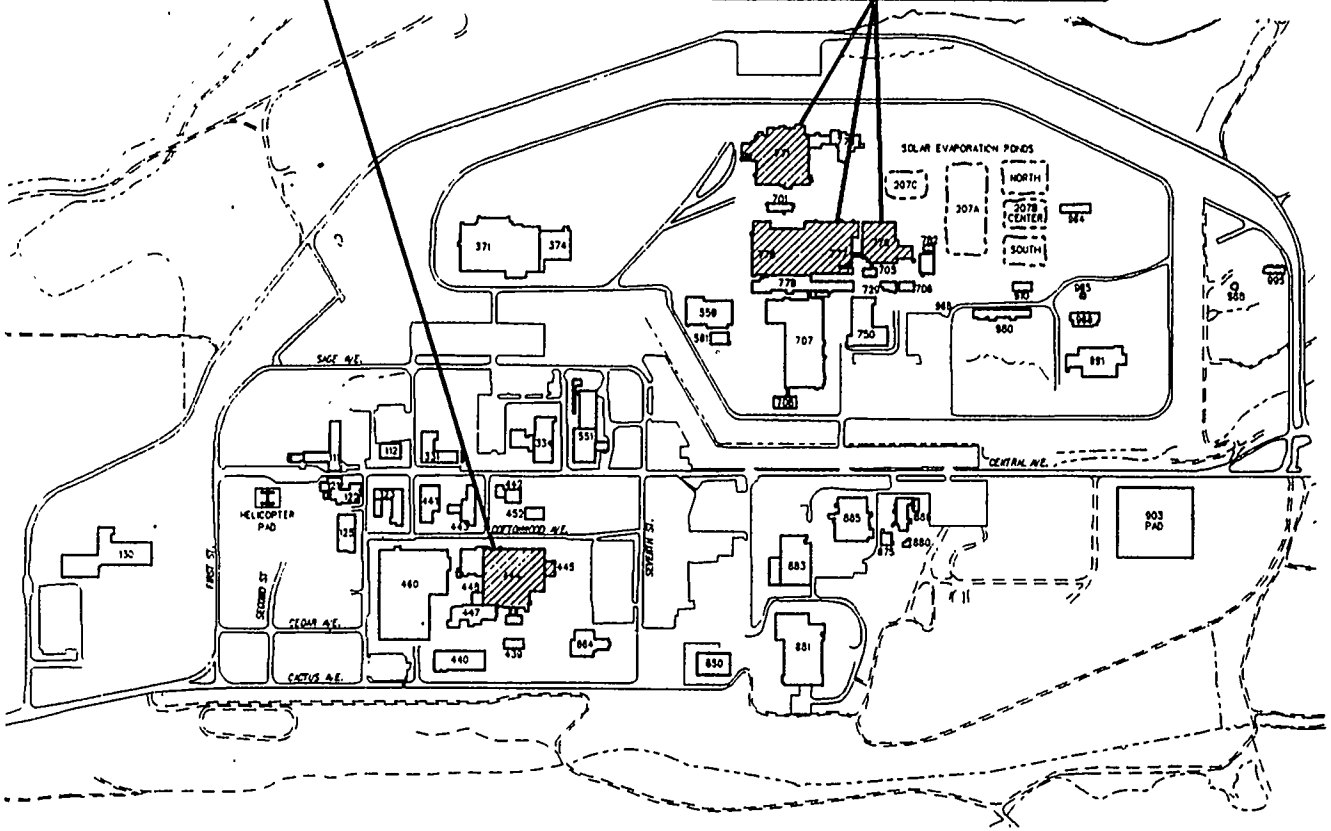
Nickel plating was conducted in Building 444 up until shutdown of the plating lab in 1990

No Emission Estimates Available

Building No. 771, 779, and 777

Nickel plating of weapons parts using nickel carbonyl was conducted in Building 771, 777, and 779. Nickel carbonyl use was active from the early 1950s until the early 1960s or 1970s

No Emission Estimate Available



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0' SCALE 1000'

FIGURE 4-23
NICKEL COMPOUNDS AIR EMISSION SOURCES

ChemRisk
A Division of McLaren/Hart

RckvFlts/Hstry 3-4/04-24 REV: 01-08-92

SYNONYMS: Metal: elemental nickel. Compound synonyms vary by compound.

CHEMICAL FORMS AND PROPERTIES:

- Nickel metal is a lustrous, silvery solid.
- Nickel compounds include nickel carbonyl, nickel nitrate, and nickel monoxide.

USES BY MAN AND PRESENCE IN NATURE:

- Nickel is used for plating, metal alloying, and in welding.

TOXICOLOGICAL HIGHLIGHTS:

- Nickel carbonyl, Ni subsulfide, and Ni refinery dust are carcinogens (evidence in humans and animals).
- Chronic Ni exposure is associated with emphysema, loss of sense of smell, and severe nasal injuries.
- Dermal exposure can produce a contact dermatitis which is called "nickel itch" and is common among nickel platers.
- Nickel carbonyl poisoning is insidious since there is no particular discomfort during the exposure and serious effects are delayed for hours to days.

USES AT ROCKY FLATS:

- Nickel plating of weapon components was conducted in B-444 up until shutdown of the plating lab in 1990 (ChemRisk, 1991; RE-891[56]). Some plating solutions are made by mixing metal salts with acids, others are purchased in aqueous form. Ni plating solutions are heated and used in 75-gal. tanks. Some liquid evaporates, but measurements show that the metals do not (Simmons, 1992).

- Since RCRA went into effect, plating wastes have been drummed and shipped off-site as hazardous waste. Before RCRA, they were treated in B-774 (Simmons, 1992) by addition of sodium hydroxide and mixing with Portland cement and an absorbent material. Dilute rinsing solutions are sent to B-374. Prior to B-374, the solar ponds were used to treat wastewater (Anderson, et al., 1984).

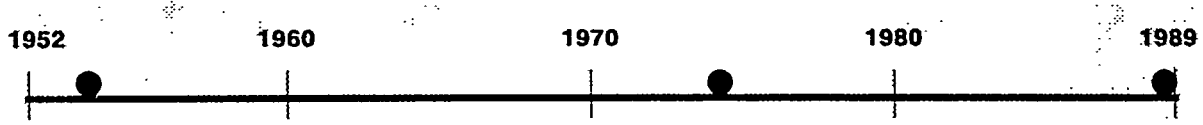
- Nickel carbonyl plating was conducted in B-771, 777, and 779 from the early 1950s until the early 1960s or 1970s (ChemRisk, 1991; RE-891[3,40,49,67]). Nickel plating by nickel carbonyl decomposition was used for U and delta phase (alloyed) Pu. It was carried out by heating the cleaned metal in a vacuum to 80-85° C, charging in a partial atmosphere of Ni carbonyl to flash coat the part, and increasing the temperature to 100-110° C to accelerate the plating (Pitts, 1962).

MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs: Nickel is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

Nickel compounds have not been routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:



Building No. 371

Nitric acid is present in waste solutions and reagents used in the Plutonium Analytical Support Laboratory, and is used in the Chemical Standards Laboratory to prepare and process standards for the plant site

Under 1% of Site Emission Total

Building No. 374

Nitric acid is present in liquid process waste solutions treated here Treatment processes generate heat, leading to potential for increased emissions.

5% of Site Emission Total

Building No. 771

Nitric acid is used to dissolve plutonium metal and plutonium bearing residues; nitric acid and aluminum nitrate are oxidized to form NOX. NOX also released from evaporation and peroxide precipitation processes and Chemical Technology method development activities.

11% of Site Emission Total

Building No. 774

Nitric acid is used in the first stage of radioactive decontamination treatment, a caustic precipitation process used to decrease plutonium and americium concentrations No NOX air emissions because no heat is applied.

Under 1% of Site Emission Total

Building No. 559

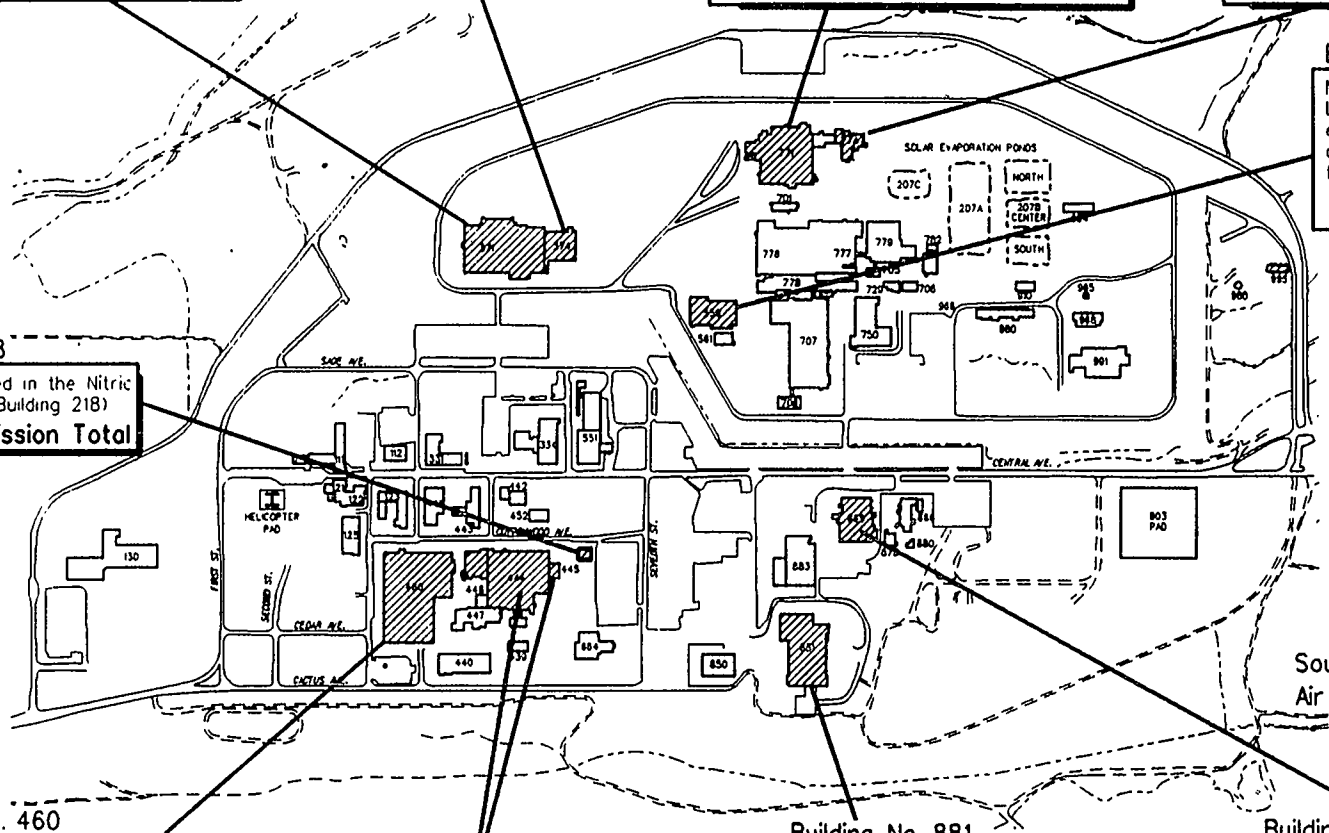
Nitric acid is used in Plutonium Analytical Laboratory to dissolve metal samples for emission spectroscopy and various analyses of uranium content Emission estimates are for NOX generated from HNO_3

Under 1% of Site Emission Total

Building No. 218

Nitric acid is stored in the Nitric Acid Tank Farm (Building 218)

5% of Site Emission Total



0' SCALE 1000'

Source Of Emission Data:
Air Pollution Emission Notice Reports

Building No. 460

Nitric acid is used for parts cleaning. Emission estimates are for NOX from nitric acid.

3% of Site Emission Total

Building No. 444/5

Nitric acid is used in Production Plating etching and plating operations. Uranium parts are treated in an ultrasonic etching bath prior to assembly coating Emission estimates for the above processes are for NOX. Titanium buildup on fixtures is stripped by immersion in acid solutions NO_2 is generated in the process

64% of Site Emission Total

Building No. 881

Nitric acid is used in laboratories, at room temperature, in baths and rises, and in sample preparations. The remainder of HNO_3 used (about 20%) is boiled to dryness under acid scrubber hoods Release estimates are for nitric acid.

11% of Site Emission Total

Building No. 865

Nitric acid is used in chemical etching to prepare metal parts for inspection. Nitric acid is also used in etching step of quality control analyses conducted in the Metallography Laboratory Emission estimates are for nitric acid

1% of Site Emission Total

ChemRisk
A Division of McLaren/Hart

FIGURE 4-24
NITRIC ACID AIR EMISSION SOURCES

Rockyflts/Hstry 3-4/04-23 REV. 01-08-92

SYNONYMS: aqua fortis, engravers acid, hydrogen nitrate, red or white fuming nitric acid

CHEMICAL FORMS AND PROPERTIES:

- Nitric acid is colorless, yellow or red fuming liquid with an acrid, suffocating odor.
- Often in aqueous solutions. Fuming nitric acid is concentrated acid containing dissolved nitrogen.

USES BY MAN AND PRESENCE IN NATURE:

- Nitric acid is used to dissolve metals, for etching and cleaning metals, and to make fertilizers and explosives.

TOXICOLOGICAL HIGHLIGHTS:

- Nitric acid is not listed as a carcinogen by the EPA.
- Chronic nitric acid exposure may result in chronic bronchitis or pneumonia.
- Acute exposure may cause pulmonary congestion and edema.

USES AT ROCKY FLATS:

- Nitric acid is used in large quantities to dissolve plutonium metal and plutonium bearing residues to facilitate purification and recovery of plutonium (EG&G, 1990e). In times of high production, about two railroad tank cars of nitric acid were used per month (ChemRisk, 1991; RE-891[39]).
- Nitric acid is used in metal etching and plating operations. Uranium parts are treated in an ultrasonic etching bath prior to assembly coating (EG&G, 1991h).
- Titanium buildup on fixtures is stripped by immersion in acid solutions (EG&G, 1991h).
- Nitric acid is used in the first stage of radioactive decontamination treatment to decrease plutonium and americium concentrations (EG&G, 1991a).
- In other operations, nitric acid is used for parts cleaning (EG&G, 1991f) and various laboratory analyses (EG&G, 1990c, 1991c, 1991g).

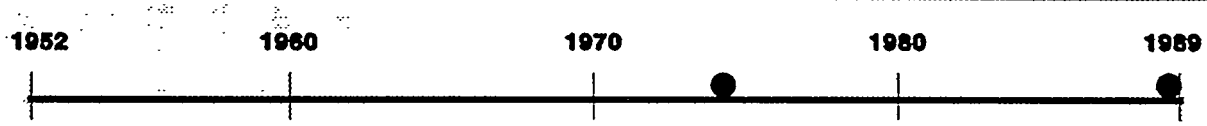
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

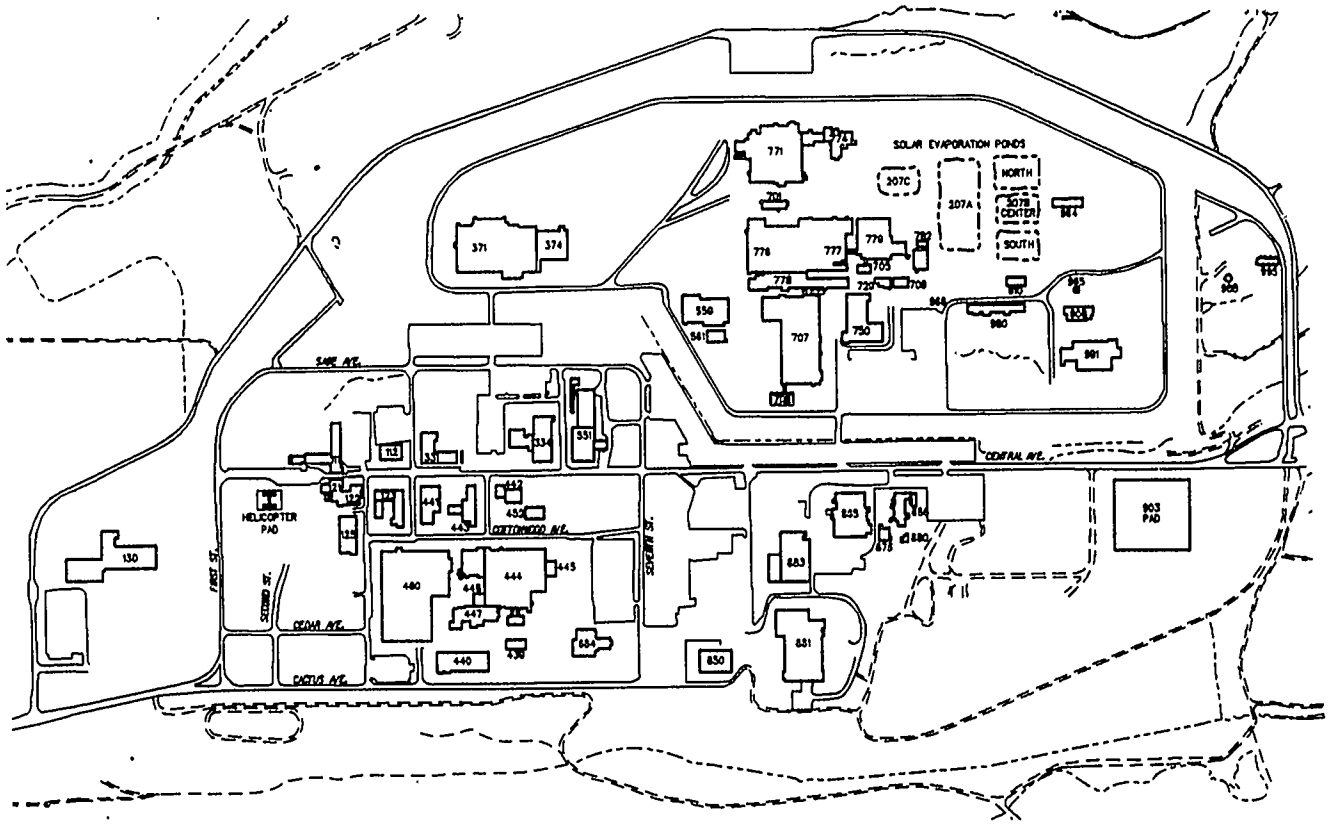
0.37 ton per year, which equals 740 pounds per year. This emission estimate is for nitrogen oxides (NOx) resulting from nitric acid use.

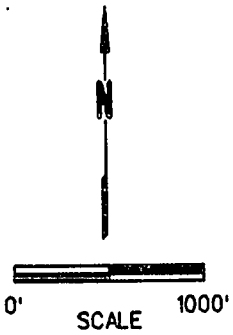
MONITORING DATA AVAILABILITY:

Nitric acid has not been routinely monitored in airborne or waterborne effluents. Some special studies of nitric acid and nitrogen dioxide emissions have been done (Hobbs, 1974).

PERIOD(S) OF USE AT ROCKY FLATS:







No Emission Sources Identified

Dow may have experimented with propylene oxide as a possible substitute for carbon tetrachloride as a solvent that could be used with plutonium without the hydrogen generation problems associated with some solvents contacting plutonium.

No Emission Estimate Available

ChemRisk
A Division of McLaren/Hart

FIGURE 4-25
PROPYLENE OXIDE AIR EMISSION SOURCES

RckyFlts/Hstry 3-4/04-25 REV: 01-06-92

ROCKY FLATS MATERIAL USE PROFILE; PROPYLENE OXIDE

SYNONYMS: 1,2-epoxy propane, methyl ethylene oxide, methyloxirane, propene oxide, 1,2-propylene oxide

CHEMICAL FORMS AND PROPERTIES:

- Propylene oxide is a colorless liquid with a benzene-like odor.
- Propylene oxide is a gas above 94° F.

USES BY MAN AND PRESENCE IN NATURE:

- Propylene oxide is used as a chemical intermediate, for example in polyurethane manufacturing, and in the preparation of lubricants and demulsifiers.
- It is sometimes used directly as a solvent and sterilizing agent.

TOXICOLOGICAL HIGHLIGHTS:

- Propylene oxide is a probable carcinogen (evidence in animals only).
- Chronic exposure to propylene oxide has caused eye and throat irritation and congestion.
- Acute exposure has produced temporary corneal injury and contact dermatitis.

USES AT ROCKY FLATS:

- Propylene oxide was on the 1974 chemical inventory, with a quantity of 1.5 kg and no location listed. It was not on the 1988/89 inventory.
- Dow may have experimented with propylene oxide as a possible substitute for carbon tetrachloride as a solvent that could be used with plutonium without the hydrogen generation problems associated with some solvents contacting plutonium (ChemRisk, 1991; RE-891[46]).

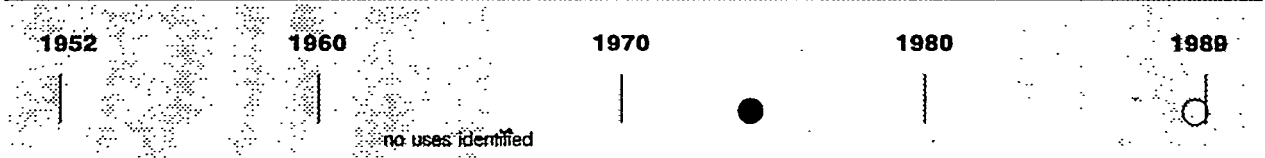
MODERN-DAY EMISSION ESTIMATE FROM EG&G APENs:

Propylene oxide is not addressed in the APEN reports.

MONITORING DATA AVAILABILITY:

Propylene oxide has not been routinely monitored in airborne or waterborne effluents.

PERIOD(S) OF USE AT ROCKY FLATS:



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5.0 HISTORICAL RELEASE POINTS

The general modes of release of materials from the Rocky Flats Plant to the off-site environment have included airborne effluents, waterborne emissions, and those resulting from solid waste disposal or accidents. Historical airborne emissions include those from routine facility operations as well as those associated with the accidents and incidents described in Section 6 of this report. Airborne effluents exit the various Rocky Flats buildings by way of numerous release points of varying geometry and significance.

Waterborne emissions from the Plant have included process wastes, laundry wastes, sanitary waste, and surface runoff from the site. Waterborne emissions from the plant have left the site via the North and South Walnut Creek and Woman Creek drainage, and spray application of certain waste waters to various area of plant property has been practiced. While there is no evidence of intentional disposal of liquids to the ground water aquifers underlying the site, various contaminants have appeared in ground water collected within the site boundary as a result of past disposal practices and/or other releases of chemicals and radionuclides to the environment.

Solid wastes have been generated at the plant since its early operation. In addition, liquid wastes which cannot be recovered are often solidified in preparation for disposal. While landfills have been operated on the plant site for disposal of certain solid wastes, and there are numerous accounts of on-site burial of radioactive and chemical wastes, a great majority of radioactive and hazardous solids have historically been shipped off the site for disposal.

This section describes the emission points which have been associated with airborne and waterborne releases of the materials of concern from the Rocky Flats Plant. Solid waste disposal practices are discussed, along with documentation of past activities surrounding Rocky Flats' handling and treatment of wastes received from off-site sources.

5.1 Airborne Emissions

Table 5-1 contains information that characterizes the emission points for airborne emissions of materials of concern from the Rocky Flats Plant. For each release point, the following types of information are provided:

Location	*The building or buildings which are associated with or provide contaminants to the release point are identified.*
Identifiers	*Codes, names, or other identifiers for the release point are provided, based on information from the DOE Effluent Information System (EIS), EG&G Air Pollution Emission Notices (APENs), and other applicable documents.*
Stack or Vent Type	*The type of release point (e.g. elevated stack, roof-top vent, wall vent) is indicated based on plant documents.*
Typical Exhaust Qualities	*Properties of the exhaust stream which are relevant to prediction of off-site concentrations and doses are summarized where available. Examples include typical velocities and temperatures.*
Expected Constituents	*The materials of concern which are expected to be contained in the emissions from the release point are identified based on APENs or the EIS.*
Contribution to Site Totals	*For each material of concern expected to be present, the percentage of the site total release expected from this release point is presented as an indicator of the significance of the release point for that material. The sources of this emission data are the modern-day APEN reports and DOE Effluent Information System totals for 1988.*

For each material of concern, knowledge of the relative significance of each release point, the spatial distribution of significant emission sources, the geometries of the release points, and the characteristics of the effluent streams are all factors which will be evaluated for potential significance in planning of the Task 6 approaches for modeling of off-site impacts of the emissions to be estimated as part of Task 5.

TABLE 5-1 ROCKY FLATS AIRBORNE EMISSION POINTS

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
371C-001 Vent #1; System 1	Dicesium Hexachloro-plutonate Ops, Chemical Standard Lab, and Maintenance Ops.	Louvered Penthouse Roof - 37 ft Stack - 4.0 ft	(1)	Nitric acid (Nox): 0.0030% Beryllium: 11.2% Plutonium: 0.80% Americium: 0.8% Uranium: 2.8%
371C-002 Vent #2; System 2	Plutonium Analytical Support Lab and Maintenance Ops.	Louvered Penthouse Roof - 37 ft Stack - 4.0 ft	(1)	Nitric acid (Nox): 0.06% Beryllium: 8.1% Plutonium: 0.83% Americium: 1.8% Uranium: 4.2%
374D-002 Vent #3	Waste Receiving and Neutralization	Circular Dia - 16.25" Roof - 37 ft Stack - 8.4 ft above roof	17.537 cfm 3.769 fpm 70 deg F	Beryllium: 0.67% Plutonium: 0.44% Americium: 1.3% Uranium: 0.58%
374J-001 Vent #'s 7,8,9	Waste Receiving and Neutralization	Louvered Penthouse Dim. 72" x 54" (3 sides) Roof - 37 ft Stack - 3.6 ft above roof	115.430 cfm 13.22 fpm 70 deg F	Nitric Acid (Nox): 5.4% Beryllium: 0.66% Methylene Chloride: 0.74% 1,1,1-TCA: 0.0081% Chloroform: 0.16% PCE: 100% TCE: 0.1% Plutonium: 0.93% Americium: 1.9% Uranium: 3.9%
444 Vent #122	Beryllium Machining Areas	(1)	(1)	Beryllium: 25%
444N-003 Vent #82	Production Plating Laboratory	Rectangular Dim. 30.5"x24.0" Stack 10.7 ft above ground level	(1)	Uranium: 0.1% Nitric Acid(Nox): 20%
444N-004 Vent #200 Filter Plenum Building 450	Foundry, Uranium Machining, Titanium Stripping, Assembly, Welding, Brazing, Etching, and Coating	Rectangular Roof Height 14.8 ft Stack 2.0 ft above roof Dimensions 108"x96"	(1)	Nitric Acid (NO_x): 47% Uranium: 4.1%

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
447D-001 Filter Plenum 201 Building 451	Electron Beam Welding Maintenance Operations Vacuum Arc Melt Furnace Chip Roaster	Rectangular Roof Height 10.3 ft Stack 2.5 ft above the roof Dimensions 60" x ?	Flow Rate: 64,000 ACFM Velocity: 2133 ft/min Temp: 70°F	Beryllium: 6.9% Methylene Chloride: 0.045% Uranium: 2.4%
Building 460 High-bay Exhaust Vents 2, 4, 5, 6, 35, 36, 38, 39, 40, and 43	Product Inspection, Maintenance Activities	63"x63"vents, 40" above roof	Flow Rate: 34,820 ACFM Velocity: 1,263 FPM Temp: 70°F	TCE: 99.9% 1,1,1-TCA: 0.015% Chloroform: 0.74%
460-14 Rooms 117 and 118 Exhausts	Material Development Part Cleaning	12" dia stack 10 feet above roof	(1)	Carbon tet: 0.0066%
460-23 Hood Exhausts	Aqueous Assembly Cleaning	36"x36" vent 2' above roof	(1)	1,1,1-TCA: 0.011% Methylene Chloride: 0.045%
460-30 Hood Exhausts	Assembly Cleaning- Automated and Internal Cleaning Lines	24" dia stack, 10 ft above roof	(1)	Nitric acid (NOx): 3.4%
460-54 Room exhaust fan	Nondestructive testing; radiographic testing	24" dia wall vent 13' above grade	(1)	1,1,1-TCA: 0.0009%
559A-001 Exhaust Vent #36 Building 561 plenum	Gallium Determination, Emissions Spectroscopy, Uranium Analysis, and Plutonium Oxidation	Double inverted J 57"x48" Roof Height 21 ft Stack 2.0 ft above roof	Flow Rate: 73,600 ACFM Velocity: 3067 ft/min Temp: 70°F	Beryllium: 6.5% Chloroform: 87.7% Nitric Acid (NOx): 0.26% Plutonium: 3.0% Uranium: 2% Americium: 3.7% Tritium: 2.6%
707 Vent 1/2	(1)	Mushroom Diameter 28" Roof Height 37.5 ft Stack Height 8.6 ft above roof	(1)	Beryllium: 0.33% Plutonium: 0.2% Americium: 1.4% Uranium: 0.6%
707 Vent 3/4	(1)	Hushroom Diameter 14" Roof Height 37.5 ft Stack Height 7.8 ft above roof	(1)	Beryllium: 0.33% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
707B-006 Vent 9/10	Pu casting, oxidation, storage, and shearing	2 Inverted J's Dim. 18"x18" Roof Height 37.5 ft Stack Height 3.0 ft above the roof	(1)	Beryllium: 0.31% Carbon Tet.: 8.32% Plutonium: 0.06% Americium: 0.08% Uranium: 0.08%
707B-003 Vent 28	Part assembly, weighing, testing, and inspection	Inverted J Dim. 36"x36" Roof Height 37.5 ft Stack Height 3.0 ft above the roof	(1)	Beryllium: 1.1% 1,1,1-TCA: 5.5% Carbon Tet.: 0.27% Plutonium: 0.80% Americium: 1.1% Uranium: 0.4% Tritium: 2.2%
707B-005 Vent 36	Pu casting ops, rolling and forming, briquetting, machining, and inspection	Inverted J Diameter 14" Roof Height 37.5 ft Stack Height 3.0 ft above the roof	(1)	Beryllium: 0.09% Carbon Tet.: 71.4% 1,1,1-TCA: 0.031% Plutonium: 0.01% Americium: 0.08% Uranium: 0.08%
707 Vent 38/39	(1)	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.33% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2
707 Vent 40/41	(1)	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.33% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2
707 Vent 42/43	(1)	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.33% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2
707 Vent 44/45	radiography	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.32% 1,1,1-TCA: 0.028% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
707B-001 Vent 55	Assembly-superdry	Inverted J Dim. 22"x22" Roof Height 37.5 ft Stack Height 3.0 ft above the roof	(1)	Beryllium: 0.76% 1,1,1-TCA: 0.25% Plutonium: 0.03% Americium: 0.05% Uranium: 0.5% Tritium: 0.5%
707B-004 Vent 65	Pu machining, part degreasing, assembly testing	Inverted J Dim. 36"x36" Roof Height 37.5 ft Stack Height 3.5 ft above the roof	(1)	Beryllium: 1.2% 1,1,1-TCA: 7.92% Plutonium: 0.10% Americium: 0.3% Uranium: 0.7% Tritium: 0.9%
707B-002 Vent 75	(1)	Inverted J Dim: 30"x30" Roof Height 37.5 ft Stack Height 3.0 ft above the roof	(1)	Beryllium: 0.33% Plutonium: 0.21% Americium: 0.4% Uranium: 1.3% Tritium: 0.9%
707 Vent 76/77	(1)	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.33% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2
707 Vent 78/79	Calibration lab, instrument cleaning	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.39% 1,1,1-TCA: <0.0001% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2
707 Vent 80/81	Assembly brazing scanning, testing	Mushroom Diameter 43.5" Roof Height 37.5 ft Stack Height 10.2 ft above the roof	(1)	Beryllium: 0.40% 1,1,1-TCA: 0.49% Plutonium: Same as 707 Vent 1/2 (2) Americium: Same as 707 Vent 1/2 Uranium: Same as 707 Vent 1/2
771C-001 Vent #86 Building 771 Main exhaust	Plutonium Recovery Facility	Stack Height: 145 ft Diameter: 120 inches	Flow Rate: 184,000 ACFM Velocity: 2313 ft/min Temp: 70° F	Beryllium: 0.11% Methylene Chloride: 21% Nitric Acid (NOx): 11.1% Plutonium: 70% Uranium: 7.1% Tritium: 20.2% Americium: 64%

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
771C-002 Vent #9 Building 771C Main Plenum	Shipping and Counting Areas	Stack Height 21 ft Diameter 2.0 ft	Flow Rate: 8279 ACFM Velocity: 2635 ft/min Temp: 70° F	Beryllium: 0.13% Plutonium: 4% Uranium: 0.33% Americium: 5.8%
771C-005 Building 771C Room Plenum Vent #'s 2 & 8	Shipping and Counting Areas	Stack Height 21 ft Diameter 2.4 ft	Flow Rate: 10695 ACFM Velocity: 1168 ft/min Temp: 70° F	Beryllium: 0.12% Plutonium: 8% Americium: 9.1% Uranium: 0.32%
771G-001 Building 771A Main Exhaust Vent #67 Paint Hood Exhaust	Paint Stripping and Paint Applications	Stack Height 16 ft Diameter 1.1 ft	Flow Rate: 1700 ACFM Velocity: 1848 ft/min Temp: 70° F	No chemicals of concern listed
774D-001 Filter Plenum 202 Vent #4	Organic and sludge immobilization system (OASIS)	Inverted J Dimensions - 60"x16.3" Roof Height 26 ft Stack 1.5 ft above roof	(1)	1,1,1-TCA: 30.9% Plutonium: 2% Americium: 1.8% Uranium: 0.12%
776E-001 Plenum 250 Vent #24	Baler, Briquetting, Machining, Disassembly and Assembly Operations, and Radiography	Louvered Penthouse Roof Height 38 ft Stack 3.3 ft above roof Four sides (N,S,E,W), all rectangular Dimensions: 244"x28"	Flow Rate: 72,800 ACFM Velocity: 150 ft/min Temp: 70° F	Beryllium: 9.0% Carbon Tet: 20% Methylene Chloride: 70% 1,1,1-TCA: 49.7% Plutonium: 1.3% Americium: 1.2% Uranium: 1.4% Tritium: 1.6%
776E-002 Plenum 206 Vent #32	Special Weapons Projects, Plutonium Metallography Lab, Ultrasonic Cleaning System, Foundry Operations, TCA Collection and Filtration System	Louvered Penthouse Roof Height 38 ft Stack 3.3 ft above roof Four sides (N,S,E,W), all rectangular Dimensions 244"x28"	Flow Rate: 19,000 ACFM Velocity: 39 ft/min Temp: 70° F	Beryllium: 7.2% 1,1,1-TCA: 4.8% Plutonium: 0.30% Americium: 0.24% Uranium: 0.36% Tritium: 52%
776E-003 Plenum 201/203 Vent #24	Baler, Briquetting, Machining, Disassembly and Assembly Operations, and Radiography	Louvered Penthouse Roof Height 38 ft Stack 3.3 ft above roof Four sides (N,S,E,W), all rectangular Dimensions: 244"x28"	Flow Rate: 72,800 ACFM Velocity: 150 ft/min Temp: 70° F	Beryllium: Same as 776E-001 Carbon Tet: Same as 776E-001 Methylene Chloride: Same as 776E-001 1,1,1-TCA: (Same as 776E-001) Plutonium: 0.03% Americium: 0.05% Uranium: 0.15%

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
776E-004 Plenum 205 Vent #32	Special Weapons Projects, Plutonium Metallography Lab, Ultrasonic Cleaning System, Foundry Operations, TCA Collection and Filtration System	Louvered Penthouse Roof Height 38 ft Stack 3.3 ft above roof Four sides (N,S,E,W), all rectangular Dimensions 244"x28"	Flow Rate: 19,000 ACFM Velocity: 39 ft/min Temp: 70° F	Beryllium: Same as 776E-002 1,1,1-TCA: Same as 776E-002 Plutonium: 0.16% Americium: 0.25% Uranium: 0.44% Tritium: 7.2%
776E-005 Plenum 204 Vent #24	Baler, Briquetting, Machining, Disassembly and Assembly Operations, and Radiography	Louvered Penthouse Roof Height 38 ft Stack 3.3 ft above roof Four sides (N,S,E,W), all rectangular Dimensions: 244"x28"	Flow Rate: 72,800 ACFM Velocity: 150 ft/min Temp: 70° F	Beryllium: Same as 776E-001 Carbon Tet: Same as 776E-001 Methylene Chloride: Same as 776E-001 1,1,1-TCA: Same as 776E-001 Plutonium: 0.36% Americium: 0.41% Uranium: 1.3% Tritium: 6.6%
776E-006 Plenum 251 Vent #45	(1)	Inverted J Roof Height 35.8 ft Stack 6.5 ft above roof Dimensions 60"x32"	Flow Rate: 4754 ACFM Velocity: 257 ft/min Temp: 70° F	Beryllium: 0.67% Plutonium: 0.08% Americium: 0.2% Uranium: 0.20%
776E-007 Plenum 252 Vent #44	(1)	Inverted J Roof Height 35.8 ft Stack 7.5 ft above roof Dimensions 36"x27"	Flow Rate: 5850 ACFM Velocity: 975 ft/min Temp 70° F	Beryllium: 0.49% Plutonium: 0.13% Americium: 0.25% Uranium: 0.10%
776E-008 Plenum 202 Vent #17	(1)	Stack to Conical Hat Roof Height 38 ft Stack Height 14.8 ft Diameter 20.25"	Flow Rate: 6000 ACFM Velocity: 25,000 ft/min Temp: 70° F	Beryllium: 0.85% Plutonium: 0.11% Americium: 0.12% Uranium: 0.10%
776E-009 Plenum 207 Vent #32	Special Weapons Projects, Plutonium Metallography Lab, Ultrasonic Cleaning System, Foundry Operations, TCA Collection and Filtration System	Louvered Penthouse Roof Height 38 ft Stack 3.3 ft above roof Four sides (N,S,E,W), all rectangular Dimensions 244"x28"	Flow Rate: 19,000 ACFM Velocity: 39 ft/min Temp: 70° F	Beryllium: Same as 776E-002 1,1,1-TCA: Same as 776E-002 Plutonium: 0.26% Americium: 0.6% Uranium: 0.55%

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
778H-001 Laundry	Laundry Facilities	Cylindrical Diameter 48" Roof Height 25.9 ft Stack 5.3 ft above roof	(1)	Plutonium: 0.77% Americium: 0.83% Uranium: 3.6%
779F-001 Vent #71 Building 729 plenum	(1)	Circular Stack Diameter 37.75 inches Stack Height 93.5 ft	Flow Rate: 17707 ACFM Velocity: 2361 ft/min Temp: 70° F	Plutonium: 0.21% Americium: 0.21% Uranium: 0.29% Tritium: 0.92%
779F-002 Vent #70 Building 782 plenum	(1)	Double inverted J Dimensions 57"x48" Roof Height 20.1 ft Stack 1.8 ft above roof	Flow Rate: 61506 ACFM Velocity: 4316 ft/min Temp: 70° F	Plutonium: 4.1% Americium: 0.68% Uranium: 2.2% Tritium: 1.3%
865P-001 Vent Pair 58/59 Building 867	Beryllium Powder work, Research and Development of Metalworking Processes, Metallography Lab, and Grit Blasters	Rectangular Dimensions 56"x56.5" Roof Height 11.0 ft Stack 4.0 feet above roof	(1)	Beryllium: 0.03% Nitric Acid(NOx): 0.64% Uranium: 2.2%
865P-002 Vent Pair 63/64 Building 866	Beryllium Powder work, Research and Development of Metalworking Processes, Metallography Lab, and Grit Blasters	Rectangular Dimensions 60"x56.25" Roof Height 14.0 ft Stack 1.5 ft above roof	(1)	Beryllium: 0.03% Nitric Acid(NOx): 0.64% Uranium: 1.6%
881Q-001 Ducts 1,2,3 and 4. These ducts exit through the same stack as 881Q-002.	Research and Development Activities	Circular (4 outlets) Diameter 96.0 inches Roof height 32.6 ft Stack 8.0 ft above roof	Flow Rate: 14,258 ACFM Velocity: 2,159 ft/min Temp: 70° F	Benzene: 100% Beryllium: 3.3% Carbon Tet: 0.002% Chloroform: 11.4% Methylene Chloride: 8% Nitric Acid(NOx): 11.8% 1,1,1-TCA: 0.23% Plutonium: 0.45% Americium: 2.1% Uranium: 6.2% Tritium: 2.7%
881Q-002 Ducts 5 and 6. These ducts exit through the same stack as 881Q-001	Research and Development Activities	Circular (4 outlets) Diameter 96.0 inches Roof height 32.6 ft Stack 8.0 ft above roof	Flow Rate: 14,258 ACFM Velocity: 2,159 ft/min Temp: 70° F	Plutonium: 0.24% Americium: 0.19% Uranium: 3.8%

BUILDING AND IDENTIFIERS	MAIN INPUTS	STACK OR VENT TYPE	TYPICAL EXHAUST QUALITIES	EXPECTED CONSTITUENTS AND CONTRIBUTIONS TO SITE TOTAL
883R-001 Vent #44 Duct A Building 879 plenum	Rolling, Shearing, Blanking/Trepanning, and Forming of Depleted Uranium	Rectangular Dimensions 98.25"x52.75" Roof Height 15.2 ft Stack 7.0 ft above roof	Flow Rate: 102 CFM Velocity and Temperature were not available	Beryllium: 4.5% Uranium: 11%
883R-002 Vent #45 Duct B Building 879 plenum	Rolling, Shearing, Blanking/Trepanning, and Forming of Depleted Uranium	Rectangular Dimensions 98.5"x52" Roof Height 15.2 ft Stack 6.7 ft above roof	Flow Rate: 102 CFM Velocity and Temperature were not available	Beryllium: 4.5% Uranium: 17%
883R-003 Vent #34 Room 139 Plenum exhaust	Rolling, Shearing, Blanking/Trepanning, and Forming of Depleted Uranium	Circular Stack Diameter 48" Stack height 69 feet	(1)	Uranium: 12%
886S-001 Vent #15 Plenum Building 875	Nitrate Storage Tanks in Rooms 101 and 103	Rectangular Dimensions 48"x24" Roof Height 17.3 feet Stack Height 1.5 feet	Flow Rate: 17.490 CFM Velocity and Temperature not available	Plutonium: 0.03% Americium: 0.04% Uranium: 1.1%
889T-001 Main exhaust plenum	No APEN available Equipment Decontamination	Cylindrical Stack Diameter 28" Stack Height 31.3 ft	(1)	Plutonium: 0.02% Uranium: 0.77%
991U-001 Building 985 plenum	Air handling system for the underground storage vaults 996, 997, and 999.	Rectangle Dimensions 48"x24" Roof Height 18.4 feet Stack 2.0 feet above roof	(1)	Beryllium: 1.4% Plutonium: 0.04% Americium: 0.29% Uranium: 0.80%
991U-002 Main exhaust	Production warehouse and non-destructive testing.	Rectangle Dimensions 60"x54" Roof Height: North 2 ft; West 4 ft; South 20 ft Stack 3.7 ft above the roof	(1)	Plutonium: 0.06% Americium: 0.37% Uranium: 0.44%

Notes: (1) Not characterized in information sources identified to-date. Will be investigated further if required for emission modeling.
(2) The percentages for plutonium, americium, and uranium are included in the percentage provided for vent numbers 1/2 in building 707.

Nitric Acid emission percentages do not include emissions from the tank farm (APEN Building 218).
Methylene Chloride emission percentages do not include data from the sludge drying beds.
Chemical emission percentages are based on data from the Air Pollution Emission Notices.
Radionuclide emission percentages are based ON Department of Energy Effluent Information System totals for 1988.

Sources: EG&G Rocky Flats, 1991
Los Alamos, 1991
USDOE, 1991a

5.2 Waterborne Emissions

The environs of the Rocky Flats Plant include a variety of surface water bodies. Various creeks drain the site, and retention ponds placed along several of them have received surface runoff and waterborne wastes from plant operations. These streams feed into a number of reservoirs which have served as sources of recreation, irrigation, and drinking water for a growing population of Front Range residents.

Surface Water Flow Patterns

Several streams occur near the Rocky Flats site. Three of them, North Walnut Creek, South Walnut Creek, and Woman Creek, drain the Rocky Flats site. North Walnut Creek flows eastward from the plant and into Great Western Reservoir, which supplies drinking water to the city of Broomfield. Woman Creek drains the south portion of the site and flows into Standley Lake, which is a source of irrigation water for the area and supplies water for the cities of Westminster, Thornton and Northglenn. Woman Creek also feeds Mower Reservoir by way of Mower Ditch. Sanitary wastes and laundry wastes have, for periods of Rocky Flats history, been released from the plant to on-site retention ponds on South Walnut Creek which flow to Great Western Reservoir. The primary creeks and retention ponds on the Rocky Flats site are shown in Figure 5-1. Because of the surface water drainage patterns of the area and prevalent airflow patterns, Great Western Reservoir, Standley Lake, and Mower Reservoir are the three water bodies most likely to have been impacted by surface water runoff, discharge of treated and untreated waste water, and airborne effluents from Rocky Flats.

Holding Pond History

Several series of retention ponds have been constructed along the creeks which drain the Rocky Flats site for use in management of plant wastes and surface water runoff. The ponds of primary importance have been known as the A-series and B-series ponds, which are located on North and South Walnut Creeks. Of lesser importance are the C-series ponds on Woman Creek. The A, B, and C-series ponds are shown on Figure 5-1.

From plant start-up in 1952 to 1953, low level contaminated waste containing nitrates and radioactive substances (laundry wastewater including plutonium and uranium) was discharged directly into North Walnut Creek. From 1953, when Pond A-1 was constructed, to 1957, when low-level contaminated waste was rerouted to the process waste treatment facility, low-level waste was discharged into Pond A-1 for eventual discharge into North Walnut Creek. In pre-1970s documents, Pond A-1 is often referred to as Pond 1.

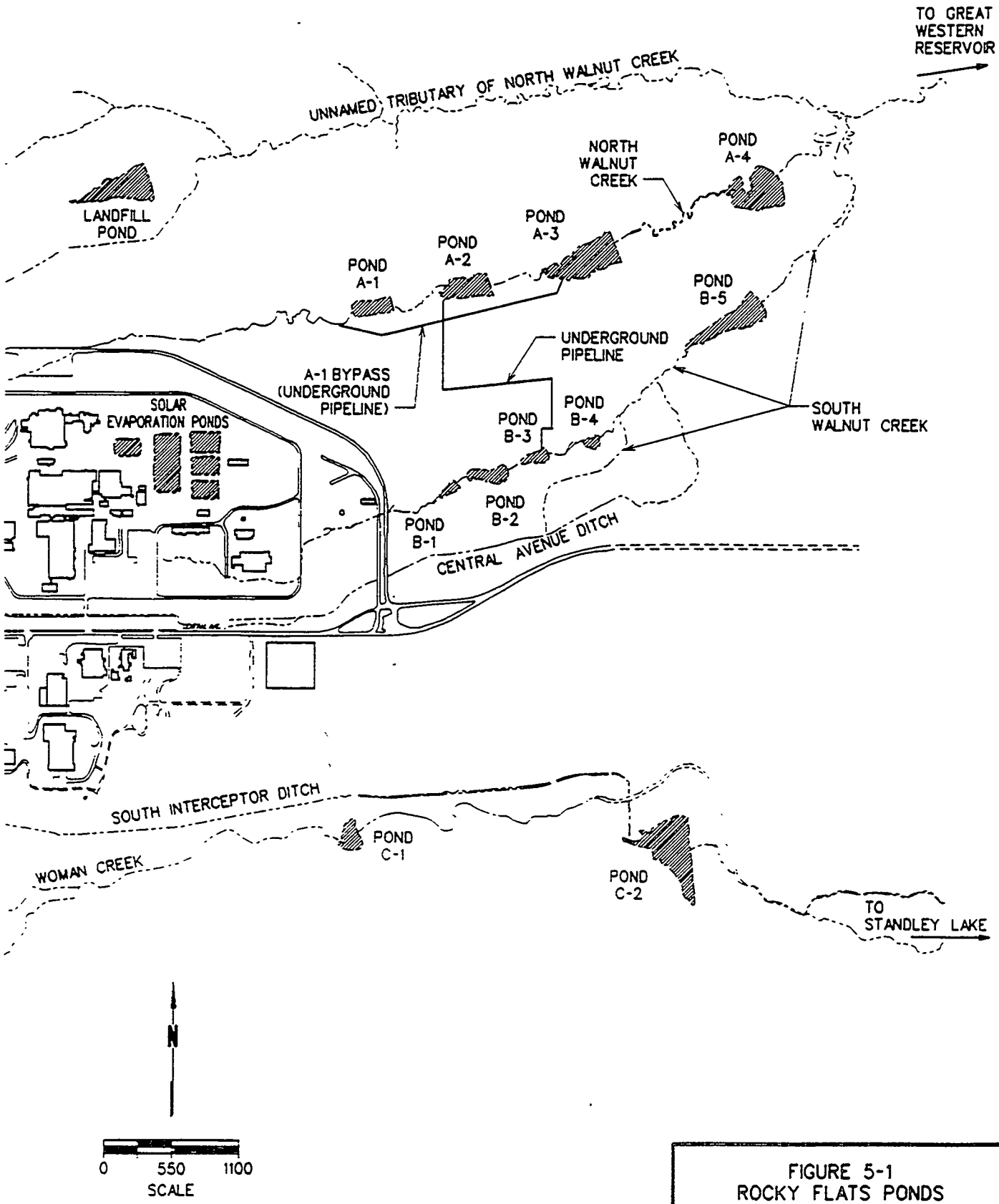

FIGURE 5-1
ROCKY FLATS PONDS
AND CREEKS

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The early discharges of low-level contaminated waste to North Walnut Creek and Pond A-1 resulted in accumulation of significant levels of plutonium in the sediments of Pond A-1 and North Walnut Creek. From 1971 to 1973, Pond A-1 underwent major reconstruction. Reconstruction activities resulted in increased plutonium concentrations in the surface water samples, but not in pond sediments (USDOE, 1991b). It is likely that resuspension of the plutonium allowed it to migrate downstream to Great Western Reservoir.

After 1957, the A-series ponds were used primarily to control surface water runoff from the northern part of the site, however, the ponds also received process liquid waste, cooling tower blowdown, and steam condensate discharges which contained chromates and algicides. After Pond A-2 was completed in the mid-1970s, water from Pond A-1 was allowed to flow into Pond A-2, from which water was disposed of by natural and spray assisted evaporation (USDOE, 1991b). Currently, Ponds A-1 and A-2 are used for spill control and receive only local surface runoff and seepage. Any water that collects in the ponds is spray evaporated.

Pond A-3 was constructed in 1971, and has been used to collect surface water runoff from northern portions of the plant for hold-up prior to being discharged downstream. Runoff from these areas is diverted around Ponds A-1 and A-2 into Pond A-3, where it is temporarily detained before being released to Pond A-4. Pond A-4 was constructed in 1980, and historically received water from Pond A-3 and B-5. Pond A-4 water is discharged into Walnut Creek.

Between 1952 and 1973 decontaminated process wastewater, sewage treatment plant effluent, and laundry wastewater after 1957, were released into South Walnut Creek and subsequently into the B-series ponds. In pre-1970 documents, Ponds B-1 through B-3 are referred to as Ponds 3, 4, and 5 (USDOE, 1991c). The only known radioactive effluent entering the sewage treatment plant and the B-series ponds occurred between 1969 and 1972 when low-level laundry effluent was channelled through the treatment plant. In the latter half of 1972, plumbing changes were made to channel all sanitary plant wastes through the sewage treatment plant and then into the sludge drying beds.

Like in the A-series ponds, the discharge of low-level contaminated wastes to the B-series ponds resulted in the accumulation of plutonium in the pond sediments. From 1971 to 1973, major reconstruction activities on B-series ponds resulted in the disturbance of bottom sediments containing plutonium. Much of the upstream sediment migrated into Pond B-1 and subsequently increased the plutonium inventory of all the B-series ponds as a result of the disturbance.

FIGURE 5-2. THE ROCKY FLATS B-SERIES (LEFT) AND A-SERIES (RIGHT) RETENTION PONDS. VIEW IS TO THE SOUTHWEST.

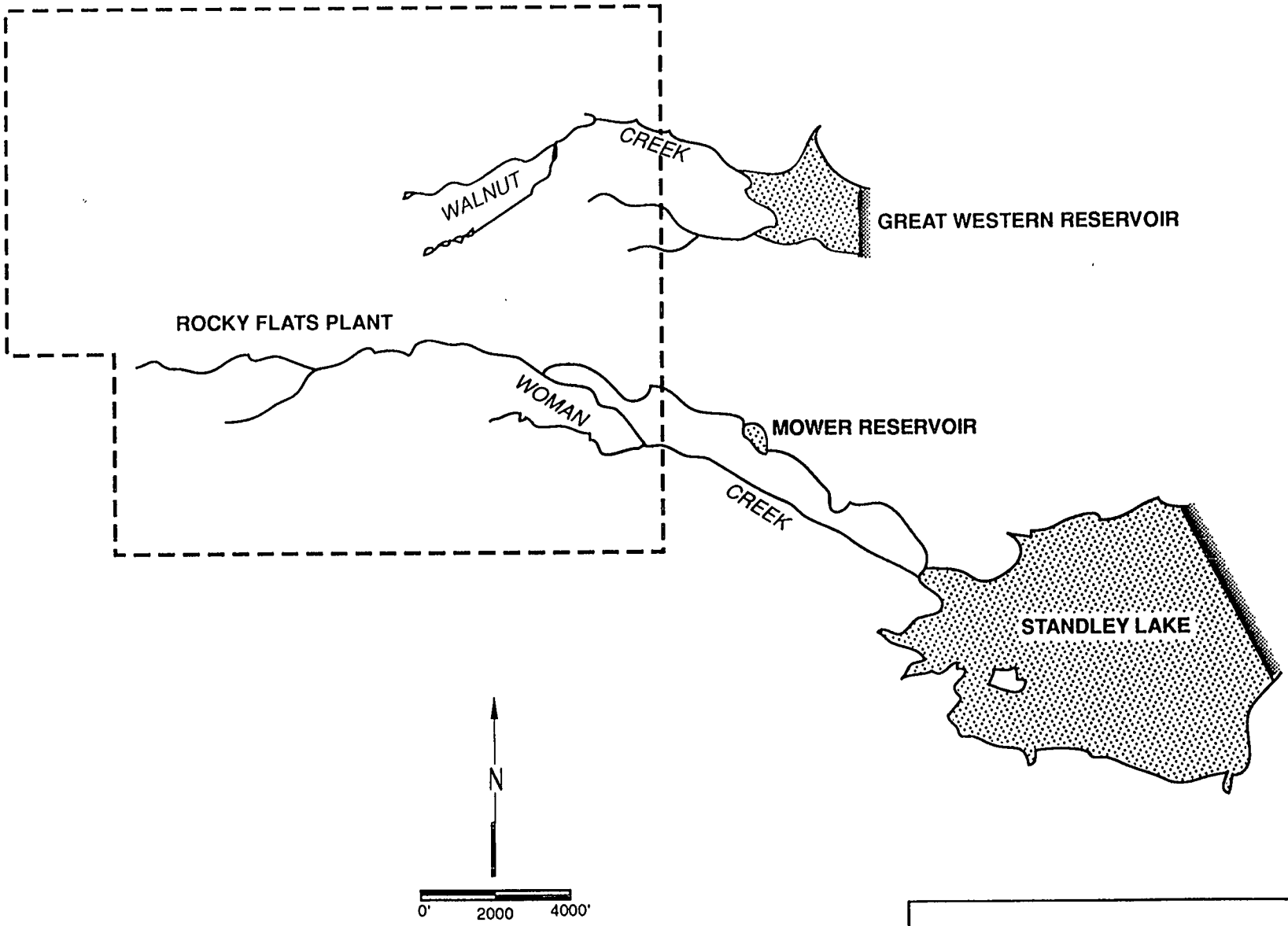
Currently, Ponds B-1 and B-2 are used for spill control and receive only local surface runoff. Pond B-4 receives discharges from Pond B-3, and Pond B-4 water is continuously released to Pond B-5. Pond B-5 was constructed after 1979, and was used as an overflow pond for Pond B-4. In 1991, a pipeline was built to allow periodic pumping of Pond C-2 water into Pond B-5. Currently, Pond B-5 receives water from Pond B-4 and surface runoff from the Central Avenue Ditch. Water in Pond B-5 is detained, then pumped to Pond A-4 prior to being discharged into Walnut Creek and diverted around Great Western Reservoir via the Broomfield Diversion Ditch (BDD).

Currently, the C-series holding ponds are used primarily to capture and control surface water runoff from the plant site. Between 1952 and 1973, filter backwash water from the water treatment facility, which treats water from Clear Creek prior to its use at the plant, was discharged to Pond C-1, detained for a period of time, then released to Woman Creek. Woman Creek empties into Standley Lake. In addition, cooling tower blowdown water was discharged to Pond C-1 until the latter part of 1974. In the early 1970s, plant practices were changed, and Pond C-1 was used principally to manage surface water runoff in the Woman Creek drainage (USDOE, 1991e).

Pond C-2 was constructed in 1980 to detain runoff water from the South Interceptor Ditch. Water in Pond C-2 is monitored monthly and discharged periodically. Discharged water is pumped through the BDD around Great Western Reservoir into Big Dry Creek (USDOE, 1991e).

Great Western Reservoir History

Great Western Reservoir is located approximately 1.5 miles east of the Rocky Flats Plant's eastern boundary. Great Western was constructed in 1904 by the Great Western Reservoir and Canal Company. The reservoir receives surface water runoff from Clear Creek through Church Ditch, Coal Creek through McKay Ditch, Upper Church Ditch, and Walnut Creek. Originally, the reservoir was 42 feet deep and had a storage capacity of 1420 acre-feet. In 1955, the Turnpike Land Company bought the reservoir and established the Broomfield Heights Mutual Service Association to own and operate water and sewer utilities for the Broomfield Heights development. In 1958, the reservoir was enlarged to its present storage capacity of 3250 acre-feet (1.06 billion gallons) and is 62 feet deep (Schnoor, 1991). In 1962, the City of Broomfield bought the water and sewer services from the Turnpike Land Company.



ChemRisk
A Division of McLaren/Hart

FIGURE 5-3
MAJOR RESERVOIRS NEAR ROCKY FLATS

Great Western Reservoir water was used for irrigation until 1955. Since 1955, the sole water use has been as the City of Broomfield's municipal water supply. Public access to the Great Western Reservoir and the surrounding area has been limited since at least 1971. Recreation activities such as fishing and boating have not been permitted. Presently, the area is fenced and posted to exclude the public.

Until 1955, Great Western Reservoir water was used for irrigation only, and no treatment was required prior to use. After the Turnpike Land Company purchased the reservoir, the Company built a water treatment plant. This early "filter plant" had a single treatment unit called a perifilter. The raw water was coagulated with alum, then gravity filtered and disinfected with chlorine. From 1968 to 1972, the water treatment plant was expanded. This expansion included the addition of treatment steps for clarification, additional filtration, and fluoridation. In 1978, the treatment plant was again expanded. This expansion increased the filtering capacity, changed the perifilter unit to a flocculator, added tubes in the clarifier, added another clearwell, and upgraded fluoride feeders (Schnoor, 1991).

The radionuclides contained in plant discharges accumulated in the sediments of the holding ponds, Walnut Creek, and Great Western Reservoir. The U.S. Environmental Protection Agency concluded in 1975 that historical releases of contaminants from Rocky Flats to Great Western Reservoir resulted primarily from the following activities (USDOE, 1991c):

- Early operational practices at the plant in the 1950s and 1960s.
- Holding Pond Reconstruction between 1970-1973, which resuspended pond sediments and released bound radionuclides to Great Western Reservoir.
- A 1973 tritium release from the Rocky Flats Plant.
- Airborne transfer of radionuclides, primarily plutonium.

Standley Lake History

Standley Lake is a large reservoir located approximately two miles southeast of the Rocky Flats Plant's eastern boundary. It is owned by the Farmers Reservoir and Irrigation Company (FRICO). FRICO had the Standley Lake reservoir constructed on Big Dry Creek from 1907 to 1912. The original capacity of the dam was 49,060 acre-feet, however structural problems developed with the dam and limited the reservoirs usable capacity to 17,541 acre-feet. In 1963, the City of Westminster and FRICO entered into an agreement concerning the rehabilitation of the reservoir. Westminster agreed to rehabilitate the reservoir to a total capacity of 42,000 acre-feet. In so doing, the City would receive the use

of the reservoir capacity exceeding 30,000 acre-feet. The rehabilitation was completed in 1966. Once again, structural problems developed with the dam and limited the reservoir's usable capacity. The full capacity of the reservoir did not become usable until 1981 (Tipton and Kalmbach, Inc., 1989).

From 1914 to 1966, water from Standley Lake was only used for irrigation. The water was first used for drinking in 1966, when the City of Westminster completed rehabilitation of the dam. Presently, the City of Westminster owns 37.3 percent of the shares in the Standley Lake Division, and the cities of Thornton and Northglenn own 13.3 and 17.7 percent of the shares, respectively. The remaining shares (31.7 percent) are still owned by FRICO and the corresponding water is transported through irrigation ditches to agricultural areas northeast of the lake, primarily between Broomfield and Fort Lupton (Tipton and Kalmbach, Inc., 1989).

Standley Lake water used for domestic purposes receives conventional treatment, involving coagulation, sedimentation, filtration, and disinfection (ChemRisk, 1991). Water used for irrigation has never been treated.

Mower Reservoir History

Mower Reservoir is a small privately-owned impoundment located just southeast of the Rocky Flats Plant (USDOE, 1991c). The reservoir is fed by Woman Creek via Mower Ditch, an irrigation ditch that originates within the Rocky Flats boundary (USDOE, 1991c). The associated water rights decree states that water from the reservoir was first diverted for irrigation in 1872. The reservoir covers an area of approximately 9 acres and is roughly 50 feet deep at its deepest point and fluctuates in capacity depending upon water supply and demand (USDOE, 1991c). Outflow flows southeast from the reservoir, eventually discharging to Standley Lake (USDOE, 1991c). Mower Reservoir is used for agricultural purposes, stock watering, domestic lawn watering, and irrigation of approximately 80 acres (State of Colorado, 1973). The water in Mower Reservoir is not treated and has never been treated prior to use.

5.3 On-Site Waste Disposal Practices

While most hazardous and radioactive wastes from Rocky Flats operations have been shipped off the site for disposal, there are about 178 inactive waste sites within the plant boundaries. Some of the involved areas have been the sites of storage, burial, incineration, detoxification, and land application of various forms of Rocky Flats waste. Some of the sites have been cleaned up, while others have not been disturbed since their period of activity ended.

It should be noted that the sites depicted in Figure 5-4 and Table 5-2 are those associated with incidents of purposeful disposal of waste. There are numerous documents describing cases of accidental spills, for example Own and Steward, 1974. For the purposes of this project, accidental spills have been evaluated as part of the accidents and incidents investigation described in Section 6.

Table 5-2 describes approximately 50 locations of on-site waste disposal at the Rocky Flats Plant. The locations of these areas are depicted in Figure 5-4. Some of the areas became operational in the early days of plant operation. Most disposal practices have ended, but several of the noted areas remain active as part of modern-day operations of the facility.

The following information is provided for each waste disposal area listed in Table 5-2:

A Description	*The popular name or names of the waste disposal area are identified.*
Map Area	*The spotting codes corresponding to the location of the area on Figure 5-4 are listed to facilitate location by the reader. The letter and number codes (for example B-2) identify the applicable area of the map based on axis labels similar to those used on road maps.*
Nature of Disposal Activity	*The nature of the disposal activity that took place in the area is described to the extent possible based on available documentation. The identity and quantities of the disposed materials are identified, as well as the estimated time period of area use and the methods of disposal. Some values indicating the extent of contamination are included when available. Any retrieval, clean-up, containment, or other remediation measures applied to each area are described.*

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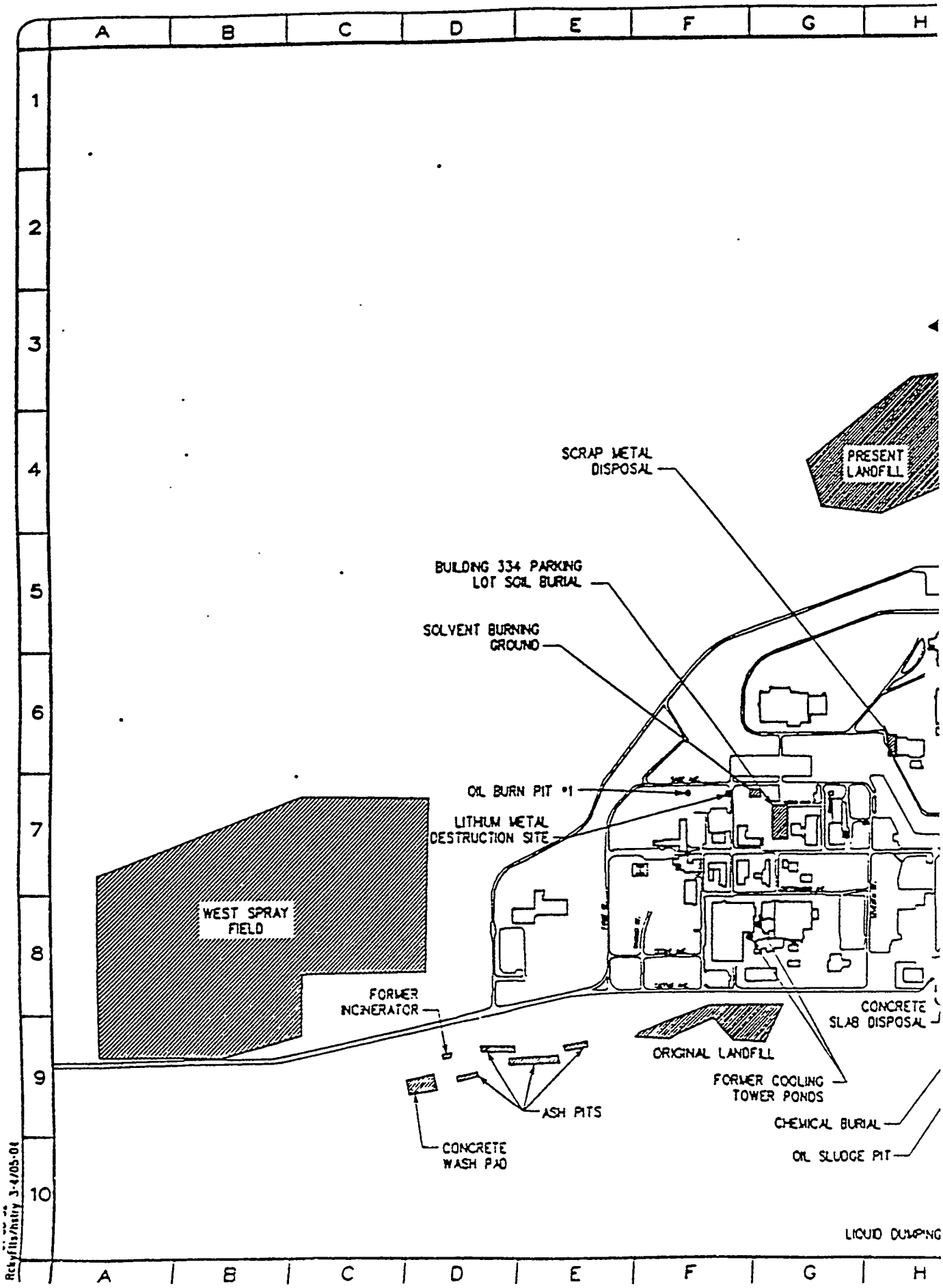
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PRESENT LANDFILL
SCRAP METAL DISPOSAL
BUILDING 334 PARKING LOT SOIL BURIAL
SOLVENT BURNING GROUND
OIL BURN PIT #1
LITHIUM METAL DESTRUCTION SITE
WEST SPRAY FIELD
FORMER INCINERATOR
CONCRETE SLAB DISPOSAL
ORIGINAL LANDFILL
FORMER COOLING TOWER PONDS
ASH PITS
CHEMICAL BURIAL
CONCRETE WASH PAD
OIL SLUDGE PIT
LIQUID DUMPING

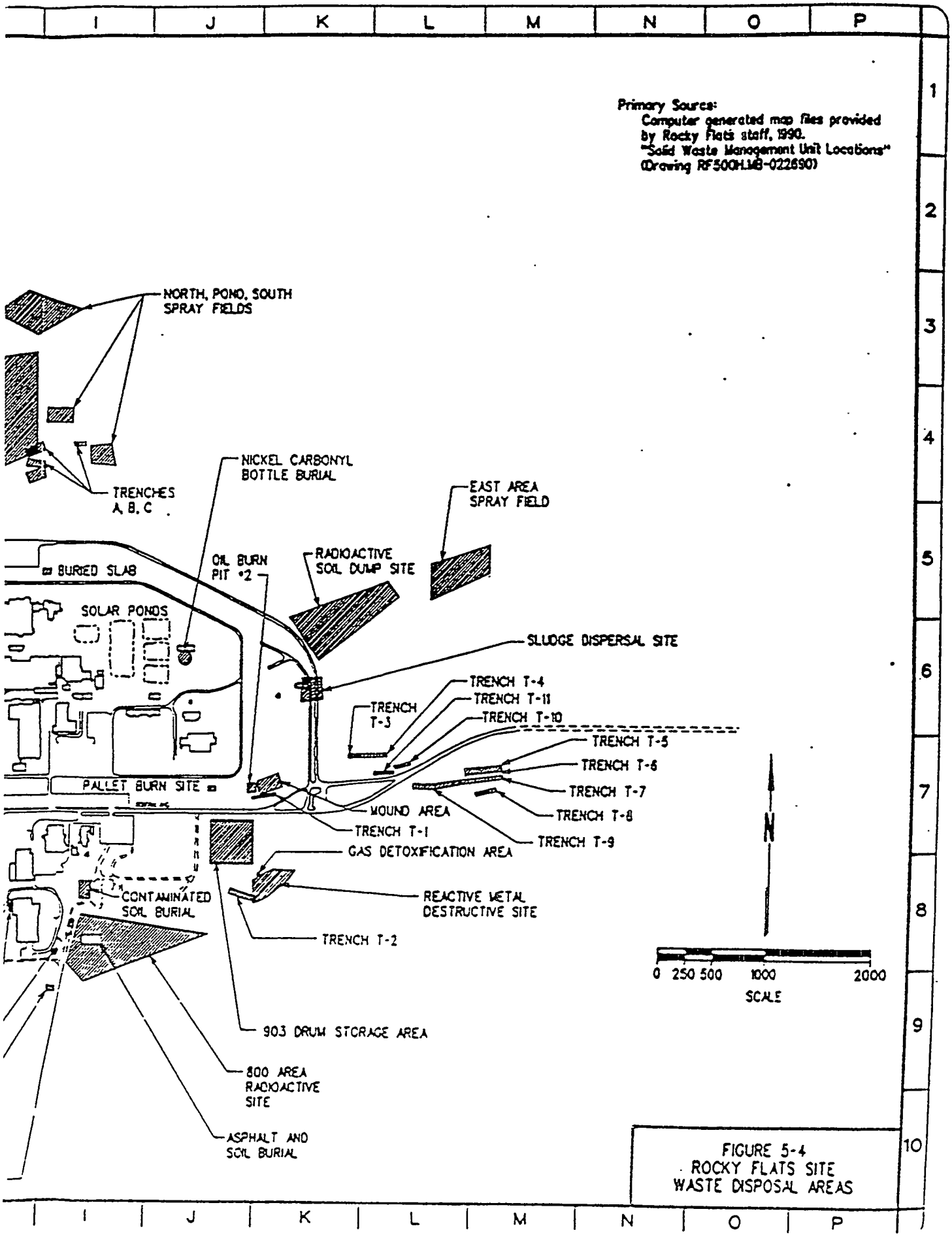

FIGURE 5-4
ROCKY FLATS SITE
WASTE DISPOSAL AREAS

TABLE 5-2: ROCKY FLATS FACILITY WASTE DISPOSAL AREAS

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Spray Fields North of the Plant	H,I-3,4	These spray fields were used shortly after the present landfill became operational in 1986, to spray water from two ponds over ground surfaces to enhance evaporation. The East Landfill Pond, also known as the existing landfill pond, and the West Landfill Pond were used to intercept groundwater that may have been contaminated by landfill leachate. The South Area Spray field was used first, until runoff was found to be draining into North Walnut Creek. Use of that field was discontinued, and use of the North Area Spray Field was also found to flow into North Walnut Creek. Spraying was then moved to the Pond Area Spray Field, and drainage flowed back into the existing landfill pond. In September of 1973, tritium and strontium were detected in landfill pond water. Several metals and radionuclides have been detected in a downgradient bedrock groundwater monitoring well installed in 1989, but may represent natural background conditions (USDOE, 1991b). In May of 1981, the West Pond was covered over as part of an expansion project for the existing landfill (USDOE, 1991b).
Trenches A, B, C	H,I-4	Trench A appeared to be active from 1964 to about 1974. Trench B was active in 1959, with date of closure unknown. Trenches A and B received uranium- and/or plutonium-contaminated sludge from the sewage treatment plant. Trench C is actually two separate trenches, that apparently were active from 1964 until 1974. Materials placed in Trenches C have not been identified, but sewage sludge is most probable. Several metals and radionuclides and TCE have been detected in a groundwater monitoring well in Trench A. Metals and radionuclides may represent background (USDOE, 1991b). The trenches are no longer active. A road was built across Trenches A and C in 1978 (USDOE, 1991b).
Contaminated Concrete Slab Burial Area	I-5	A concrete slab with direct count (non-removable) americium contamination was buried here (Owen and Steward, 1974). The concrete slab was later excavated, and the contaminated portion of the slab was cut off for off-site disposal (Owen and Steward, 1974).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Nickel Carbonyl Bottle Disposal Area	J-6	Between March and August of 1972, approximately 185 pounds of nickel carbonyl ("X-gas", $Ni(CO)_4$) contained in seven 25-pound cylinders, two 5-pound cylinders, and one lecture bottle were disposed of. A "dry well" hole about fifteen feet deep and three feet in diameter was drilled in a remote area of the plant site, and the cylinders were opened by individuals wearing supplied air packs and suspended in the hole until they were drained. In some cases, the chemical ignited immediately after release to the well. In other cases, the well remained silent for long periods before a muffled ignition occurred. Samples at the lip of the hole indicated concentrations around 10 parts per million during the disposal (Hobbs, 1972). The map location is the approximate location where empty nickel carbonyl bottles were buried after the chemical was destroyed by burning during the 1957 fire in Building 771 or when ready for discard. Explosive charges were used to destructively vent the cylinders and ignite any residual gas (Owen and Steward, 1974). There are reports that an additional 12 cylinders were vented and buried one-half mile north and west of the current sanitary landfill (Smith, 1975).
East Area Spray Field	L,M-5	The East Spray Field became operational in 1989 to provide additional area for spray evaporation of water from Pond B-3, which is sewage treatment plant effluent and local surface runoff (USDOE, 1991b). Use of this area was discontinued shortly after it became operational in late 1989 due to problems with excessive runoff (USDOE, 1991b).
Radioactive Soil Dump Area	K,L-5,6	The Soil Dump Area received 50 to 75 dump truck loads of soil containing low levels of plutonium. The soil was excavated during construction of Parking Area No. 334 in the middle of the western half of the plant production area, and had been put there after excavation near Building 774, the waste treatment plant (USDOE, 1991b).
Trench T-1	K-7	Approximately 25,000 kg of depleted uranium chips in 125 drums were deposited in the trench during 1952-1962. The drums were covered with about 2 feet of fill dirt (Owen and Steward, 1974). Depleted uranium was put in the trench primarily due to the hazards of transporting the metal. All drums buried were from Building 444 (Putzier, 1970).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Trenches T-2 through T-8	J-8 K,L,M-7	Approximately 100,000 kg of sanitary sewage sludge and about 275 flattened empty drums contaminated with uranium were disposed of in these trenches. Activities ranged from 800 to 8,000 dpm/g. T-4 also contains some uranium-plutonium contaminated asphalt planking from the 207 solar ponds. Estimated total alpha activity is between 100 and 150 mCi (Owen and Steward, 1974). The first sludge buried on the plant site dates back to July, 1954. Trenches T-2 through T-8 were used for sludge burial up to August 14, 1968, when the sanitary landfill became operational. Concentrations of radioactivity in the dried sludge have not varied much over the years; the maximum reported was 7,900,000 dpm/kg in June 1960, and the minimum was 840,000 dpm/kg in August, 1964. Earlier activity was primarily uranium, with probable increasing plutonium fraction leading up to primarily plutonium composition in later years (Putzier, 1970). Some contaminated asphalt planking discarded from Pond 2A repair work was buried in Trench T-4. Contamination was principally uranium, with minor Pu contamination possible. No quantitative data are available (Putzier, 1970).
Trenches T-9, T-10, and T-11	L,M,N-7	Trenches T-4 through T-11 are all located just east of the East Access Gate outside the security fence. The trenches, approximately 50 by 300 feet in size, were used from 1954 to 1968 for the disposal of flattened drums contaminated with uranium and plutonium. Activity ranges were from 800 to 8,000 dpm per gram. Trenches T-4 and T-11 also contain some uranium and plutonium-contaminated asphalt planking from the solar evaporation ponds and quantities of sanitary sewage sludge (USDOE, 1986).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Mound Area	K-7	A total of 1,045 drums of oil and solid waste were buried. Most contamination was depleted uranium, with some enriched uranium and possibly low-level plutonium (Owen and Steward, 1974). The first mound burial was in April, 1954. Drums were buried here steadily up to March, 1957, at which time uranium contaminated oil from 90 drums was burned. In April, 1957, another 79 were burned. The final burial was in September, 1958, involving 89 plutonium contaminated oil drums from Building 776. The distribution of waste drum sources was as follows: From B-444; 1298 drums of oils, stillbottoms, sand, perclene From B-776; 89 drums of oils with carbon tetrachloride From B-881; 85 drums of oils From B-991; 79 drums of concentrated dry waste From B-771; 46 drums of oils with carbon tetrachloride From B-441; 9 drums of dry waste, paper, glass Assuming similar concentrations of plutonium as from 903 area drums, the mound contained about 285 grams of plutonium. After September, 1958, oil and coolant drums were moved to the mound area but were not buried. In July of 1959, they were moved across the road to begin accumulation in the Building 903 drum storage area (Putzier, 1970). Complete Retrieval and off-site disposal were achieved in May, 1970. No plutonium was detected. Soil samples ranging from 0.8 to 112.5 dpm/g were attributed to 903 Area infiltration (Owen and Steward, 1974).
Pallet Burn Site	J-7	An area southwest of oil burn pit number 2 was used to destroy wooden pallets in 1965. The materials that may have been spilled on the pallets is unknown (USDOE, 1986). A 1974 summation of incidents affecting soils near Rocky Flats indicated on two maps the presence of a "pallet destruction area" south of Building 991. Other than indicating the site was active in 1968, no discussion was provided (Owen and Steward, 1974). There are also indications of pallet disposal activities in a burning pit south of Building 881 in 1965. In May of 1965, a pallet containing 3 sheets (60 kg) of depleted uranium was inadvertently burned in that pit. After discovery of the event, two barrels of contaminated soil were removed for shipment to Arco, Idaho for disposal (Young, 1965).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Oil Burn Pit #2	J-7	A total of 1,082 drums of oil containing uranium were burned during 1957 and 1961-1965. The resulting approximately 10,000 cubic feet of residues and some flattened drums were covered with backfill (Owen and Steward, 1974). A burning pit was cut near the mound, and burning of the contents of 169 drums took place in March and April of 1957. Oil burning area #2 is actually two parallel trenches essentially side by side near the mound. No further burning occurred until June 1961, after which time oils were burned frequently. May 1965 was the last month any burning took place. The total number of drums burned on-site was 1093, but it is not clear how many were 30-gallon or 55-gallon drums. About 250-300 emptied drums were flattened and probably buried in trenches 3, 4, 5, 6, 7, and 8 or mounded over in the burning pit areas (Putzier, 1970). The pit was cleaned up and removed in the 1970s (USDOE, 1986).
Reactive Metal Destruction Site (the 952 area)	K-8	Approximately 400 to 500 pounds of metallic lithium were destroyed over 1956 to 1970. Residues, primarily non-toxic lithium carbonate, were buried. Smaller quantities of other reactive metals (sodium, calcium, and magnesium) and some solvents were also destroyed in this location (Owen and Steward, 1974).
Gas Detoxification Area	K-8	Building 952, utilized for Toxic Gas Storage, was located in this general area. The gas detoxification area referred to (USDOE, 1987 and Helmstadt, 1988) was most likely associated with the nickel carbonyl cylinders that were stored in Building 952 and later destroyed as described under Nickel Carbonyl Bottle Disposal Area in this table (Hobbs, 1972).
903 Drum Storage Area	J-7,8	From 1958 through 1967, approximately 5,240 drums of oil containing radioactivity were stored at this location. Of these drums, 3,570 contained plutonium. Corroded drums lead to deposition of plutonium over an area of 98,000 square feet, which was covered with asphalt and fill material in November, 1969 (Owen and Steward, 1974). Over 1959 to 1966, the distribution of drum sources was as follows: B-776 (69%), B-881 (17%), B-444 (8.6%), B-883 (3.5%), B-771 (2.5%). Drums were moved to the area after 1966. Some of the uranium contaminated oils at the 903 area were burned. The contents of 191 drums were processed for Pu recovery at the 903 filter plant. With the transfer of contents into new drums, the equivalent of 4826 55-gallon drums were transported to Building 774 for solidification. Of these, 3572 contained Pu contaminated coolant (Putzier, 1970).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
800 Area Radioactive Site Liquid Dumping Area Chemical Burial Area	I,J-8,9 I-8 I-8	From 1951 until 1972, portions of the "Hillside Area" near Building 881 were used as oil sludge pits, chemical burial sites, liquid disposal sites, solvent drum storage sites, and fire damage refuse disposal sites. As a result, soil and groundwater have been contaminated with volatile organic compounds including carbon tetrachloride, TCE, and PCE. Alluvial groundwater contains 1,1,1-TCA, and chloroform. Uranium was the only radionuclide occurring above estimated background concentrations (USDOE, 1990). One of the Solid Waste Management Units (SWMUs) in the 881 Hillside area, SWMU 130, is sometimes called the 800 Area Radioactive Site #1 (Helmstadt, 1988).
Contaminated Soil Burial	I-8	Plutonium contaminated soil from the periphery of Building 774 waste storage tanks was buried here. The soil averaged 250 dpm per gram. The 240 drums of soil were buried under 3 feet of fill dirt (Steward, 1973).
Asphalt and Soil Burial	I-8	Approximately 320 tons of plutonium-infiltrated asphalt and soil from the 1969 Building 776 fire were buried in 1969 under 1 to 2 feet of fill dirt. Less than 1 mCi of plutonium is estimated to be dispersed in about 250 cubic yards of material, with an estimated alpha activity of about 7 dpm/g. About 60 cubic yards of plutonium contaminated soil from the Building 774 waste storage tank area was placed on top of the asphalt disposal area in 1972, and covered with 3 feet of fill dirt. Estimated activity of the soil was less than 250 dpm/g total long-lived alpha (Owen and Steward, 1974). Total contained plutonium is estimated at 0.97 mCi or about 14 milligrams (Putzier, 1970).
Oil Sludge Pit	I-9	Approximately 30 to 50 drums of oil sludge from a storage tank cleanout were emptied into a pit, which was then backfilled. No radioactivity was involved (Owen and Steward, 1974).
Concrete Slab Disposal Area	H-8	An area of several hundred square feet northwest of Building 881 was involved in storage of a contaminated concrete slab in 1958. The slab had been removed from the east side of Building 776 (Owen and Steward, 1974). The slab was later broken up, removed, and the area cleaned (Owen and Steward, 1974).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Original Landfill	F,G-9	The original plant landfill was used from 1952 to 1968 to dispose of general plant wastes. An estimated 20 kg of depleted uranium ash is buried along with normal plant waste, including small quantities of various chemicals. The 20 kg of depleted uranium resulted when 60 kg was inadvertently burned and only 40 kg were recovered. (Owen and Steward, 1974). The landfill may have received nonradioactive hazardous chemical wastes generated at the plant, including solvents. A reported old graphite dump located south of Building 440 that might have received beryllium and uranium was actually the original plant landfill (USDOE, 1986).
Former Incinerator	D-9	From 1952 to August, 1968, all combustible noncontaminated waste from the Rocky Flats Plant was incinerated in Facility 219 along the west access road. All noncombustible noncontaminated trash and ashes from the incinerator were dumped adjacent to the incinerator and covered with dirt (Seastone, 1973) Small quantities of depleted uranium contaminated combustibles were burned along with the general combustible plant refuse over the years 1952 to 1968. It is estimated that less than 100 grams of depleted uranium would be involved (Piltingsrud, 1973). The incinerator burned office-type wastes and some depleted uranium chips. Ashes were put into pits located adjacent to the incinerator or were pushed over the side of the hill into the Woman Creek drainage. Incineration was discontinued and the incinerator demolished in the early 1960s (USDOE, 1986).
Incinerator Ash Pits I-1 through I-4	D,E-9	An estimated 100 grams of depleted uranium was burned with general combustible waste in the nearby incinerator from 1952 through 1968. Ashes from the incinerator were buried in these trenches (Owen and Steward, 1974). Some unknown quantity of depleted uranium contaminated incinerator ashes were dumped in an area south of West Road and within a few hundred feet southeast and southwest of the incinerator (Putzier, 1970). Ashes from operation of the incinerator were put into pits located adjacent to the incinerator or were pushed over the side of the hill into the Woman Creek drainage. Incineration was discontinued and the incinerator demolished in the early 1960s. The ash pits were covered with fill (USDOE, 1986).
Concrete Wash Pad	D-9	There have been reports that material from Buildings 444 and 881 was placed between the original sanitary landfill and the incinerator ash pits. More recently, cement trucks were washed in that area (Smith, 1975). It appears that the area was used to dispose of waste concrete from plant construction activities. It is also likely that concrete trucks were washed down in this area after delivering concrete (USDOE, 1991e).

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
West Spray Field	A,B,C,D-7,8,9	From 1982 to 1985, the West Spray Field was spray irrigated with water from solar evaporation ponds that contained elevated levels of nitrates and other wastes. The practice may have contaminated the ground water and the water in the soil lying just above the ground water (USDOE, 1991d).
Lithium Metal Destruction Areas	F-7	Approximately 400 to 500 pounds of metallic lithium were destroyed over 1956 to 1970. Residues, primarily non-toxic lithium carbonate, were buried. Smaller quantities of other reactive metals (sodium, calcium, and magnesium) and some solvents were also destroyed in this location (Owen and Steward, 1974). Building 335 is located over an old lithium metal destruction site. Lithium metal was disposed of at this location by placing it in trenches and reacting it with water. Residues were covered with soil (USDOE, 1986).
Soil Burial Area, Building 334 Parking Lot Area	G-7	Soil containing low levels of plutonium was placed near Building 334 after excavation near Building 774, the waste treatment plant. The volume of the soil containing plutonium and the associated concentrations are not known (USDOE, 1991b). Between 50 to 75 dump truck loads of soil were removed during construction of Parking Area No. 334 and placed in the Soil Dump Area on the northeast side of the plant (USDOE, 1991b).
Oil Burn Pit #1	F-7	Ten drums of oil containing depleted uranium were burned in August 1956. The residue was covered with backfill. The area is now located under Building 335 and involves approximately 70 cubic feet of depleted uranium residue (Owen and Steward, 1974). The first oil was burned in August 1956 in what was referred to as the garage oil burning pit (Putzier, 1970). Building 335 was constructed over burn pit number 1 and a lithium metal destruction site (USDOE, 1986).
Solvent Burning Ground	G-7	A "solvent burning ground", designated at solid waste management unit number 171, is listed in various documents (Helmstadt, 1988; EN-589 and USDOE, 1987). Building 335 has been used in the past, and still is to some degree, for training of fire department personnel. The original, preconstructed building was placed in an area north of Building 331 after the 1969 fire (PAC 700-157.7). Experiments took place to test heat and water effects on different types of materials, for example, filter plenums. When this area was first used for training purposes, magnesium chips coated with a water soluble material were burned. Diesel fuel was the main material that was used. Gasoline was utilized to ignite the diesel fuel. The fire fighters may have also used waste solvents.

DESCRIPTION	MAP AREA	NATURE OF DISPOSAL ACTIVITY
Scrap Metal Disposal Area	H-6	Scrap metal components, mostly from original construction, were buried in this area. Although no detectable radioactive or chemical contamination was observed, some pieces came from process areas and low level contamination of a small percentage is possible (Owen and Steward, 1974).
Former Cooling Tower Blowdown Retention Ponds	F,G-8	These small ponds were used to contain water from cooling towers. Hexavalent chromium is present. Some quantity of lithium was also destroyed in the two eastern-most ponds. These ponds were covered with fill (Owen and Steward, 1974) and may have been used to bury small amounts of depleted uranium (USDOE, 1986).
Present Landfill	G,H-3,4	Started operation in 1968, and currently in use. Materials with less than Minimum Detectable Activity radioactivity (500 dpm/60 square cm direct or 50 dpm/square ft smear) are accepted for burial. From August 1968 to February 1970, approximately 1,000 kg of sanitary sewage sludge, with 800 to 8,000 dpm/g of alpha activity, were buried. Estimated total activity was 1 to 1.5 mCi. Recent surveys have detected other radionuclides, including tritium, in small quantities (Owen and Steward, 1974).

Most of the waste disposal activities described in Table 5-2 involved shallow-land burial of materials or localized contamination of soil. The potential off-site impacts of these waste disposal activities are associated primarily with surface water or ground water contamination. In this study, burial and soil contamination incidents will be addressed in terms of potential off-site impacts via surface water and ground water pathways.

A smaller number of disposal practices resulted in airborne emissions. The activities potentially impacting off-site air quality that were of sufficient duration or extent to be considered quantifiable for source term development are the burning at the Pallet Burn Site, oil burning at Pit 1 and Pit 2, and the oil storage at the Building 903 Drum Storage Area which lead to soil contamination and dispersal that is being studied in detail as part of the accident and incident portion of the project.

5.4 Waste Received from Off-Site Sources

Because of the unique capabilities of the Rocky Flats Plant to handle hazardous materials, process wastes, and arrange for shipment of wastes to federally-approved disposal facilities, a number of private companies, educational institutions, and federal facilities have historically called upon Rocky Flats for assistance with waste treatment, storage, and shipment. Instances in which Rocky Flats received wastes from off-site entities are described in this section.

In June of 1957, the Rocky Flats AEC Office granted permission for the Dow Chemical Company to accept at Rocky Flats wastes generated by local off-site institutions and government agencies. Wastes initially received originated from Lowry Air Force Base, Martin Aircraft Company, The Bureau of Reclamation, and the U.S. Geological Survey. Over the period from 1957 to 1971, in which Rocky Flats policy allowed handling of off-site waste, wastes were received from the following industries and agencies (Ryan, 1957 to 1971):

The U.S. Bureau of Reclamation
The Colorado School of Mines
Colorado University School of Medicine
The Coors Porcelain Company
The Denver Research Institute
"Dow Construction"
General Electric Sandia Laboratories
Lawrence Radiation Lab

Martin Aircraft Company
The Rocky Mountain Arsenal
Sunstrand
TOSCO
U.S. Department of the Interior
"USF and WL" (US Fish and Wildlife Commission?)
Veterans Administration Hospital

With the exception of some of the wastes received from the Coors Porcelain Company, which are discussed in detail below, information about the types of wastes received at Rocky Flats from off-site sources is limited. Most of the information was obtained from monthly reports generated by the Rocky Flats Waste Disposal Coordination Group. These reports document the types and numbers of containers received, the date received, the date of disposal, and place of disposal. Sometimes totals given are combined waste shipments from several sources, with the percent contribution from each individual source not indicated. Further information describing the composition of wastes received has not been located.

With the exception of the liquid wastes received from Coors, which were dumped into the solar evaporation ponds and treated in the same manner as Rocky Flats liquid wastes, all wastes received at Rocky Flats documented in the monthly reports were shipped off-site for disposal, most commonly in Idaho, without treatment at Rocky Flats. Wastes introduced to the solar ponds were treated as described in Section 3, with residues shipped off-site for disposal. While there is evidence that other off-site originating wastes were introduced into the solar ponds, for example wastes from the Colorado State University beagle dog studies (USDOE, 1986), they were not documented in the waste disposal group monthly reports. Our investigation has indicated no cases of waste being received at Rocky Flats from off-site sources and being disposed of on the Rocky Flats site.

From 1957 to 1971, Rocky Flats trans-shipped to off-site, government operated disposal facilities in Arco, Idaho, the following quantities of waste: 318 fifty-five-gallon drums, 48 twenty-gallon drums, 4 thirty-gallon drums, 126 cartons, 3 boxes, and 3 Chemical Warfare Service (CWS) filters for off-site generators. Table 5-3 presents a chronology of the wastes received at Rocky Flats from the various industries, institutions, and agencies. More detailed available information about some of the cases of Rocky Flats involvement in handling of off-site generated wastes is summarized in this section.

TABLE 5-3
ANNUAL SUMMARY OF OFF-SITE WASTES RECEIVED AT ROCKY FLATS

CALENDAR YEAR AND SOURCE	WASTE RECEIVED AT ROCKY FLATS
1957	
Martin Aircraft	Nine 55-gallon drums
Lowry AFB	51 cartons
US Bureau of Reclamation	Two 55-gallon drums One box One carton
1958	
Lowry AFB	64 cartons
Sunstrand	Twenty-nine 55-gallon drums
1959	
Sunstrand	Ten 55-gallon drums
Lowry AFB	Two 55-gallon drums
1960	
Denver Research Inst.	3 Chemical Warfare Service Filters
1961	
GE Sandia	Twenty-eight 20-gallon drums Thirteen 15-gallon drums
Denver Research Inst.	Four 55-gallon drums Two 30-gallon drums One carton
Lowry AFB	Four 55-gallon drums
Sunstrand	Two 30-gallon drums
Coors Porcelain	99,700 gallons of beryllium contaminated waste "First shipment of beryllium contaminated waste was received from Coors on June 23, 1961."

CALENDAR YEAR AND SOURCE	WASTE RECEIVED AT ROCKY FLATS
1962	
GE Sandia	Nine 20-gallon drums
Denver Research Institute	Seven Cartons
Coors Porcelain	137,000 gallons of beryllium contaminated waste A total of 502 drums of waste for temporary storage was received from Coors during 1962. "The first shipment of high level wastes from Coors was received July 30, 1962 and consisted of 13 drums. These drums were stored in the "Bull Pen". "The first uranium contaminated wastes were received from Coors on August 20, 1962."
CU Medical School	"The first of contaminated wastes from the Colorado Medical School were received on July 5, 1962."
1963	
Lawrence Radiation Lab	Forty-two 55-gallon drums
Coors Porcelain	22,000 gallons of beryllium contaminated waste. 246 drums of wastes for temporary storage (bringing the total drum storage to 748). In March of 1963 "a crew from Coors worked the drums of solid wastes in preparation for a shipment. Coors also returned six drums to Golden, Colorado." In May of 1963 "Coors Porcelain Company made a rail shipment of solid wastes during the month."
1964	
CU Medical School	Three 55-gallon drums
Colorado School of Mines	Two 55-gallon drums
Coors Porcelain	Twenty-six 55-gallon drums

CALENDAR YEAR AND SOURCE	WASTE RECEIVED AT ROCKY FLATS
1965	
January through June	No information
USGS and Denver Research Inst.	One 55-gallon drum
1966	
USGS and Denver Research Inst.	Three 55-gallon drums One 30-gallon drum One carton
1967	
USGS and Denver Research Inst.	Two 55-gallon drums
USGS	One 55-gallon drum
U.S. Dept. of the Interior	Two 55-gallon drums
1968	
Dow Construction, USGS, U.S. Dept. of Interior, VA Hospital	Eight 55-gallon drums One 30-gallon drum Two wooden boxes
1969	
Dow Construction, USGS, U.S. Dept. of Interior, VA Hospital, TOSCO, Rocky Mountain Arsenal, and Coors Porcelain	Thirty-two 55-gallon drums One carton
1970	
TOSCO	Twenty-five 55-gallon drums
VA Hospital	One 55-gallon drum
USGS	Sixteen 55-gallon drums
Coors Porcelain	Forty-four 55-gallon drums

CALENDAR YEAR AND SOURCE	WASTE RECEIVED AT ROCKY FLATS
1971	
USGS	Twenty-one 55-gallon drums
Denver Research Inst.	Five 55-gallon drums
USF & WL	Thirteen 55 gallon drums including 1 drum containing 20 Ci of tritium tracer material

Sources: Ryan, E.S. 1957-1971; History Reports - (Issued Monthly) - Waste Disposal Coordination Group, Rocky Flats Plant.

The Coors Porcelain Company

The Coors Porcelain Company (CPC) of Golden, Colorado entered into a contract in September of 1960 to manufacture 756,000 beryllium and beryllium-uranium fuel elements as part of a project to develop a nuclear propelled "ramjet" (air breathing) low-altitude supersonic missile system. In what was called the Pluto Program, CPC processed about 225 kilograms of uranium-235 in making the unfueled beryllium and fueled beryllium-uranium elements for the Tory II-C reactor designed by the Lawrence Livermore Laboratory. The following discussion is based on a package of information concerning project Pluto that was assembled by Rocky Flats staff in 1986 (Vejvoda, 1986). Details have been verified by ChemRisk review of waste management group records.

Agreements were reached with the AEC to allow CPC to dispose of Pluto program wastes at Rocky Flats, and to use Rocky Flats as an intermediate stopping point for solid wastes destined for federally-approved radioactive waste burial grounds. The first shipment of liquid waste received at Rocky Flats from CPC was reportedly on June 23, 1961. There is no indication of the amount. In 1962, 73 shipments of liquid waste were received from CPC, for a total of 179,700 gallons. Liquid wastes containing beryllium oxide and enriched uranium from the CPC fuel element fabrication process were transported to the Rocky Flats solar evaporation ponds in a 2,500 gallon tanker truck. For waste water to be eligible for transfer to the Rocky Flats solar ponds, the uranium concentration was required to be less than 20 parts per million. There was no similar limit on beryllium concentration. During fiscal year 1963, 33 shipments of liquid waste were received from CPC, for a reported total of 81,500 gallons.

The CPC, in their final operations report for the project, estimated that the total amount of uranium deposited in the solar ponds was 962 grams, accompanied by a minimum of 631.4 kilograms of beryllium, 1.0 kilogram of yttrium, and 0.6 kilogram of zirconium. Of the uranium processed by CPC, 5,276 grams were ultimately "not located", 3016 grams of which were unaccounted for, and 962 grams were "suspected" to have been sent to the Rocky Flats solar evaporation ponds. Rocky Flats did not validate or monitor the composition of the CPC liquid waste that was discharged to the solar ponds. The major portion of the CPC material deposited in the solar evaporation ponds was reportedly removed during 1970 and 1971, after a "Pond Alligator" system was installed in 1970 to pump sludge from Pond 207B to Building 774 for dewatering and packaging. The dewatered sludge was reportedly shipped to Idaho for disposal, and the filtrate returned to the solar evaporation ponds.

Rocky Flats also received some solid wastes with low-level uranium contamination from CPC and arranged shipment to the federally-operated National Reactor Testing Station (NRTS) in Idaho and temporarily stored some high-level uranium-235 scrap from the CPC. Records indicate that twenty-six 55-gallon drums of low-level uranium contaminated waste

from the CPC, with a gross weight of 5,373 pounds, were trans-shipped to NRTS from Rocky Flats between June 30, 1964 and June 30, 1965.

Some enriched uranium contaminated government-furnished "excessed" (GFE) equipment associated with the Pluto Program was reportedly part of the contaminated waste stored at Rocky Flats, possibly in the area that was to become known as the 903 pad, prior to being shipped to Idaho in 1964 or 1965 for ultimate disposal.

CPC grinding and inspection activities reportedly generated significant quantities of enriched uranium scrap. When faced with a shortage of suitable storage space, CPC arranged for high-level uranium-235 scrap to be temporarily stored in a locked, fenced area on the Rocky Flats site called the "Bull Pen". This practice started with the receipt of 13 drums by Rocky Flats on July 30, 1962. By February 1963, a total of 748 drums of the scrap were in storage at Rocky Flats. Rocky Flats was not involved in any processing of this waste. The drums were shipped back to CPC by rail during May of 1963 for shipment to NUMEC for uranium recovery reprocessing.

Lawrence Livermore Laboratory terminated its contract with CPC in 1964. The fuel element fabrication project was abandoned. However, Rocky Flats waste records indicate that CPC's radioactive waste was still being accommodated in fiscal year 1970 (Vejvoda, 1986). Since 1971, Rocky Flats has had a policy prohibiting the receipt, storage, or trans-shipping of waste generated off-site.

PCB Waste Handling

Some limited details regarding handling of PCB wastes at Rocky Flats have been identified by the project (Buffer, 1991). They include:

- In 1980, "Rocky Flats Plant responded to a request by Congressman Tim Wirth and temporarily accepted for storage 17 barrels of PCB oil located on a Lafayette farm."
- In 1981, "the fluidized bed incinerator was used to successfully burn a gallon of PCBs."
- In 1982, "PCBs were shipped from Rocky Flats June 24 for disposal in Deer Park (near Houston) Texas; this included shipment of 17 drums of PCBs taken from a farm at Lafayette and stored on plant site." (Buffer, 1991).

None of these events are associated with releases of PCBs to the environment. Incidents involving PCBs are discussed in Section 6.0.

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6.0 ACCIDENTS AND INCIDENTS AT THE ROCKY FLATS PLANT

One of the objectives of the Rocky Flats Toxicologic Review and Dose Reconstruction project is the identification of any non-routine plant releases that significantly contributed to the off-site dose of chemicals or radionuclides to the public. As a result, a considerable amount of effort was invested in attempting to locate documentation of events not previously publicized that might have resulted in significant off-site exposures. This section discusses the accident investigation process and provides a summary of the available historical information associated with the major accidents or well known events.

6.1 Sources of Accident Information

In investigating accidents, incidents, and "as-found conditions" at the Rocky Flats Plant, the following information sources were used. Many of these resources were also used to reconstruct the history of normal operations:

Industrial Safety Files (1952-1990)
Occurrence Managements's Summary of Events Database (1952-1990)
The Legal/Environmental (Church Litigation) Files
The Environmental Master File
Rocky Flats Public Reading Room
Building 706 Technical Library (classified and unclassified reports)
Personnel Interviews
Building 881 Archives
Denver Federal Records Center

Accident reporting to the U.S. Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA), or to the Department of Energy (DOE) has always been mandatory. The criteria for a reportable accident has varied considerably over time. The criteria for a reportable accident are related to worker injuries, worker radiation exposure levels, shutdown of any operations, damage costs, publicity, and the potential for off-site release. Documented accident reporting criteria were identified for the period from 1943-1975 and those currently in effect (effective May 30, 1990). Changes in accident reporting requirements to the federal agency over time has led to the reporting of accidents associated with lower exposure levels and lower damage costs.

Accidents reported to DOE include fatalities (e.g., death from complications following a fall) and high cost damages (e.g., roof blown off a building), which may have little or no potential for any off-site impacts. In this respect, the list of accidents reported to DOE is too broad for the purposes of this study. However, the list does not include minor worker accidents, such as cut fingers, on-site car accidents, and small contained fires which are documented by voluminous reports maintained at the plant. The list also does not include "as found conditions," such as the release of plutonium from leaking drums at the Building 903 drum storage area.

A list of accidents reportable to the AEC is summarized for 1943 to 1970 in an AEC publication (USAEC, 1971) and an updated version of that document for 1943-1975 (USAEC, 1975). A similar listing has not been identified for the period 1975-1990, but numerous other documents and reports cover this period.

Internal Rocky Flats Plant documents and external sources of accident information were reviewed to identify large releases of chemicals or radionuclides that were either not identified in the DOE reports or which did not meet DOE reportable criteria.

Industrial Safety Office Records

Industrial Safety/Occurrence Management records are made up of the following file types:

"Occurrences" from 1952 to 1981
"Supervisor Investigation Reports (SIRs)" from 1982 to 1988
"Unplanned Events (UEs)" from 1988 to 1989
"Unusual Occurrence Reports (UORs)" from 1982 to 1989
"Internal Investigation Reports (IIRs)" for unstated dates

The file contents reflect changes in report names, definitions of accident-related terms, and threshold levels for reportability of events over the years of Rocky Flats Plant operation in response to DOE Orders and plant policy changes. For the major incidents, a committee is formed to conduct an investigation and prepare a report, consisting of findings and recommendations. The Industrial Safety files typically contain the committee's report, documentation of recommended actions, and detailed supporting documentation. The file for a given incident is considered "open" until corrective action plans are completed.

Review of Industrial Safety Office records allowed the project team to document the detail and completeness of Rocky Flats accident and incident records. While background information in the records facilitated evaluation of the significance of particular events from among the wide range of occurrences documented in other sources, no new accidents or incidents were discovered in the Industrial Safety records that appear to have had potential for off-site impact from large releases of chemicals or radionuclides.

Occurrence Management Department Database

The most complete historical record available of all accidents at Rocky Flats is maintained by the Occurrence Management Department of EG&G Rocky Flats in the form of the Summary of Events (SOE) database that covers the period from 1952-1990. The SOE database was created in the early 1980s based on a review of the Industrial Safety files and has been updated on an annual basis since that time. At the time of ChemRisk's review, the database contained approximately 1,767 accident entries.

The SOE database includes all accidents reported to DOE which are listed in Operational Accidents and Radiation Exposure Experience within the U.S. AEC, 1943-1975. The Summary of Events database does not include "as found conditions," such as the 903 Pad, and it does not always provide information on the off-site release potential of an accident.

While the Occurrence Management Department SOE database identified a wide range of events associated with operations at Rocky Flats, a great majority of the events have no significance from an off-site chemical or radionuclide exposure standpoint. No new accidents or incidents were discovered in the Occurrence Management Department records that appear to have had potential for off-site impact from large releases of chemicals or radionuclides.

Legal/Environmental Files

Document titles and summaries from a keyword search of the Legal/Environmental Index (LEI), which references Legal/Environmental File documents from the period 1957-1978, were reviewed to identify any discussion of accidents not listed in the SOE database. The keywords used include "accident," "incident," "unusual occurrence," "unplanned event," and "investigation." Twenty occurrences are mentioned in various documents that are not listed in the SOE database. Seven are small fires, five are localized radioactive contamination, two are small contained spills of radioactive liquid, three involve contaminated outside soils, one involves a worker exposure and two are transportation related incidents.

Two accident summary documents were located in the keyword search of the LEI. The first is Compilation of Incidents Excerpted from the Executive Safety Council Minutes (December 21, 1965) which lists 99 incidents, 77 of which are not listed in the SOE database. However, the 77 incidents are primarily laboratory spills involving small amounts of non-radioactive chemicals. The second document, Report on Reference Material in Reply to Summary of Known Incidents at Rocky Flats (November 11, 1973), identifies one incident that is not listed in the SOE database. The incident involved a nonreportable to DOE enriched uranium fire recorded in a Health Physics Status Report. In addition, the November 11, 1973 document includes "as found conditions," such as on-site burial at 881 Hillside and the 903 Pad.

The Legal/Environmental files, as accessed by the LEI, were a source of much background information on events of environmental significance at Rocky Flats. While they contributed significantly to project team understanding of Rocky Flats operations and activities associated with accident and incident investigation, documentation, evaluation, and clean-up, no new accidents or incidents were discovered in the Legal/Environmental Files that appear to have had potential for off-site impact from large releases of chemicals or radionuclides.

Environmental Master File

The following accident-related reports were found in the Environmental Master File (EMF) at Rocky Flats:

- Review of the Exhaust Air Filtering and Air Sampling, B-771 (1965)

  This document correlates elevated stack effluent emissions and accidents for the period 1953 to 1963. All accidents identified in the document are also listed in the SOE database and the DOE listing. However, some elevated stack releases are associated with damaged filters and filter system configuration changes that are not associated with an accident.

- Compilation of Incidents Excerpted from the Executive Safety Council Minutes (1965)

- Report on Reference Material in Reply to Summary of Known Incidents (1973)

- A Historical Summation of Environmental Incidents Affecting Soils at or Near the U.S. AEC Rocky Flats Plant (1974)
- Comprehensive Environmental Assessment and Response Program (CEARP)-Phase 1, Installation Assessment Rocky Flats Plant (1986)
- Past Accidental Releases of Radioactivity from the Rocky Flats Plant by C.W. Barrick (1981)
- The Past 30 Years at the Rocky Flats Plant by E.A. Putzier (1982)
- Response to CERCLA 104(e) and RCRA 3007 Information Request (1990)
- RCRA Spill Documents (1989, 1990)

  RCRA Spill Documents for the years 1989 and 1990 identified three releases that do not appear on other accident listings. Two of the spills were captured in retention basins and the third was contained in a valve vault. These three spills were therefore not associated with significant off-site releases.

The Environmental Master File was a source of much background information on plant design features, effluent and environmental surveillance practices, and events of potential environmental significance at Rocky Flats. However, no new accidents or incidents were discovered in the EMF that appear to have had a potential for off-site impact from large releases of chemicals or radionuclides.

The Building 706 Technical Library

Both classified and unclassified documents located in the Rocky Flats Technical Library were reviewed. Classified reports of three accidents were noted. One accident is listed in the SOE database as the August 22, 1971 "Smith-Olveda" inhalation exposures of two workers to plutonium. The other two involved a small fire and a localized release of radioactive material that was captured by ventilation filtration systems. Neither of these two incidents appear to have had potential for off-site health impacts. In the "Smith-Olveda" incident, two workers received reportable lung burdens, but the classified report identifies low releases of plutonium to the environment. The 1980 Environmental Impact Statement states that the accident-related plutonium release total for Building 771 for 1971 (including this accident and an incident where contamination resulted from a hole in a barrel liner) was less than four microcuries (USDOE, 1980). A review of the unclassified section of the

library led to the identification of three other accidents not listed in the SOE database; two small, contained fires and a hydrogen peroxide spill.

Although the Building 706 Technical Library was the major source of useful information addressing classified aspects of some of the accidents and incidents identified from other sources, no new accidents or incidents were discovered that appear to have had potential for off-site impact from large releases of chemicals or radionuclides.

Broomfield Water Department

The City of Broomfield Water Department prepared a Rocky Flats Fact Sheet, Environmental Impact (1951 to 1989) that identifies 14 accidents not listed in the SOE database. Three of these accidents involve broken radioactive sources, 10 are liquid effluent spills or NPDES violations, and one is the discovery of two trenches used for on-site burial. However, it was reported that no contamination left the site as a result of any of these accidents.

6.2 Accidents of Potential Interest

The extensive review of accident-related databases and documents, both classified and unclassified, resulted in the identification of thousands of small-scale releases and "accidents" over the forty-year operating history of the Rocky Flats Plant. Our investigations did not, however, identify any major events that are likely to have had the potential for significant off-site health impacts that have not already been reported to cognizant agencies or the public in the past. Many of the events reviewed in the course of the investigation resulted in releases that passed through building ventilation systems that included filtration and radioactivity monitoring systems, so the associated releases were recorded as part of normal plant operating emissions. The purpose of this section is to identify and describe many of the widely reported historical events, only a few of which are likely to have any significance with regard to having a potential for off-site health impacts. Any statements regarding the significance of releases or off-site health impacts in the descriptions of these events are quoted from official documents reviewed by the project team, and are not conclusions made by ChemRisk. The magnitude of any potential releases associated with these events, and therefore their relative significance with regard to potential off-site impacts, will be addressed in a report to be developed under Task 5 of this project, which addresses the identification of source terms for both normal operations and for accidents.

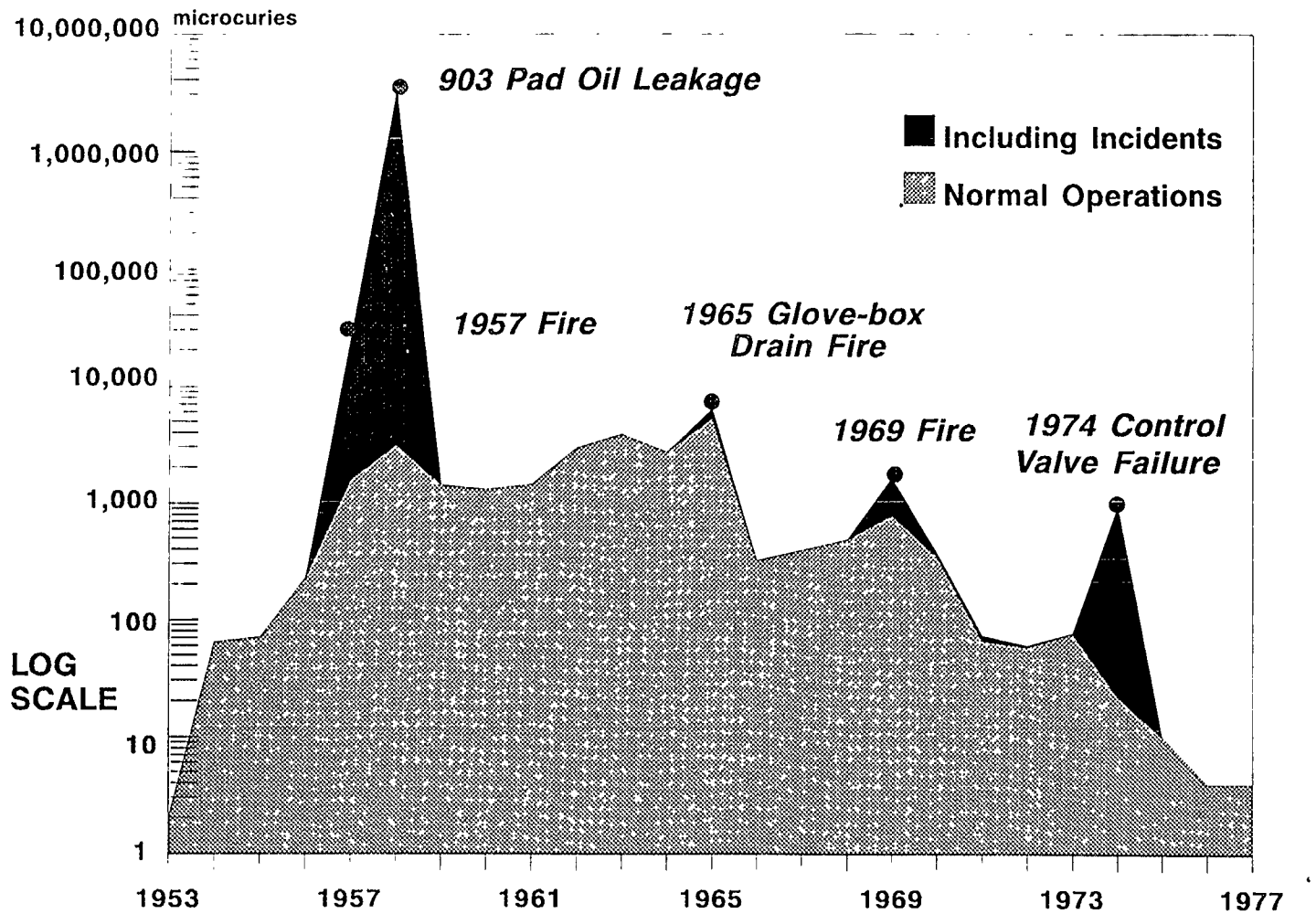
The accidents discussed in this section have been grouped under three headings based on the identities of the principal materials involved in the event; plutonium related accidents, tritium related accidents, and accidents associated with the release of non-radioactive chemicals.

Five plutonium accidents and incidents having the highest accidental releases of plutonium (as estimated by the plant; USDOE, 1980) are discussed. The main plutonium release from Rocky Flats resulted from the leakage of contaminated oil from drums stored in the Building 903 drum storage area. Tritium has been released from the plant in both air and water effluents. Three tritium accidents are described. Small-volume releases of non-radioactive chemicals from laboratory operations and spills have been routine occurrences throughout plant history. Several events associated with chemical accidents have drawn public concern and media attention. A number of these are discussed.

Based on extensive investigation of accident records, incidents involving uranium have been relatively rare. One exception was associated with the practice of on-site burning of wood pallets that is described in the discussion of on-site waste disposal in Section 5. In May of 1965, three depleted uranium sheets were accidently burned as a result of their being shipped to Rocky Flats from Medina, Ohio, in a package that resembled a non-standard size wooden pallet. Improper labeling and the non-conventional packaging apparently caused the depleted uranium to go undetected, and the "pallet" containing 60 kilograms of slightly-radioactive depleted uranium was destroyed by burning on May 1, 1965 (Young, 1965).

6.2.1 Plutonium Accidents

Review and analysis of the available classified and unclassified information indicates that accidents having the greatest potential for off-site release of contaminants have been associated with plutonium. Such releases appear to have been primarily associated with the 1957 fire and the leakage of plutonium contaminated oil from drums stored at the 903 Pad. The plant has characterized the contribution of accidental releases relative to normal operational releases in data presented in Table 2.7.2-1 in the Final Environmental Impact Statement (USDOE, 1980). Figure 6-1 presents this information graphically. Figure 6-2 shows the locations of the major Rocky Flats accidents.



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SOURCE:
USDOE, 1980, EN-1

FIGURE 6-1
REPORTED GROSS ALPHA
RADIOACTIVITY EMISSIONS FROM
ROCKY FLATS PLUTONIUM FACILITIES

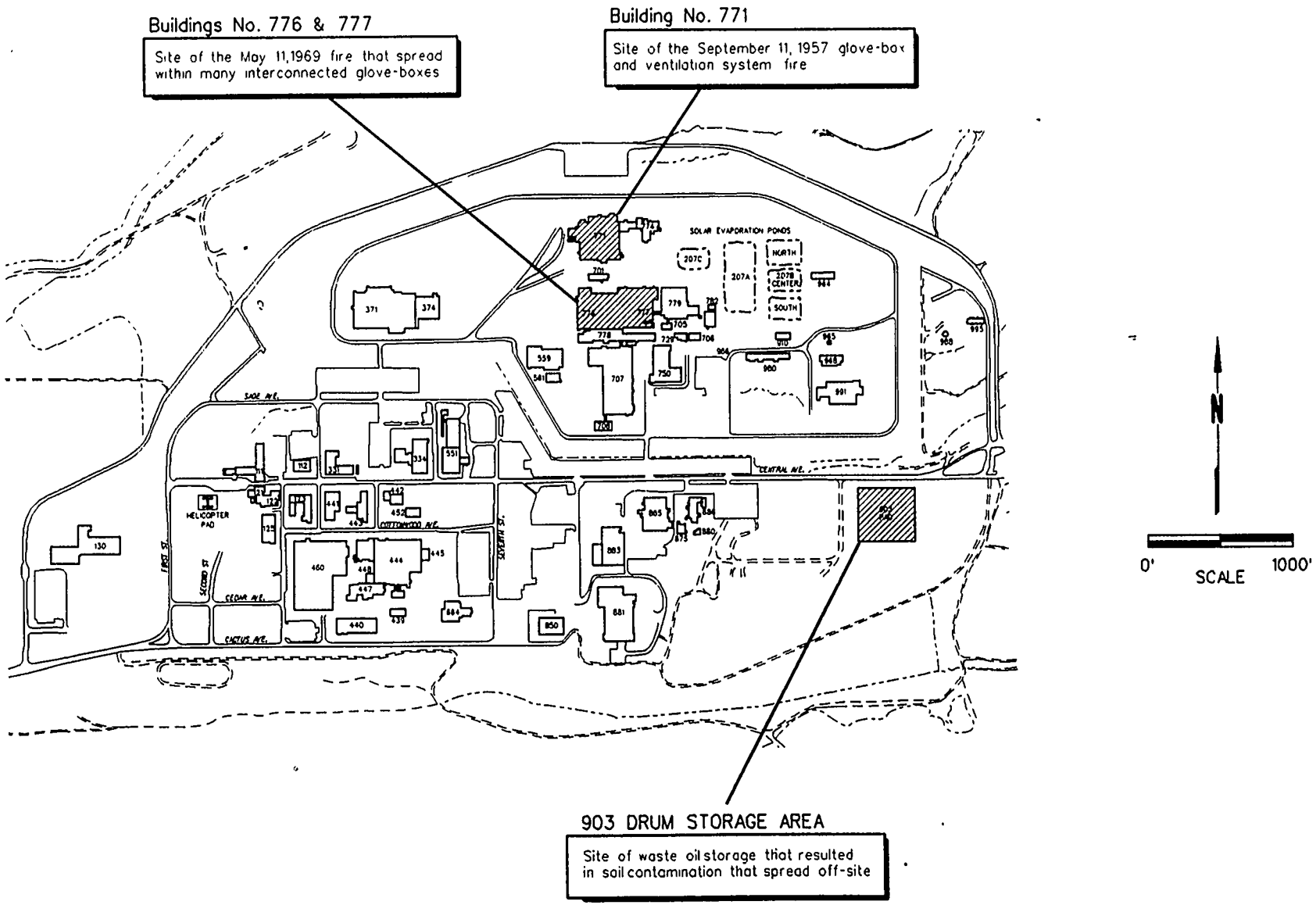

FIGURE 6-2
SITES OF THE MAJOR ACCIDENTS AT THE ROCKY FLATS PLANT

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RockyFlts/Hstry 3-4/06-02 REV: 01-08-92

Hohenemser (1987) states:

> "According to the Department of Energy, the leaking oil drums (from the 903 Pad) produced 99% of all plutonium that ever got off-site... and are responsible for the bulk of the airborne plutonium in the environs of Rocky Flats. Critics Johnson and Chinn suggest that additional environmental deposits may have originated in the 1957 and 1969 fires."

Plutonium is routinely burned under confined and controlled conditions at Rocky Flats to produce plutonium oxide during reprocessing operations. Fire is also a continual accident hazard when working with plutonium. For example, Rocky Flats data (Graves, 1974) indicates 623 reportable fires (most of them small) at Rocky Flats between January, 1955 and December 1974. Of those fires, 387 (62%) occurred within the plutonium processing areas of the plant. Graves also claims that there were no reportable fires from the beginning of construction in 1951 through 1954, even though occupancy of some of the buildings began in 1953.

Discussing fire experience at Rocky Flats between 1966 and May of 1969, the accident report on the 1969 fire (USAEC, 1969), page 99, says:

> "There have been a total of 164 fires that were reported to the Fire Department. Of these, 31 involved plutonium of which 10 occurred in Building 776/777. Of the remaining 133 fires, 17 occurred in Building 776/777. There is no good estimate of the number of plutonium fires during this period which were not reported to the Fire Department."

Chips from plutonium machining operations easily ignite if exposed to the air. Barrick (1981) states that "...plutonium metal burns at a temperature near the 640 C melting point of plutonium and...no odor, smoke or flames are produced until other combustibles are involved." Small plutonium fires are therefore part of normal operations at Rocky Flats, and many such fires are not reported if they remain confined within the production apparatus and there is clearly no risk of human exposure. This subject is discussed further in Appendix J-2 of Volume II-B of the 1969 fire report (USAEC, 1969). Emissions from most plutonium fires occurring during normal operations pass through multi-stage HEPA filter systems and contribute to the normal operational releases of radionuclides from the plant. The 1957 fire was a significant exception.

The September 11, 1957 Fire

The 1957 fire is discussed in an October 7, 1957 report prepared by an accident investigation committee chaired by J.G. Epp of Dow Chemical/Rocky Flats (Epp et al., 1957a). The Epp report has 28 pages of text and 20 pages of drawings and photographs. Dow Chemical (Rocky Flats) also published a "Supplementary Report on Fire in Building 71, September 11, 1957" on December 10, 1957 (Epp et al., 1957b).

The fire began at about 10:10 p.m. on September 11, 1957, when metallic plutonium casting residues spontaneously ignited in a glove box in Room 180 of Building 71 (now Building 771). The fire then spread to an exhaust filter plenum, Rooms 281 and 282, consuming a considerable quantity of filters and damaging the ductwork and fan system.

Pertinent excerpts from Epp et al. (1957a) are as follows:

> "The exhaust filter plenum consisted of a long concrete-block-walled room into which the individual exhaust systems discharged. The 620 CWS (Chemical Warfare Service) 24-inch square filters were held in a structural steel framework. The four exhaust fans connect to the filtered side of the plenum and discharge into a common exhaust duct leading to a concrete tunnel and concrete stack." (page 10)
>
> "At approximately 10:10 p.m., September 11, a fire in a glove box (in Room 180, Building 771) was discovered by two Plant Protection men...on a routine clock tour of the building. The fire, when first discovered, appeared to consist of materials within the glove box, the plexiglas box itself and neoprene gloves.
>
> Since it was known that gross amounts of plutonium were handled and stored in this area, people were delayed in fighting the fire until adequate radioactive contamination protection was put on. Then, attempts to fight the fire with carbon dioxide from hand extinguishers and a hundred pound cart proved to be ineffective; however when a water spray nozzle was brought in and used, it was effective, although there was considerable uncertainty as to the criticality problems which it might produce. During this period, the fire was transmitted to the filters, and hot gases were introduced through the ventilation booster system and the main exhaust duct.
>
> At about 10:39 p.m., an explosion in the exhaust system, probably due to accumulated unburned gases, occurred; but, by this time, the fire in room 180 had been extinguished.

Thereafter, the filter fire became of prime importance, although there were several minor rekindlings in room 180. Figure 6-3 shows the condition of some of the Building 771 exhaust filters after the 1957 fire.

"It is doubtful that shutting down the fan system would have been the proper action in view of the contamination problems involved; however, the draft undoubtedly contributed to the intensity and spread of the fire in the filters.

...The flammability of the CWS filters had been known for some time; however they were the only commercially available filters adequate to do the job from the contamination point of view." (page 18)

Chronology - September 11, 1957:

10:10 p.m. -	Fire discovered in room 180...
10:12 p.m. -	First fire truck arrived...
10:24 p.m. -	...Carbon dioxide extinguishers first discharged at fire.
10:25 p.m. -	Fan system ordered on high speed...
10:37 p.m. -	Water spray nozzles discharged at fire...
10:38 p.m. -	Water shut off. Fire extinguished in room 180.
10:39 p.m. -	Explosion in exhaust system. People forced out of room 180. ...building evacuated due to contamination...
10:40 p.m. -	Fans went off...
10:58 p.m. -	Second fire truck called...
11:10 p.m. -	...Electrical power failed in entire building.
11:15 p.m. -	Water (sprayed) on filter bank.

September 12, 1957

2:00 a.m. -	Filter fire knocked down.
11:28 a.m. -	Final fire out" (pages 14-17).

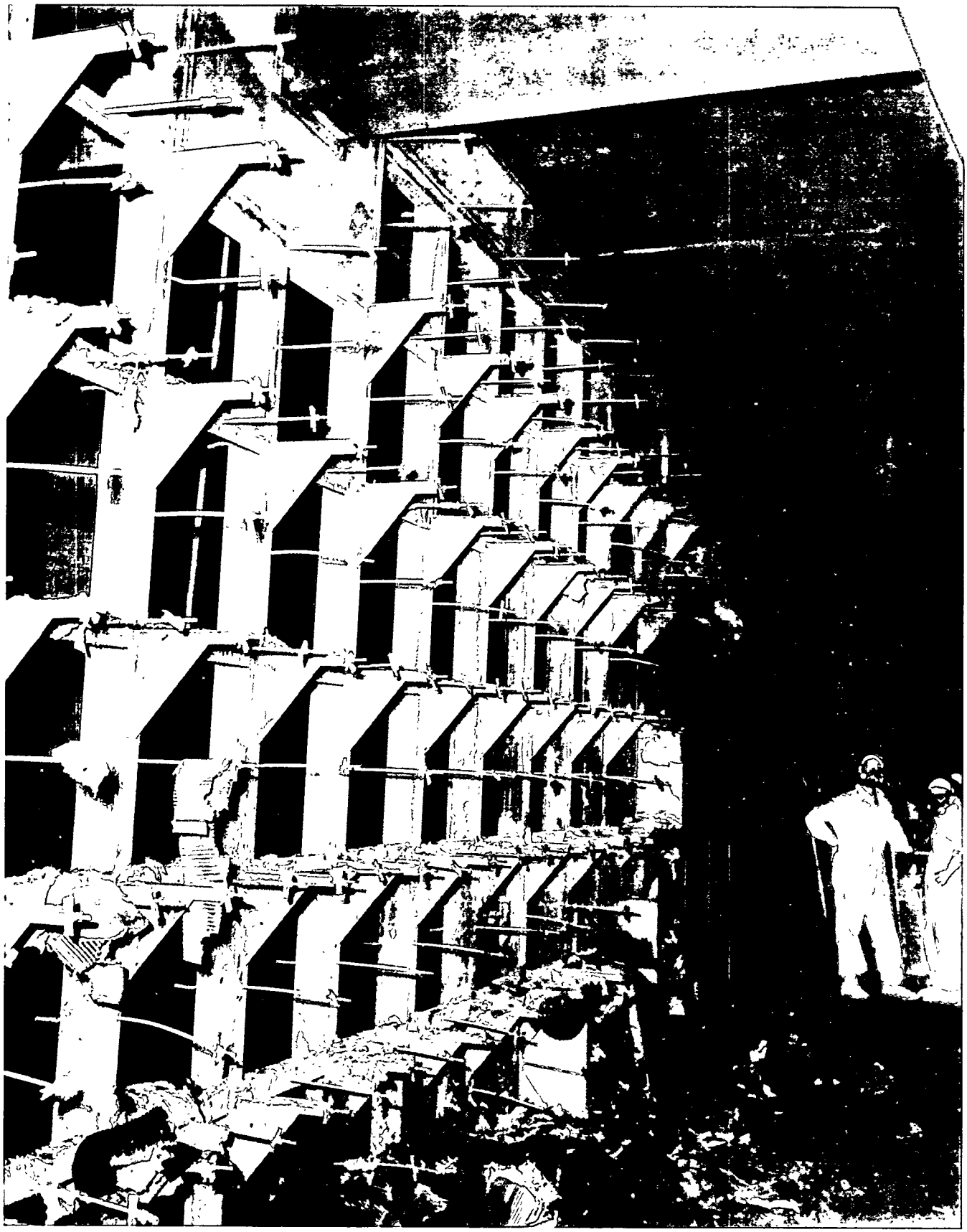

FIGURE 6-3. INTAKE SIDE OF BUILDING 771 EXHAUST FILTER BANK FOLLOWING THE 1957 FIRE. MANY OF THE FILTERS BURNED, AND SOME WERE PULLED OUT OF THEIR FRAMES TO LIMIT SPREAD OF THE FIRE. PARTIALLY BURNED FILTERS CAN BE SEEN ON THE FLOOR.

Plaintiff arguments during the Church litigation emphasize the confusion at the time of the 1957 fire, the undesirability of turning the exhaust fans on to high speed, and the design features of the building and equipment which contributed to the severity of the fire (Fairfield and Woods, 1978).

Reporting on the 1957 fire, Barrick (1981) says:

> "Smoke from a burning glove, detected in a building hallway, led two watchmen to discover flames extending 18 inches out of a Plexiglas window on a glove box. The time was approximately 10:10 p.m. on Wednesday, September 11, 1957. The fire had started in a...can of plutonium turnings in the 'fabrication development line' in Room 180 (first floor) of the plutonium processing and fabrication building (Building 771)... Fires in the box exhaust booster filters and main filter plenum on the second floor may have...started around this time, but were not discovered until 10:28 p.m. An explosion of collected flammable vapors in the main exhaust duct at 10:39 p.m. resulted in spreading plutonium throughout most of the building...probably contributing to the release of plutonium from the 152 foot tall stack.
>
> The fire in Room 180 was controlled at 10:38 p.m., but rekindled several times. The main filter fire was controlled at 2:00 a.m., September 12th and the fire was officially declared out at 11:30 a.m., Thursday, September 12, 1957."

A Rocky Flats Fact Sheet (Linkon, 1985) says:

> "No major injuries were reported in the 1957 fire. The Atomic Energy Commission reported an estimated property loss of $818,000."

Putzier (1982) notes that the Building 771 exhaust fans shut down at about 10:40 p.m. (Epp et al., 1957, page 16) when power was lost during the 1957 fire. "Therefore the only draft would have been that created by the natural updraft of the stack and through 100 feet or so of horizontal ductwork that leads to the base of the 175 foot stack. There was, however, a possibility that supply fans may have created a positive pressure inside the building for a period of one-half hour or so" (Putzier, 1982, page 10).

Putzier notes that Building 771 "...was designed with a main filter plenum, single stage, with Chemical Warfare Service (CWS) filters..." (page 22). He goes on to say that one of the two prefilter systems leading to the main plenum burned through during the 1957 fire. This was a two stage prefilter system for laboratory glove boxes and hoods and also for the production development laboratory on the first floor.

Reporting on an inspection of the duct between Building 771 and the stack "a couple of days after the fire," Putzier (1982, page 46) says:

> "There appeared to be some damage at the very top of the stack. By visual observation, it appeared that something up at the top of the rim had been dislodged. ...someone made the conclusion something might have been blown off from one of the pressure releases associated with the fire."

Putzier concurs that fire propagation was probably enhanced by the increased draft when the Building 771 fans were turned up to high speed at about 10:25 p.m., 200,000 cfm or more according to Epp et al. (1957a, page 15).

Contamination and Dispersal of Soil From the Building 903 Drum Storage Area

Another type of plutonium release, also not subjected to multi-stage HEPA filtration, occurred when plutonium contaminated soil was resuspended from an outside drum storage area at the east end of the plant site between 1957 and 1969. In 1971, Dow Chemical (Rocky Flats) published a 50 page report with five appendices (Seed et al., 1971) describing Building 903 drum storage area events and the resulting soil contamination. The report was produced by a committee appointed by the General Manager of Rocky Flats on August 19, 1970 to assess the long-term potential hazard of plutonium contaminated soil under and around an asphalt pad (the 903 Pad) put in place to prevent further spreading of contaminated soil.

Key excerpts from the Seed et al. report are as follows:

> "In July 1958, at the USAEC Rocky Flats Installation, an area on the plant site was designated as a temporary storage area for contaminated oil drums. Subsequently, some of the drums developed oil leaks and some plutonium contaminated oil was deposited on the soil. The area was later covered by an asphalt pad.

After a fire on May 11, 1969 at Rocky Flats, studies were conducted by the Health and Safety Laboratory (HASL) of the USAEC and by the Colorado Committee on Environmental Information, concerning the possible release of plutonium. These investigations detected measurable amounts of plutonium in the soil around the Rocky Flats Plant. The epicenter quite clearly showed that this contamination could not be attributed to the May 1969 fire but is due to the resuspension and redistribution of contaminated soil from the oil drum storage area" (page 1).

"HISTORY OF PLUTONIUM CONTAMINATED OIL DRUM STORAGE AREA: From the beginning of operations of the Rocky Flats Plant, organic liquids contaminated with radioactive materials were generated in various manufacturing operations. In the initial design of the facilities, very little attention was given to this particular radioactive waste problem. The volumes were very low and it had been assumed that this form of contaminated waste could be either burned or packaged in some manner and shipped for burial as were the low level solid wastes.

...Changes in weapons design and in manufacturing processes significantly increased the amount of contaminated oils being generated. ...The problems of permanent disposal, and of storage of the increasing quantities generated, were recognized in 1956.

As a result of one study, the Part IV addition (completed in 1957) to the plant included a high-speed centrifuge in Building 776 to process plutonium-contaminated organic liquids. The operation was disappointing and resulted in a recommendation made in 1958 that a substitute process be developed for disposal.

...The outside plutonium contaminated oil drum storage areas was first established in July 1958.

Most of the drums transferred to the field were nominal 55-gallon drums, but a significant number were 30-gallon drums. Not all were completely full. Approximately three-fourths of the drums were plutonium-contaminated, whereas most of the balance contained uranium. Of those containing plutonium, most include lathe coolant consisting of straight-chain hydrocarbon mineral oil (Shell Vitrea) and carbon tetrachloride in varying proportions. Other liquids were involved, however, including hydraulic oils, vacuum pump oil, trichloroethylene, perchloroethylene, silicone oils, acetone, still bottoms, etc. Originally, contents of these drums were indicated on the outside, but some of the markings became illegible through weathering, and adequate records were not kept of the specific contents of each barrel. Leakage of the oil was recognized early,

and in 1959 ethanolamine was added to the oil to reduce corrosion rate of the steel drums.

Development work on a potential process to dispose and/or reclaim the materials continued. As a result of the development studies which had been initiated, however, a recommendation was issued in December of 1959 that a still be constructed for the separation, purification and reuse of the carbon tetrachloride and the Shell Vitrea. ...The process was set up in Building 771. Because of time and funding problems, surplus stainless steel equipment was used. On May 15, 1960, test runs of this equipment were begun, and shortly afterward drums of currently generated oil, together with some transferred from the field were processed through the system.

...In June of 1960 corrosion of the stainless steel equipment, caused by hydrolysis of the carbon tetrachloride to hydrochloric acid, became a problem and in September the operation was discontinued because of severe corrosion.

...Installation of (a) mixer-extruder system (for processing contaminated liquids) was completed in January 1964, but start-up work revealed major deficiencies which required extensive modifications in the installation. These modifications were not completed until late in 1965.

...After (further delays) and more start-up problems, the final phase of emptying the drum field began on January 23, 1967. By this time the field contained about 5,240 drums of which approximately 3,570 contained plutonium contamination. The oldest drums and those containing plutonium were processed first. To the best of our knowledge, the last of the plutonium-contaminated oil was removed on January 25, 1968. The last of the uranium-contaminated oil was transferred to a new drum on May 28, 1968, and shipped to the disposal plant on June 5, 1968.

...An estimate of leakage, based on a material balance around the drums, indicated that 5,000 gallons of oil containing about 86 grams of plutonium leaked from the drums into the soil.

The significant or pertinent events associated with the Plutonium Contaminated Drum Storage Area (903 Pad) can be summarized as follows:

July, 1958	Drum storage area established. During subsequent years, drums were continually added which primarily contained plutonium contaminated machining oils.

July, 1959	First drum leakage discovered. Rust inhibitor, ethanolamine, was added to drums prior to storage to minimize corrosion.
January, 1964	First evidence of large scale deterioration of drums reported. Soil contamination reported increasing.
January, 1966	Small building added to filter and transfer contaminated oil from leaking drums to new drums.
January, 1967	Last drums added to storage area and removal to (Building) 774 began. Oldest drums shipped first.
June, 1968	Last drum shipped to Building 774 for processing. High winds spread some contamination.
July, 1968	Radiation monitoring and mapping of area completed. Levels of 2.0 E+05 disintegrations/ minute/gram of soil (d/m/g) to over 3.0 E+07 d/m/g reported. Penetration of from 1 inch to 8 inches reported.
September, 1968	Preliminary proposal for containment cover prepared by Rocky Flats Facilities Engineering.
July, 1969	First coat of fill material applied.
August, 1969	Fill work completed, paving contract let.
September, 1969	Overlay material, soil sterilant and asphalt prime coat completed.
November, 1969	Asphalt containment cover completed including four sampling wells.

The deposition of contamination in the soil of the drum storage area began shortly after the drums were placed in the area. Resuspension and redistribution of the contamination, however, was certainly not a simple mathematical function of time. The quantity redistributed was directly associated with the removal of the drums which exposed the contaminated soil, physical activity in the area, and the periodic high winds at Rocky Flats" (pages 5 and 6).

The 1973 tritium release report (USAEC, 1973), page 58, summarizes the 903 Pad events as follows:

"First drums stored - October, 1958
Last drums stored - January, 1967
First drums removed - January, 1967
Last drums removed - June, 1968

Contents: 3,572 drums of oil contaminated with plutonium
1,254 drums of oil contaminated with uranium

Comments:

1. A total number of 5,237 drums were stored in the oil drum storage field. There were 4,826 drums transferred to the plutonium waste processing plant. The difference of 411 drums is attributed to leakage of the oil into the soil and some of the drums were not full when first transferred to the field for temporary storage.

2. The first indication that drums were leaking in the field was in 1964. As a result the storage area was fenced and contents of the leaking drums were transferred to new drums. Approximately 420 drums leaked to some degree and of these about 50 leaked totally empty. Approximately 86 grams of plutonium leaked into the soil.

3. In 1967 a heavy rain storm spread contamination to a ditch near the drum storage field.

4. In November 1968 grading was started for...applying an asphalt cap over the area.

5. In July 1969, installation of an asphalt pad was started and completed in November of 1969.

6. In February, 1970, six inches of road base course was applied east and south of the asphalt pad. This was completed in March 1970."

A letter from Dow Chemical (Rocky Flats) to Dr. Roy L. Cleare, Executive Director of the Colorado Department of Health, (Joshel, 1970) says:

> "In 1964 it was realized that a few of the drums were leaking in the (903 Pad drum storage) field and contaminating the soil beneath. Contamination was detected on air samplers at the east fence following high winds...
>
> In 1967 a heavy rain storm spread contamination from the drum field to the ditch along the road at the fence line."

A Rockwell International (Rocky Flats) Fact Sheet (Linkon, 1985) states:

> "An estimated 5,000 gallons of used oil containing 150 grams of plutonium leaked into the soil inside the Rocky Flats Plant southeast security fence between 1964 and 1967...
>
> ...by the end of 1967, plant officials discovered that soil contaminated by the leaking drums had been resuspended into the air and redeposited. Most of the resuspension occurred between July 1968 and March 1969. The highest airborne value was 0.34 picocuries per cubic meter. Releases continued into July 1969 when the storage area was covered with a gravel fill. The storage area was coated with asphalt in November 1969."

Much of the plutonium carried off the site in contaminated soil from the 903 Pad oil drum storage area appears to be immobilized in the soil of the buffer zone southeast of the plant. According to a Colorado Department of Health report on Rocky Flats (CDH, 1990):

> "A new round of soil sampling in a seven mile radius around the plant was completed in late 1989. (The survey) showed the following:
>
> 1. There is an overall decline in plutonium concentration in the soils since 1970.
>
> 2. Plutonium concentrations are highest just east of the plant."

The May 11, 1969 Fire

A major plutonium fire started in a glove box in the North Plutonium Foundry glove box line in Building 776 on Sunday, May 11, 1969. The fire burned for several hours, spreading through combustible materials in several hundred inter-connected glove boxes in Building 776 and Building 777.

The U.S. Atomic Energy Commission prepared a five volume report on the 1969 fire (USAEC, 1969a). Pertinent excerpts from the report, summarizing the 1969 fire, are as follows:

> "The first indication of a fire was an alarm in the Fire Station at 2:27 p.m., in the North Foundry Line. Although the Fire Department responded promptly, on arrival the fire was moving rapidly through the Foundry Conveyor Line. It subsequently spread through one of the interconnecting conveyors and into the Center (fabrication) Line. The fire was brought under control about 6:40 p.m., but continued to burn or reoccur in isolated areas through the night. On Monday morning, a fire was discovered in a glove box on the South Foundry line. This fire was quickly extinguished and caused little damage.
>
> The dense smoke, crowded conditions, and presence of large quantities of combustible material in the form of Plexiglas windows and Benelex-Plexiglas shielding, made the fire very difficult to fight and extinguish.
>
> ...The fire did not breach the building roof, and only a small part of one exhaust filter system was ruptured. Consequently, most of the smoke and essentially all of the plutonium remained in the building. One fire fighter received a significant internal body burden of plutonium, but has responded well to treatment. There were no disabling injuries to personnel or deaths. There is no evidence that a criticality incident occurred or that any significant amount of plutonium was carried beyond the plant boundaries.
>
> The damage to Building 776-777 and its equipment was very extensive. In addition to actual fire and smoke damage, the building was grossly contaminated with plutonium. Substantial parts of the utility system serving the building were severely damaged. Some of the adjacent buildings sustained minor exterior and interior contamination" (pages 1-3).

The following excerpts from the report on the 1969 fire (USAEC, 1969a) provide background about operations and ventilation systems in Buildings 776-777 as they were at the time of the 1969 fire:

> "All production operations in Building 776-777 are carried out in glove boxes which are interconnected by a series of conveyors. There are four principal glovebox systems: (1) North Foundry Line, (2) South Foundry Line, (3) Center Line, and (4) North-South-East Machining Lines" (page 23).
>
> "The conveyors are equipped with pendants or carriers on which containers or plutonium parts are placed" (page 25).
>
> "The basic philosophy of the building and glove box ventilating systems is that conditioned air will be furnished to all plant areas and any leakage will be from less hazardous into more hazardous areas in order to control contamination spread. To accomplish this, the ventilating system is divided into two major areas (i.e., room and glove box) with several subdivisions under each.
>
> ...Building 776 is maintained at a negative pressure with respect to outside atmosphere. Within the building the pressure becomes even more negative as one progresses from the office space to the equipment spaces (largely on the second floor) to the operating spaces within which are the glove box lines where the pressure is lowest of all" (pages 26 and 27).
>
> "There are three basic systems of glove box ventilation: Booster System No. 1, Booster System No. 2, and the Glove box Dry Air System. All maintain a negative pressure with respect to the operating areas of Building 776-777 so that any air leakage will be from the room into the glove box system. Booster System No.1 serves the Center Line and parts of Building 777. Booster System No. 2 serves the North and South Foundry Lines and some miscellaneous glove boxes at the west end of Building 776. The Glove box Dry Air System serves the North and South Machining Lines in Building 776, and parts of Building 777.
>
> Booster Systems Nos. 1 and 2 draw air into the glove boxes from the first floor of Building 776 through filters on the glove boxes. The air is then drawn from the glove boxes into the connecting conveyors, into ductwork on top of the conveyors, and up to the filters on the second floor whence it is discharged through exhaust vents to the outside of the building. (Pages A-26 and A-27 of Appendix A-13, Volume II-A state that Booster No. 1 had 4-stage bank of filters, while Booster No. 2 had a 6-stage bank of filters).

Some of the conveyors on the North and South Foundry Lines contain filters where the return air ducts are connected.

There is no barrier between the parts of the glove box system served by Booster Systems Nos. 1 and 2" (pages 28 and 29).

"The Glove box Dry Air System supplies dehumidified air by ducts attached to the conveyor lines. The air from the conveyors is then drawn through the glove boxes and returned to the filters on the second floor by ducts attached to the glove boxes. From the filters the air is exhausted outside. (Page A-28 of Appendix A-13, Volume II-A, states that the glove box dry air system had a bank of four stages of HEPA filters in the exhaust.) In normal operation, this system is isolated from the Booster Systems Nos. 1 and 2 by means of doors at six places" (page 30).

"On the first floor of Building 776-777 there is approximately 100,000 square feet of open space, without any built-in automatic fire suppression system" (page 34).

"There are three principal operating activities conducted in Building 776-777: (a) foundry, (b) fabrication, and (c) assembly. ...All of this work involves the manufacture of plutonium parts for weapons and test devices. In the foundries, plutonium is cast into either ingots suitable for rolling and further wrought processing or into shapes amenable to direct machining operations. The fabrication operation takes the ingots or cast shapes furnished by the foundries and makes the plutonium parts by rolling, forming and machining. The assembly operation involves the assembling of various components into completed units. Primarily, the units contain nuclear materials such as plutonium and uranium. After assembly, completed units are packed and shipped.

...Charges for the casting furnaces are made up from two general sources of feed material: refined plutonium metal ("buttons") from elsewhere at Rocky Flats or off-site, and scrap from within Building 776-777.

...Scrap metal and chips generated in the rolling, forming, and machining operations are placed in containers and returned to the foundries by conveyors. This material is briquetted before being incorporated into furnace charges. Since the material is oily, it is first dipped in successive baths of carbon tetrachloride, allowed to dry and then taken to the briquetting press. There it is removed from the containers, and pressed into a briquette about 3 inches in diameter and 1 inch thick" (pages 36 and 37).

The following excerpts from pages 49-57 of the 1969 fire report (USAEC, 1969a) provide additional details about the May 11, 1969 fire in Buildings 776-777:

> "The first indication of a fire in Building 776 came from an alarm received in the Fire Station at 2:27 p.m.
>
> The fire captain on duty...and three firemen, responded to the initial alarm. (He) arrived at the west end of Building 776 at 2:29 p.m. On entering the building he saw smoke coming toward him from the east. ...He proceeded further into the building and observed heavy smoke and fire in the North Foundry Line at about Column K-4 (just west of Glove box 134-24). The fire was out of the top of the line with flames about 18 inches high.
>
> One of the firemen heard two loud reports (like rifle shots) and saw two fireballs (about basketball size) go to the ceiling in the area of the North Foundry Line. This occurred while the firemen were laying out a fire hose, and before any water had been used on the fire.
>
> ...In general, the initial firefighting activities were concentrated on the North Foundry Conveyor Line and glove boxes east from Glove box 134-24. By 2:50 p.m., there was fire along the top of the North-South Conveyor Line (Column Line 8). About this time the firemen on the second floor (over the North Foundry Line) heard a loud noise and felt the floor shake. At approximately 3:20 p.m. the fire was reported moving into the rolling mill on the Center Line, and at 3:40 p.m. the entire area from Columns G-J and 11-13 was glowing orange through dense smoke. There was also a fire in the ceiling in the vicinity of the North-South Conveyor Line.
>
> Almost from the beginning it was virtually impossible to see because of the thick black smoke and the loss of lights in the main fire area. The crowded conditions in the fire areas made fire fighting very difficult.
>
> ...water was used (on the fire) almost exclusively; although some magnesium oxide was used on plutonium. Since the conveyor lines and glove boxes were now open, it was not possible to avoid getting water on the burning plutonium. In order to fight the fire in the Benelex (radiation shielding material) facing on the conveyor lines it was necessary to put the hose lines into the openings and play water up and down the lines, or to direct a water stream towards the ceiling and bank it toward a burning area. The fire fighters reported seeing burning plutonium erupt with showers of sparks when hit with water. In some instances there were unsuccessful efforts

to move piles of burning plutonium by directing streams of water on the material itself.

The persistence of the fire was a matter of serious concern for a period of hours. Attempts to pry or knock the Benelex shielding from glove boxes and conveyor lines (were) not successful. Although the firefighters were generally successful in 'knocking down' the fire in particular locations, by the time they returned with new air supplies -or from directing their attention to other areas - the fire would be going as intensely as before.

Some smoke came out the west end doors of Building 776 when they were opened (at about 2:29 p.m.). Between 3:20 p.m. and 4:10 p.m. smoke was observed coming from the roof of Building 776. It billowed over the side of the building toward Buildings 778 and 750. Two Dow (Rocky Flats) employees reporting to the plant observed a smoke plume while on the Denver-Boulder turnpike about 10 miles away. Firefighters sent to the roof saw smoke coming from some exhaust vents. Although there were no signs of fire in the roof, the roof did get soft in one area (near the location of the 4 High Mill, Columns H-G and 6-7). The roof was sprayed with water and a fire watch maintained until after 5:00 p.m.

By 6:40 p.m. the fire was contained. Between 7:00 p.m. and 8:00 p.m. a door on the second floor of Building 776 was opened and the main building exhaust system was changed from recirculating to single pass in an effort to help clear the heat and smoke from the building. By 8:00 p.m. the fire was extinguished for all practical purposes, and a fire watch was established. Some small fires continued to reoccur in the North Foundry Line, the North-South Conveyor Line, and the ceiling above the North-South Conveyor Line.

During the early morning hours of Monday, May 12, the storage container in Glove box 134-24 on the North Foundry Line continued to smolder and reignite. Both water and magnesium oxide were used when this occurred. At times, flames five to six feet high appeared along the side of the box. According to the testimony, two cans of burning plutonium were removed from Glove box 134-24 and placed in Glove box 134-25 to decrease the fire potential; another can of burning plutonium was removed and placed to the south of the Benelex storage container on the floor of Glove box 134-24.

Between 8:00 and 9:00 a.m. on Monday the fire watch discovered a fire in the plutonium storage box on the South Foundry Line (Glove box 134-70). This fire was quickly extinguished by breaking the Plexiglas windows and using water on both the inside and outside of the box. This was the only fire in the South Foundry Line."

A Dow Chemical (Rocky Flats) report (Willging, 1969) suggests that the smoke issuing from Building 776 during the May 11, 1969 fire was a combination of contaminated smoke that escaped from the Booster No. 1 filter plenum and uncontaminated smoke from thermal decomposition of roofing material heated from below by fires contained within the building.

A detailed fire chronology is supplied in Volume II-A, Appendix D-1, of USAEC (1969a). This report also says:

> "Most of the plutonium metal in the fire damaged area was completely burned and lying in the bottom of the burned out conveyors and boxes" (page 66).
>
> "One area of the roof of Building 776-777 near the exhaust vent from Booster System No. 1 was contaminated with plutonium. The adjoining ground areas and the exterior of Building 777 also were contaminated" (page 69).
>
> "The ventilating, electrical and other utility systems on the second floor of Building 776 were heavily contaminated with plutonium.
>
> ...Some of the filters on all four stages of Booster System No. 1 were burned or damaged by heat and air pressure" (page 70).
>
> "...During the fire, the gamma (radiation) alarm system in Building 776 was destroyed but the Building 777 alarm system remained operational. Neither this system nor the ones in Buildings 559, 779, and other locations on the plant site were set off during or after the fire. A Hurst dosimeter retrieved from Building 776 after the fire showed no evidence of being exposed to neutrons or gamma radiation. No one reported seeing a visible flash or any other sensory evidence that a nuclear criticality had taken place" (page 95).
>
> "Since there is no evidence that the roof of Building 776 was breached, and the smoke observed coming from the roof lasted only a short time, it is not credible to attribute such smoke to the fire inside the building. There is evidence of fire downstream of the fourth (and final) stage of Booster System No. 1 filters. Accordingly, it appears more likely that the smoke seen outside the building came from this fire.
>
> ...Only an insignificant amount of plutonium appears to have escaped from Building 776-777. It was primarily deposited on the roof of the building, and on the ground and one building adjacent to Building 776-777.

> The fact that the building structure, including the roof, was not breached by fire, that most of the ventilating systems continued to operate, and only a part of the final stage of one set of filters (Booster System No. 1) was damaged, appear to have been the controlling factors in limiting the amount of plutonium released" (pages 110-112).

A summary of the 1969 fire report published in an Atomic Energy Commission newsletter (USAEC, 1969b) states:

> "...Because of the concern about the possibility of a nuclear criticality accident (a chain reaction), the standard firefighting procedures then in effect for Building 776-777 did not specify the use of water, except as a last resort. For this reason, there was no automatic sprinkler system in this area of the building. The first attack on the fire...with carbon dioxide...was ineffective. Less than ten minutes after the fire alarm was received, the fire captain initiated the use of water. Thereafter, water was used almost exclusively in the firefighting activities. No nuclear criticality occurred. The fire was brought under control about 6:40 PM, but continued to burn or recur in isolated areas throughout the night.
>
> The fire originated within the North line, moved rapidly through the North-South Overhead Conveyor Line and subsequently spread through one of the interconnecting conveyors and into the Center Line. Some plutonium contained in these lines burned, and as the glove box windows burned out, plutonium oxide was released into the room. ...Because of the extensive plutonium contamination and smoke, all personnel entering the area during the fire were required to use self-contained breathing air systems which severely limited...access to, and time in, the fire area...
>
> The damage to Building 776-777 and its equipment was extensive. In addition to...fire and smoke damage, the building was heavily contaminated internally with plutonium. Substantial parts of the utility systems were severely damaged. Some of the interconnected buildings sustained minor interior contamination... The fire did not breach the building roof, but slight exterior contamination was measured on the roof of Building 776 and an adjoining building, apparently due to a minor failure of a filter. Plutonium...was tracked out of Building 776 by the firefighters and was detectable on the ground around the building. There is no evidence that plutonium was carried beyond the plant boundaries. The present estimate of the financial loss for the damage to buildings and equipment, including cost of decontamination is $45,000,000."

An attachment to the Dow Chemical letter to Dr. Roy L. Cleare (Joshel, 1970), says:

> "...It is theorized that the fire started when pressed plutonium briquettes self-ignited in the metal container where (they were) stored within a Benelex and Plexiglas storage cabinet in the north line. Heat from the burning plutonium ignited the Benelex and Plexiglas within the glove box line which created large quantities of smoke.
>
> The fire progressed west within the north line until the dense smoke clogged the Booster 2 ventilation system which serviced the north line. The Booster 1 ventilation system, which serviced the north-south overhead conveyor line and the center line, then took over the air processing function for the north line, reversing the air flow and causing the fire to move east within the north line.
>
> When the fire reached the junction of the north line and the north-south overhead conveyor line, the fire was forced into the latter by a closed fire door on the north line and the direction of the air flow into the north-south overhead conveyor line. The renewal of the air supply from the Booster 1 system caused the substantial volume of hot, unburned gases given off by the burning materials to ignite, creating a very hot fire...
>
> The fire was drawn into the center line by the ventilation system. When the flames reached the HEPA filter of the Booster 1 system, the intense heat caused breaches of the first and second banks of the four bank HEPA filter system. The gaskets which contain the third and fourth banks of the HEPA filter system were breached, allowing amounts of unfiltered smoke to be released into the environment.
>
> The Booster 1 stack, like all ventilation stacks in Building 776-777 directed the smoke back onto the roof of Building 776 where significant alpha activity was discovered. Plutonium, believed to have been tracked out by firefighters, was also detected on three sides of Building 776."

A letter from General E.B. Giller of the USAEC to Governor Love of Colorado (Giller, 1969) says:

> "A multistage absolute air filtration system was incorporated into each building handling radioactive material during initial construction. In addition, there is a separate absolute filtration

> system for all air circulated through enclosures containing radioactive materials. All air in the ventilation system is either recirculated so that it does not leave the building or is vented after complete filtration... These filtration systems were not destroyed by the fire and all except one operated as designed both during and after the fire. One was damaged by fire but was deactivated prior to permitting the spread of contamination beyond the immediate area on the roof where it exhausts."

Langer (1979) says that, during the 1969 fire,

> "...plutonium briquets ignited spontaneously and set the glove box shielding (Benelex) on fire. Resulting combustible gases were ignited and burned the first three filter stages. The last one was slightly damaged. Smoke was also released to the room and was collected by the room exhaust filters. As the latter have only two stages, greater overall filter penetration would be expected" (page 30).

After the 1969 fire, processing and production glove boxes at Rocky Flats were converted to an inert nitrogen atmosphere to attempt to prevent spontaneous ignition of plutonium.

The 1965 Glove Box Drain Fire

A plutonium fire that did not attract as much public attention, but was estimated by DOE (USDOE, 1980) to have released more gross alpha activity than the 1969 fire (see Figure 6-1) occurred during a maintenance operation on a plugged glove box drain in Building 776/777 in 1965. The flash fire vented to the room air and was spread throughout the buildings by the normal ventilation system.

A Colorado Committee for Environmental Information report (CCEI, 1970), referencing Mann, J.R. and R.A. Jirchner (1976) says:

> "... plutonium chips caught fire in a large room with about 400 employees, many of who were [potentially] exposed to high airborne concentrations of plutonium dioxide without respirators. Body counter measurements indicated that 25 employees received 1 to 17 times the permissible lung burden."

Putzier (1982, page 54) says that this was "... probably the most serious incident in terms of number of people affected that Rocky Flats has had."

According to the official accident investigation report on the 1965 glove box drain fire (Hammond et al., 1965),

> "At approximately 10:25 a.m. on Friday, October 15, 1965, a fire occurred during a lathe maintenance operation in Building 76-77 of the Rocky Flats Plant. ...fifteen employees ... received significant radiation exposures- greater than 0.008 microcuries in the lung. Plutonium contamination was spread through a major portion of Building 76 and throughout part of Building 77. Major areas of the buildings were cleaned up by Monday morning, October 18, and nearly all of the production operations were resumed at that time" (page 7).
>
> "the October 15, 1965 fire occurred during a maintenance operation which involved unplugging a coolant recirculation line for a tape-controlled turning machine. Attempts to remove the line obstruction from the glove box end of the line failed and attempts were made to unplug the line through a drain leg located close to the glove box. A cap was removed from the bottom end of the drain leg and a double-bagged center punch was inserted to dislodge the obstruction. Sparking was observed when the punch was struck, and a flash fire resulted, burning the bag enclosure for the punch and igniting a plastic and paper pen directly beneath the drain leg. The fire was extinguished with carbon dioxide...
>
> The source of ignition is presumed to be sparking caused by contacting plutonium settled in the drain leg with a steel center punch. The fire vented to the room atmosphere and the combustion products were widely spread by the normal ventilation pattern" (page 8).
>
> "The fire occurred in Room 130 of Building 77... The location of the fire was at Box 752 on the southeast machining line. ...Contamination from the fire was generally spread throughout Building 76 and over approximately 25,000 square feet of Building 77" (page 9).
>
> "Estimates of duration...of the fire ranged from one half to one and a half minutes" (page 22).
>
> "The first evidence of excessive contamination release at the job was noted by the radiation monitor...when his alpha survey instrument showed an off-scale reading" (page 24).

"...checks of people leaving Building 76-77 revealed contaminated booties on all personnel, with a large majority showing contamination of varying degrees on coveralls and/or exposed portions of the body. This was evidence that the entire area of Building 76-77 was suspect" (page 25).

"Residues of the fire and residues from a drain leg removed from an adjacent lathe have been analyzed. These analyses indicate that, during the fire, a chemical reaction had occurred between plutonium and carbon tetrachloride" (page 28).

"...sparking occurred when a center punch contacted the material collected in the drain leg of the coolant line. Upon the second blow, a considerable amount of sparking was observed immediately before the actual fire occurred at the end of the pipe drain leg. Residues from a drain leg removed from an adjacent lathe have been analyzed as plutonium chips, plutonium dioxide, oil and small amounts of plutonium hydride. There is no reason to assume that these residues differ from the original material in the other drain leg before the fire. However, one difference that did exist was that the drain system which burned had been flushed with carbon tetrachloride before the maintenance operation. Operations on the two lathes are similar and on the same material. Therefore, it was concluded that the sparking resulted from friction caused by contacting plutonium metal or plutonium hydride with a steel center punch.

Chemical reactions considered include the reaction of plutonium (and plutonium oxides) with carbon tetrachloride, the reaction of plutonium with oxygen and the reaction of plutonium metal with hydrocarbon oil.

The expected products of the first reaction would be plutonium trichloride, chlorinated hydrocarbons, carbon, phosgene, and in the presence of oxygen, carbon monoxide, carbon dioxide and plutonium oxychloride. The expected products of the second reaction would be plutonium oxide. The expected products of the third reaction would be hydrogen, plutonium carbide and plutonium hydride.

The burning of plutonium in air is generally non-violent and described as smoldering. The reaction of plutonium and a chlorinated solvent (e.g., carbon tetrachloride) can be quite violent.

> The sparking or fizzling observed immediately before the fire could be expected of a reaction between plutonium and air or carbon tetrachloride. The appearance of a ball of fire suggests the presence of a vapor which was ignited by the burning plutonium or the reaction between plutonium and carbon tetrachloride. This vapor could have been created by the heating of the hydrocarbon oil.
>
> Chemical analyses of the fire residues within the pipe indicate the major crystalline constituents were plutonium oxychloride and plutonium trichloride. Both are products of the plutonium-carbon tetrachloride reaction" (pages 31-33).

The 1974 Control Valve Release

Radioactive particulates escaped from an exhaust stack on the roof of Building 707-A at Rocky Flats following a glove box atmosphere control valve accident at about 9:53 a.m. on April 2, 1974. The reversed flow of contaminated air due to manual operation of a control valve during a maintenance operation was not subject to any HEPA filtration and therefore contaminated ducts normally handling uncontaminated air with plutonium. This accident is discussed in detail in a Rocky Flats accident investigation report (Freiberg et al., 1974).

Inert System No.2 is one of the recirculating nitrogen handling systems designed to maintain the oxygen content of the atmosphere in glove boxes and storage vaults below the levels that will support combustion. To maintain negative pressures in the glove boxes, the system must compensate for the inevitable leakage of room air into the glove boxes and the resulting dilution of the nitrogen-rich inert atmosphere. This is done by purging part of the recirculating system gas after it has passed through the HEPA filter plenums, using purge exhaust fans that release filtered gas to the atmosphere through stacks on the roof of the building. The rest of the recirculating system gas goes through recirculation fans and a chiller where additional nitrogen is added to make up for that lost in the purged gas.

The accident resulted when the inert atmosphere exhaust valve from the Building 707 storage vault was being closed during a glove box maintenance procedure. This was evidently done too quickly, resulting in a pressure surge which forced contaminated gas back upstream through the inert gas supply system. The pressure surge forced contaminated gas back through the chiller and the standby recirculation fan that had been turned off as part of the maintenance procedure. From there, the contaminated gas was pumped into the atmosphere by the purge exhaust fans through the exhaust stack shared by Inert System No. 2 and Downdraft Plenum No. 4. This transport of contaminated gas in turn contaminated the exhaust ducts.

Freiberg et al. (1974) state that:

> "...an [elevated] count was detected on the exhaust stack sample of Inert System No. 2 and Downdraft Plenum No. 4. The detection was at approximately 1300 hours, Wednesday, April 3, 1974. ...At approximately 1030 hours on Thursday April 4, 1972, results of extensive Health Sciences surveys showed the path of contamination movement in the inert system. A flow reversal had apparently occurred through the recirculating fans resulting in a release to the environment" (page 6).

The purge exhaust fans, that were pumping gas through the exhaust ducts contaminated by the events that took place around 10:00 a.m. on Wednesday, continued operating until 2300 hours on Friday, April 5, 1974. However, according to Freiberg et al. (1974), the flow from the purge fans had been "reduced to a minimum...less than 25 cubic feet per minute" late on Thursday.

The pressure surge also caused contaminated gas to flow out the open window of glove box 7-K-65, which had been removed for maintenance, into Module K. This contaminated Module K to levels up to 100,000 counts per minutes and tripped the selective air monitors at 0953 hours on April 2, 1974.

After the 1974 accident, the inert gas systems were modified so that the recirculation pumps draw gas from the filter plenum between the second and fourth stages. Now, contaminated gas from a repeat of the 1974 accident would pass through two stages of HEPA filters before being pumped into the atmosphere by the purge exhaust fans.

6.2.2 Tritium Accidents

As evidenced by effluent monitoring performed since the 1970s (See Appendix B), the Rocky Flats Plant is the source of routine, low-level tritium emissions. Tritium emits only low-energy beta particles and mixes throughout the global pool of hydrogen atoms whenever it is released to the environment. Sources of tritium include disassembly of contaminated returned components and natural generation of tritium from other materials present on the site. Low levels of tritium are generated by non-hazardous spontaneous fissioning of plutonium and uranium and by interaction of neutrons given off by plutonium with other materials, such as beryllium. Tritium from these sources is not released in large quantities.

As will be discussed in this section, there have been a small number of incidents reported in which significantly larger amounts of tritium were released from Rocky Flats. Associated documentation has been reviewed by members of the ChemRisk project team. Some aspects of tritium handling at Rocky Flats are matters of national security, are considered classified information, and therefore cannot be discussed in this report. The identified quantities of tritium release are not typically associated with the potential to cause off-site health impacts. However, the source term estimates for these off-site releases of tritium will be presented in the Task 5 source term report and their significance for off-site health impacts evaluated in Task 6 and 8 activities.

The Final Environmental Impact Statement (USDOE, 1980, page 2-172) acknowledges two accidental releases of tritium from Rocky Flats. Regarding the potential community health risks from these releases, Cuddihy and Newton (1986) say that:

> "Two large release of tritium...occurred from the Rocky Flats Plant. An accident in 1968 led to the release of several hundred curies and another in 1973 released 500 to 2000 Ci. The release in 1973 occurred when material... contaminated with tritium was inadvertently processed. It was estimated that about 60 Ci of tritium was released in water effluents, 100 to 500 Ci was retained in ponds and tanks on-site, and the remainder escaped into the atmosphere. ...airborne tritium disperses widely in the atmosphere and may never redeposit on ground surfaces. In addition, tritium decays by emitting low-energy beta radiation that is less damaging to body tissues than the high-energy alpha radiation emitted by plutonium."

The accident investigation report on the 1974 tritium release (USAEC, 1974, page 24) states:

> "There are five known sources of tritium effluent releases at Rocky Flats. They are Building 779, Building 561, Building 777, which released...tritium in the 1973 incident, Building 774 where tritium contaminated water is evaporated, and the four solar evaporation ponds adjacent to Building 779. The solar ponds are the source of water fed to the Building 774 evaporator."

The February 1968 Tritium Release

In 1968, several hundred curies of tritium were accidentally released. Discussing previous tritium incidents, USAEC (1973) says:

> "There was one incident in 1968 of a 600 curie tritium release from a special project. This incident involved gaseous tritium which was released up the stack. No detectable on or off-site contamination was found" (page 34).

A 1968 tritium release is also briefly discussed on page 2-172 of the Final Environmental Impact Statement (FEIS). The release is described as an accidental release of "several hundred curies", and a statement is made in the FEIS that investigations indicated that "no threat to human health or safety occurred." The details of the incident are classified, and several classified documents describing the event have been reviewed by project team members. Relevant facts about the release will be factored into the Task 5 source term estimation process for tritium.

The 1973 Tritium Release

A shipment of scrap plutonium from Lawrence Livermore Laboratory was received at Rocky Flats on March 19, 1973, for reprocessing. The plutonium "contained an unanticipated and unknown amount of tritium later estimated to range from 500 to 2,000 curies" (Barrick, 1981). The radioactive gas monitoring equipment in the receiving building (B-554) did not detect the tritium. The scrap plutonium was processed from April 9 through April 25 in Building 779A (USAEC, 1973) using procedures appropriate for non-tritiated plutonium, because the plutonium contamination was not discovered prior to processing (Barrick, 1981).

Barrick (1981) says that Rocky Flats (RF) and the Colorado Department of Health (CDH) set up sampling programs for tritium and other radionuclides in 1972. Barrick (1981) goes on to say:

> "Tritium sample results during 1972 showed good agreement at background levels (500-1000 pCi/l) between CDH and RF. In 1973, environmental samples were not checked for tritium by RF prior to September. CDH sampled plant effluent during the entire year, and on April 24, 1973, a routine monthly water sample collected by CDH from Walnut Creek indicated...3,000,000 pCi/l tritium, which equalled the maximum permissible concentration...for uncontrolled areas and which was well above background level.
>
> CDH questioned RF by telephone...and at a June 26 Information Exchange Meeting. Rocky Flats had no knowledge of any tritium being processed and did not believe the known small quantities of tritium in sources, targets, etc. on the plant site could have accounted for the anomalous results. Colorado Department of Health continued sampling after May 1973 and these samples showed decreasing

concentrations each month. The subject of tritium was discussed again by CDH in the July 31 Information Exchange Meeting with RF. It was agreed to request that the Environmental Protection Agency (EPA) perform confirmatory sampling. The EPA confirmed elevated tritium levels (during) the week of September 6, 1973.

On September 13, 1973, CDH and EPA personnel toured Rocky Flats Plant facilities and obtained additional water samples to be analyzed by several EPA and USAEC laboratories. These analyses all verified elevated tritium levels in Rocky Flats effluents.

A letter...by CDH to the Governor of Colorado on September 14 (asserted that)...Rocky Flats was the probable source of ...tritium concentrations equal to the maximum allowable in Walnut Creek waters. The release started in April, reaching the maximum in May and...declined after that. The Broomfield water supply remained at a much lower concentration and had not reached or exceeded the guide levels for drinking water.

Internal searches and audits for a source of tritium by Rocky Flats starting in June and continuing through September were unable to find a probable tritium source.

Finally, on September 20, 1973, H.C. Donnely (USAEC Manager of Albuquerque Operations Office) appointed an AEC investigating committee... The committee...reported the probable source of the tritium (on) 11/26/73."

The official tritium release report (USAEC, 1973) says:

"Hydrating and oxidizing operations in Building 779A resulted in gaseous discharges of tritium and tritium oxide to the atmosphere through the building exhausts. The recovery products, contaminated by tritium, were routed through other processing areas probably resulting in the elevated tritium levels observed in other work areas.

Treated liquid wastes from these scrap recovery and waste treatment operations were discharged to the plant waste evaporation ponds and to Walnut Creek, providing a plausible explanation for the contamination levels found in evaporation ponds, holding ponds, Walnut Creek and Great Western Reservoir" (page 5).

Describing the accident in more detail, the report (USAEC, 1973) says:

> "...several items of plutonium scrap were received at Rocky Flats from LLL (Lawrence Livermore Laboratory) which had been exposed to (a) tritium environment. The LLL staff believed that the plutonium scrap had been decontaminated prior to shipment so that alerting Dow (Rocky Flats) to the possibility of tritium contamination was unnecessary.
>
> The plutonium scrap (believed to be free of tritium) was shipped from Lawrence Livermore Laboratory on March 13, 1973, and received by Dow on March 19, 1973. ...A series of experiments, on similar scrap material, has been performed at LLL. The results revealed that the decontamination procedure was ineffective. As a result, rather than trace quantities of tritium, approximately 500 - 2,000 curies were shipped to Rocky Flats" (pages 18 and 19).
>
> "The scrap was received at Rocky Flats in shipment AEC-741-LZB-AWA-293 on March 19, 1973, with hydrating and oxidizing operations performed during April 9-25, 1973 in Room 154 of Building 779A. Contamination surveys in this room revealed elevated tritium levels in equipment and glove boxes.
>
> A subsequent review of tritium contamination in process streams was made. This review revealed a correlation between the locations of elevated tritium levels and the movement of the LLL materials through the recovery process, from the initial recovery area to the plant effluents. The LLL materials were received at Rocky Flats in four 30-gallon shipping containers. The incoming materials consisted of scrap plutonium contaminated with deuterium or tritium. These were unpackaged on a downdraft table, checked for alpha contamination, weighed, repackaged in uncontaminated shipping containers, and transferred to Building 779A, Room 154 for plutonium recovery.
>
> The operations in Building 779A consisted basically of inserting individual portions of the scrap into a hydrating reaction chamber which was filled with hydrogen to convert the plutonium metal at 350 C to plutonium hydride... During the hydrating operations, curie quantities of tritium were vented through glass wool filters, an oil vacuum pump, an oil demister, a water flame trap, a hydrogen burner and up the stack. The hydrogen burner and the water flame trap are contained in a separate non-inerted glove box. As a result, the hydrating vessel, the pump oil, the flame trap, the associated glove boxes and exhaust plenums were all contaminated with tritium and tritium oxide.

Following the hydrating operation, the plutonium hydride was transferred to an oxidizing vessel (in the same argon inerted glove box) where the hydride was converted to plutonium oxide at 350C by controlled purging of the vessel with room air at reduced pressures. This operation was vented through the same equipment as described for the hydrating vessel, and it is likely that a major portion of the tritium was evolved as HTO (tritiated water) at this time.

Following this operation, the plutonium oxide was reburned at 500 C in a separate non-inerted glove box to assure complete oxidation of the plutonium. All three of the glove boxes (numbered 4933, 1363 and 2025) utilized for these operations in Room 154 were found to be contaminated with tritium...

The "burned" oxide was subsequently transferred to Building 771 for processing to reusable plutonium metal. It appears likely that curie quantities of tritium oxide were transferred to Building 771 with the plutonium oxide, thus providing an explanation for the elevated tritium levels in the process waste streams of Building 771. Process wastes from Building 771 subsequently go to Building 774 for further waste treatment, or to the sanitary sewers or the solar evaporation ponds, providing a plausible explanation for the elevated tritium levels found in Building 774 process wastes and in the solar evaporation ponds.

After the hydrating step in Building 779A, scrap residues were sent to Building 771 for further plutonium reclamation by sulfamic acid leaching. Approximately 16 grams of plutonium were removed during this treatment. The scrap residues, after initial plutonium leaching in Building 771, were transferred to Building 881 for trace level plutonium decontamination. Subsequent activities resulted in eventual rework and shipment of these residues as pure product. Sampling data indicate that low levels of tritium remained with these residues, providing an explanation for the elevated tritium levels in the acid tanks and other selected work areas in Buildings 881 and 444 which handled or processed these residues" (pages 20-27).

Discussing previous tritium incidents, the report on the 1973 tritium release (USAEC, 1973) says:

"...three prior shipments from LLL (Lawrence Livermore Laboratory), not including the March 1973 shipment may have contained curie quantities of tritium. It is believed that these special materials

> and possibly others in past years may have been a source of occasional curie level releases of tritium to the environment" (pages 34 and 35).

A draft report to the committee investigating the tritium release (Dow, 1973, page 67) estimates that the maximum amounts of tritium that might have been contained in the three shipments from LLL other than the April 1973 shipment are as follows, based on LLL calculations:

Shipping Date	Maximum Estimated Tritium
April, 1969	57 Ci
March, 1971	40 Ci
November, 1971	29 Ci

The magnitude of these three tritium release estimates and their relative significance with regard to potential off-site impacts, compared to the 1968, 1973 and 1974 tritium release estimates, will be addressed in the Task 5 source terms report.

The 1974 Tritium Release

As stated in the 1974 tritium release report (USAEC, 1974, page 28):

> "During the period August 30 - September 4, 1974, about 1.5 Ci of tritium was released from exhaust system 205, Building 777. Tritium concentrations detected in the air effluent exhaust during the period of release were about 50% of the applicable Radioactive Concentration Guidelines (RCG) specified in AEC Appendix 0524, Annex A, Table 1, Column 1...
>
> There was no increase of tritium background levels in the environment outside of Buildings 776/777 as determined by environmental monitoring techniques, both by Dow (Rocky Flats) and the Colorado Department of Health.

> An air sample collected in room 452 (Special Assembly Line), Building 777, between 8 am and 4 pm on August 30 was evaluated at about 7 times applicable RCG, and average air concentrations for the 40 hour work week were about 1.5 times above applicable guidelines.
>
> The most probable cause for the high air sample in room 452, Building 777 was an operation conducted at the room 452 downdraft table on August 30. The air sampler is located adjacent to the downdraft table.
>
> The operation involved opening a sample shipping container called a pressure cooker. The pressure cooker was located on September 11th and found to be tritium contaminated.
>
> The pressure cooker was received from Battelle (Northwest) on July 17, 1974, and was not surveyed for tritium contamination at that time."

6.2.3 Chemical Accidents

Rocky Flats never routinely monitored airborne chemical releases, except for special studies of limited duration. Monitoring of chemicals in waterborne emissions has been relatively recent, and has been limited to analytes that provide useful information for only a few of the materials of concern for this project. Small spills of chemicals and radioactive liquids were common throughout the operating history of the plant. For example, in September of 1963, a hydrogen peroxide tank explosion in Building 771 was listed in a compilation of 99 incidents from the Executive Safety Council Minutes occurring between 1953 and 1965 (Hicks, 1965). In most spill cases, affected areas were cleaned, associated waste was processed, and any contaminated soil was excavated and shipped off-site (Dow, 1974 and Hicks, 1965).

The 1989 Chromic Acid Spill

One example of a chemical accident which attracted public interest and media attention was the 1989 chromic acid spill, which passed through sanitary waste treatment systems and reached the on-site retention ponds (EG&G, 1990). At about 4 PM on February 22, 1989, an engineer connected a hose line to a sink to raise the fluid level in a chromic acid plating bath in the Plating Laboratory in Room 245 of Building 444. The engineer accidentally left the hose running when he left the building for the night. During the night, the plating bath overflowed into an acid waste drain system, and then filled an acid waste collection tank in

Room 9A in the basement of Building 444. The official report on the accident (USDOE, 1989) states:

> "The acid waste high level alarm was silenced (with a high degree of probability) by persons unknown in the Plating Laboratory with no one taking remedial action. Pipefitters were working in the room and a security guard made routine periodic watchman tours and noted no alarms."

As a result, the acid waste collection tank overflowed into a secondary containment berm, which in turn overflowed onto the floor of the Building 444 basement. The solution then leaked through cracks in the floor into the building foundation drain system, where it was collected in a sump and automatically pumped into the plant's sanitary sewer system. The engineer turned off the hose when he returned to work the next day (7:30 AM on February 23).

A greenish-yellow discoloration was observed in the primary clarifier at the sewage treatment plant, Building 995, at 10:30 AM on February 23. The contamination moved through the treatment plant in about 24 hours and was discharged to retention pond B-3. The chromic acid-contaminated B-3 pond water was pumped to spray fields, as allowed by the Rocky Flats NPDES permit. Because the surfaces of the spray field and pond were frozen, significant amounts of chromic acid-contaminated spray water ran off the hillsides adjacent to the spray fields. This contaminated runoff water collected in the water impoundment ponds on the Rocky Flats Plant site. Chromium was not identified as the contaminant until February 28th.

A one-time agreement was reached between Jefferson County, Broomfield, Rockwell, and DOE officials to pump the water from pond B-5 into Upper Church Ditch, which flows into a series of ponds near the Jefferson County Airport (EG&G, 1990). The water from pond B-5 was below the Clean Water Standard of 0.05 part per million.

Incidents Involving PCBs

Incidents involving polychlorinated biphenyls (PCBs) and pesticides and herbicides are also discussed here because of public interest in the storage of PCBs at the plant in the early 1980s, and the discovery of Atrazine in an on-site pond in 1989.

PCBs were used in electrical transformers, capacitors, hydraulic presses and diffusion pumps throughout the Rocky Flats Plant (Hanes, 1972). PCBs were widely used throughout industry in electrical transformers and capacitors because of their fire resistance and dielectric properties. Under the Toxic Substances Control Act (TSCA), the manufacture of PCBs was banned after 1979. The plant has not purchased any fluids known to contain PCBs since 1972 (EG&G, 1991a).

In the mid 1980s, 54 transformers containing PCB fluids were either replaced (25) or refilled (29) with non-PCB fluids. The 25 transformers that were replaced were removed by an off-site contractor. One highly specialized PCB transformer remains on site (EG&G, 1991a). PCB dielectric fluids have also been used in electron beam welders as coolants. PCBs from 1 of 6 transformers on the roof of B-707 leaked and water washed the oil through storm vents and a storm pipe to a courtyard below, which was sampled (Demos, 1991).

In 1991, a transformer pad on the roof of Building 707 contained PCBs which had apparently leaked into a nearby roof drain and onto a soil area adjacent to B-707. The transformer was removed in 1983, but the pad was not cleaned. Concentrations of PCBs ranged from 4,500 micrograms per 100 square centimeters on the roof of Building 707 to approximately 920 micrograms per 100 square centimeters in the drain. The plant informed both EPA and CDH of the contamination, and has stated that, in their opinion, no potential for off-site release exists (EG&G, 1991a).

Rocky Flats has initiated an expanded program to sample other areas of the plant site where PCB transformers and equipment were previously located to determine if any further PCB contamination exists (ChemRisk, 1991). Thirty-four sites potentially contaminated with PCBs were examined, a soil sampling program was designed, and sampling began on June 24, 1991. A PCB Action Plan was due to be completed in July of 1991 (EG&G, 1991b).

In summary, no evidence was located that suggests significant off-site release of PCBs or information that could be used to accurately quantify historical releases.

Incidents Involving Pesticides and Herbicides

Many chemicals have been used at the Rocky Flats Plant to control weeds, insects and rodents for security, fire hazard, agricultural, and health reasons. Scattered records documenting the use of various herbicides and pesticides have been located back as far as 1969.

A particular incident in 1989 involving Atrazine is an issue of public concern. From February 1989 until April 1989, Vegetation Services, a private contractor, used 1100 pounds of Aatrex herbicide to control weeds near fences and in the Protected Area of the Rocky Flats Plant. Atrazine, the active ingredient in Aatrex, has a long-term residual of 12 months. In June and July of 1989, Atrazine was detected by the U.S. EPA in retention ponds A-4, B-5 and C-2 at levels of 5 to 46 ppb. Although there was no official limit for allowable levels of Atrazine in water discharged from the ponds at Rocky Flats at the time, CDH asked the plant not to discharge water containing Atrazine at levels above a proposed Federal drinking water standard of 3 ppb. In August of 1989, activated carbon treatment systems were installed at A-4 and B-5 ponds to reduce Atrazine in water discharged to Walnut Creek to levels below the proposed federal standard of 3 ppb (Porter, 1989).

In summary, no evidence was located that suggests significant off-site releases of pesticides or herbicides or information that could be used to accurately quantify historical releases..

6.3 Conclusions Regarding Rocky Flats Accidents and Incidents

The following conclusions emerge from review of the sources and documentation of accident information:

- Most of the voluminous records on accidents at Rocky Flats discuss events having only on-site or worker impacts.
- There is general agreement between disparate sources of information regarding identification of accidents having the potential for off-site impacts.
- Of all accidents identified involving chemicals and radionuclides of concern used at Rocky Flats Plant, plutonium accidents have posed the greatest potential for off-site releases.
- Of all plutonium accidents identified, the 903 Pad and 1957 Fire appear to have the greatest potential for off-site impacts to the public.

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7.0 SUMMARY AND CONCLUSIONS

The work performed for the purposes of Tasks 3 and 4 of the Toxicologic Review and Dose Reconstruction Project which is summarized in this report represents extensive efforts to address a number of project objectives. These objectives are to:

- Document the basic history of the Rocky Flats plant, outlining its physical development and its historical mission,
- Document the nature of the historical use of materials of concern identified in project Task 2,
- Identify any significant historical use of materials not evaluated as part of the selection of materials of concern under Task 2 by locating specific reference to the use of chemicals and radionuclides in plant documents or personnel interviews, or through the examination of major changes in plant mission or processes,
- Identify potential points of significant release of the materials of concern to the air, surface water or soil for which appropriate source terms will be developed in project Task 5,
- Identify the potential for the existence of significant uncontrolled routine releases of radionuclides as a result of normal operations that would not have been detected by the effluent monitoring systems,
- Identify accidents, incidents or waste disposal practices that may have resulted in the release of contaminants with a significant potential to move off-site for which release source terms will be developed under project Task 5.

The extensive review of information repositories located both on and off the plant site and the documents they contain has made it clear that the plant's mission has remained unchanged since its initial operation. Although the plant has grown in physical size; the nature of the processes and the general types of materials used in these processes has remained largely the same since the 1950s. Therefore, the reliance of Task 2 efforts primarily on information on material usage in the past two decades in selecting the materials of concern appears to have resulted in the identification of relevant materials for evaluation of potential off-site impacts.

Environmental monitoring was instituted prior to plant construction and has continued on an ongoing basis since initial plant operation. The initial plant designs included effluent filtering and treatment systems and surface water retention ponds to control radionuclide releases. The records clearly indicate a recognition of the need to control and limit radionuclide releases since the beginning of plant operations, driven by a combination of economic, national security and health concerns. The extensive reviews failed to identify any historical evidence of significant intentional uncontrolled routine releases of radionuclides from the plant to the off-site environment.

A number of materials on the initial list of materials of concern generated as part of project Task 2 were included because no information was immediately available with regards to the nature of their use and potential for release. For a number of these materials, even after the extensive searches and interviews performed as part of this Task 3 and 4 effort, no information could be found with regards to their potential use at the plant. These materials include:

Benzidine
1,3-Butadiene
Ethylene Oxide
Propylene Oxide

In addition, information obtained on a number of the materials of concern has indicated that based on the nature of their use and potential for release they do not warrant further investigation from the standpoint of potential off-site impacts. These include:

Benzene
Cadmium Compounds
Chromium Compounds
Formaldehyde
Hydrazine
Lead Compounds
Mercury
Nickel Compounds
Nitric Acid

With regard to contaminant release points, airborne emission points are identified for each of the materials of concern in this report. Surface water emissions are associated primarily with releases from the terminal surface water retention ponds on the plant site which have collected some plant effluents as well as site runoff. Releases of contaminants to the groundwater may have resulted from seepage from retention or evaporation ponds, as well as from various waste disposal activities or spills.

The review of historical accidents and incidents at the plant site led to the identification of voluminous amounts of information documenting numerous small fires, spills, injuries and property damage. However, none of the documentation indicated the occurrence of any previously unreported major events potentially impacting the off-site public. Major events of potential interest are those that were studied and publicized following the 1969 fire.

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GLOSSARY

Radiological

alpha particles	positively charged particles of discrete energies emitted by certain radioactive materials; alpha particles usually expend their energy in short distances and will usually not penetrate the outer layer of skin; they are a significant hazard only when taken into the body where their energy is absorbed by tissues.
beta particles	negatively charged electrons of a continuous energy spectrum emitted by certain radioactive materials; beta particles have a greater range in tissue than alpha particles, but deposit much less energy to tissues than alphas and are therefore less damaging to tissues.
gamma radiations	photons emitted by certain radioactive elements which are identical in form to x-rays; gamma rays are of most concern as an external hazard due to their high penetration ability.
curie (Ci)	the conventional unit of activity equal to 3.7×10^{10} nuclear disintegrations per second.
criticality (p.90)	a self-sustaining nuclear fission reaction.
fission	the splitting of a heavy atomic nucleus into approximately equal parts, accompanied by a large amount of energy.
fissionable	material capable of undergoing fission by interaction with fast neutrons.
fusion	formation of a heavier atomic nucleus from two lighter ones, with an attendant release of energy, as in a hydrogen bomb.
HEPA filter	high efficiency particulate air filter
implosion	to collapse inward as if from external pressure; compression.
isotope	elements having the same atomic number but different atomic weights; they have similar chemical properties but different physical properties.

minimum detectable activity (MDA)	limit of detection for radioactivity measurements.
pit	the first stage fission component used to initiate the second stage fusion reaction in a nuclear weapon/hydrogen bomb; also referred to as triggers.
radionuclide	a radioactive nucleus of an element distinguished by their atomic number, atomic weight and energy state.
site returns (p.61)	weapon components that have been retired and returned for disassembly and recovery of materials.
thermoluminescent dosimeter	a dosimeter utilizing one of more phosphors which when heated produce light in proportion to the radiation dose it has absorbed; indicative of external exposure.
transuranic	an element with an atomic number greater than uranium (92); all eleven known are produced artificially and are radioactive.
trigger	see pit.

General

alloy	a substance composed of two or more metals united by being fused together and dissolving in each other when molten.
oralloy (p.77)	enriched uranium (containing 0.7 to 93% uranium 235) named for "O"ak "R"idge alloy.
tuballoy (p.76)	depleted uranium (containing less than 0.7% uranium 235) named for a British project called Tube Alloys Limited.
combustible	material that is difficult to ignite and that will burn slowly.
cooling tower blowdown	the continuous or periodic discharge of a portion of cooling tower water to control the level of solids in the circulating water.
effluent	used or waste gas, liquid or solid discharged from a building or facility.

near-net shape	close to final desired shape.
pesticide	an agent used to destroy pests (a plant or animal detrimental to man).
herbicide	an agent used to destroy or inhibit plant growth.
rodenticide	an agent that kills, repels or controls rodents (small gnawing animals).

Chemical

hydrofluorination	chemical conversion to a form containing fluorine.
calcination	heating to drive off moisture which results in a change in chemical and physical state.
reduction	the addition of electrons to an atom or ion; combustible or flammable agents are often reducing agents.
ion exchange	a reaction between a solid and a liquid solution used to move ions from one substance to another.
solvent extraction	the process of removing a substance from a solution by contacting it with a second liquid that stays separate; used when a substance is more soluble in one solution than in another.
molarity	chemical concentration of a solution (i.e., formula weight per liter).
scrubber	a device for removing impurities from a gas stream.
induction	the process by which an electrical (or magnetic, or electromotive) conductor becomes electrified (or magnetized, or produces an electromotive force) when near a charged body (or in a magnetic field, or in a varying magnetic field).
spray leaching (p.68)	in this case, a spraying of hot nitric acid to remove residual plutonium surface contamination.

APPENDIX A

ROCKY FLATS
HISTORICAL INVESTIGATION INTERVIEWS

APPENDIX A
ROCKY FLATS HISTORICAL INVESTIGATION INTERVIEWS

No.	NAME	EXPERTISE	YEARS AT RFP
1	Aldrich, Joe	Health Physics for 800 bldgs and 991	11 (1981-present)
2	Angell, Otis	Health & Safety	12 (1953-1965)
3	Barrick, Chuck W.	Hazardous Materials, accident summaries	38.5 (1952-1990)
4	Beranek, Michael W.	Chemical Operator B-771	21 (1970-present)
5	Boss, Merlyn	Health Physics, radionuclide effluents	29.5 (1962-present)
6	Bower, John	Operations B-776/777	1.5 (1990-present)
7	Bukowski, Dale	Health Physics, radionuclide effluents	31 (1961-present)
8	Coles, Gary W.	Facilities/Utilities	10 (1981-present)
9	Conner, William V.	Production support and R&D B-771	29 (1963-present)
10	Costain, Dave	Clean Air Environmental Reporting	4(1989-present)
11	Crisler, Larry R.	Historical chemical recovery processes B-771, B-444	28 (1964-present)
12	Crocker, Robert	Non-radiological monitoring (early APENs, carbon tet)	10 (1981-present)
13	Cypher, Norm	Waste (B-771 incinerator, B-374)	21 (1970-present)
14	Delhierro, Mike	Chem Operator B-771, electrician, Production B-371	22 (1969-present)
15	DeWitt, Steve	Operations B-771 (Pu recovery)	24 (1968-present)
16	DiGiallonardo, Louie	Foundrys: B-776/707(Pu), B-444 (U, Be); Production Mgr.	39 (1952-present)
17	Dingman, Vern	Production B-707,777	36 (1955-present)
18	Dye, Art	Health Physics, B-779 Hydride Lab	23 (1968-present)
19	Elofson-Gardine, Paula	Committee Against Radiotoxic Pollution	N/A

No.	NAME	EXPERTISE	YEARS AT RFP
20	Foppe, Terry	Safety Analysis Reports	10 (1982-present)
21	Forrey, Charles	B-771, B-371: Chem labs, Pu recovery, B-771 fume scrubber	34 (1957-present)
22	Freiberg, Ken	903 Pad	37 (1953-1990)
23	Frick, Laura	Chemical usage (NEPA)	7 (1985-present)
24	Garcia, Andy	Installation/Testing/Maintenance of HEPA filters	16 (1976-present)
25	Gisler, Richard	Chem Operator B-771, B-776, production	31 (1961-present)
26	Hazel, Al	CDH Radiological Monitoring	N/A
27	Hebert, Joe	Operations Mgr. B-771, Facilities Engineering	18 (1974-present)
28	Hickle, Gordon	Facilities Engineering; Waste	17 (1974-present)
29	Hilbig, Robert	B-460 tooling; B-771 and B-559 labs	27 (1963-present)
30	Hobbs, Farrell	liquid effluents, retention ponds	22 (1969-present)
31	Hoffman, Rod	Instrumentation, Product Engineering, Classification	28 (1963-present)
32	Hornbacher, Daryl	Product Chemistry; 70's Environmental (Rads effluent)	24 (1968-present)
33	Hudson, Fred	Maintenance, B-771, 371, 444	19 (1973-present)
34	Hunter, Duane	Analytical labs in B-777, 707, 559, 881	22 (1970-present)
35	Ideker, Gene	B-881 stainless steel, B-460	24 (1968-present)
36	Jackson, Ross	Uranium and Be in B-444, 865, 883	28 (1964-present)
37	Johnson, Rodney	Non-Plutonium Facilities B-881, 444, 460	23.5 (1967-present)
38	Karpen, Barbara L.	Health Physics secretary (radioactive effluent records)	13 (1979-present)
39	Kelchner, Burt	Chemical Operations B-881 (U and Pu); Waste Projects B-374	32 (1952-1983)
40	Link, Dick	Chemical usage (700 buildings)	29 (1962-present)
41	Loudenberg, Gerry	Purchasing (hazardous materials records)	18 (1973-present)
42	Maas, Maurice	Waste Treatment B-774, 374	32 (1952-1983)

No.	NAME	EXPERTISE	YEARS AT RFP
43	Martella, Larry	Recovery Operations B-771 (aqueous), B-776 (pyro/salt)	20 (1971-present)
44	McMenus, Frank	Chemical Operator B-771; Waste processing B-774/374	22 (1969-present)
45	Melick, Steve	Warehouse Operations	39 (1952-present)
46	Merriman, Jim	B-559 Analytical lab, equipment standardization	22 (1970-present)
47	Milner, John Jr.	Filter installation and testing	22 (1969-present)
48	Morrison, James D. "Dave"	Water plant, early B-881 operations	38.5 (1953-present)
49	Morrison, John	B-771: Chemical Operator to Mgr; B-371; recent accidents	40 (1952-present)
50	Putzier, Ed	Health Physics, effluents, accidents	31 (1952-1983)
51	Quayle, Robert E. "Joe"	B-771 Utilities Mgr. (ventilation)	17 (1974-present)
52	Risinger, Joe	Chemical operator in B-776, 771, 371 (recovery)	23 (1969-present)
53	Rothe, Robert E.	B-886 criticality experiments	27 (1965-present)
54	Schubert, Allen	RCRA Permit Applications	3 (1989-present)
55	Sheets, Bob	B-771 Pu recovery troubleshooting	29 (1962-present)
56	Simmons, Mike	B-444 (plating lab, beryllium)	11 (1980-present)
57	Slaybaugh, Robert	Utilities Operating Engineer and Mgr. B-771, 707	20 (1971-present)
58	Steckline, Ron	Utilities (every major building, esp. B-444, 460)	18 (1972-present)
59	Swenson, Barbara	Legal (Grand Jury Investigation)	14(1979-present)
60	Tallman, Ken	Production Engineering B-776/777, 707, 778, 559, 460	34 (1957-present)
61	Teel, Ronald P.	Waste processing B-774/374	25 (1966-present)
62	Trump, Carl	B-771 recovery; Material Control B-771, 706, 707	21 (1969-present)
63	Vejvoda, Ed	Production (EU, Pu); analytical, manufacturing	35 (1952-1987)

No.	NAME	EXPERTISE	YEARS AT RFP
64	Waddell, Judy	CDH Hazardous Materials	N/A
65	Weaver, Jack D.	Chemical operations and Production B-771, 371, 776	31 (1961-present)
66	Whicker, Dr. Ward	CSU Dept. Radiology and Radiation Biology	N/A
67	Young, Ed	Production Control, Safeguards & Security	33 (1959-present)
68	Zarrett, Jerry	Production Support Labs (B-371, 771, 881, and 559)	28 (1963-present)
69	Simmons, Richard	Health Physics Monitor, Experimental Operator, Quality Engineer, accident victim	34 (1956-1989)
70	DelPizzo, Richard D.	Operational Health Physicist	31 (1962-present)
71	Hill, John	Radiation Monitor, Health Physics Supv., Industrial Hygiene	32 (1953-1984)
72	Heberlein, Doug	Enriched Uranium Chemistry, Engineering & Troubleshooting, Patent Officer	31 (1952-1982)
73	Piltingsrud, Clarence	Los Alamos, Health Physics	27 (1953-1979)
74	Langell, F.H.	Retired Plant Manager	11 (1951-1961)
75	Epp, John	Asst. Tech. Dir., Mfg. Mgr., Quality Group	25 (1951-1975)
76	Cornelison, Bill	Security, Fire Department, Document Control	26 (1951-1976)
77	Stone, Jim	Austin Co., Private Practice, Subcontractor at Rocky Flats, Utility Design at RFP	7 (1980-1986)
78	DiCarlo, Gene	Health Physics, Safety Committee	40 (1953-1992)
79	Ray, Johnny	Laborer, Radiation Protection, Performance Assurance	36 (1957-present)
80	English, Ernie	Laborer, Radiation Monitoring	25 (1968-present)
81	Shannon, Wm. M. "Mike"	Cost Accounting, Budget & Planning, Finance Director	35 (1956-1990)
82	Greinetz, Rosamund	Chemist at RFP Briefly. Now a Concerned Member of Public.	5 (1976-1980)

No.	NAME	EXPERTISE	YEARS AT RFP
83	Clark, Norm	Building 883 Foundry Foreman	36 (1957-present)
84	Dorr, Jack	Retired General Manager	26 (1960-1985)
85	Martell, E.A.	CCEI, Soil Contamination Issues	N/A
86	Kendra, Mark	CDH Emission Database	N/A
87	Snead, J.	B-440	18 (1974 - present)
88	Niehoff, C.	B-440	18 (1974 - present)
89	Osbourne, Bill	Air Effluent Monitoring	10
90	Tyree, Bill	Air Effluent Monitoring	20
91	Cash, John	B-440	31 (1961 - 1991)
92	Woodard, Dick	B-881, Maintenance (Filter Group)	25

APPENDIX B

BUILDING SUMMARIES

BUILDINGS 122 AND 122S

I. Building History

1953 Building constructed. Use designated as medical.

II. Processes Associated with Air Emissions

No Chemicals of Concern listed.

III. Inventory

No Chemicals of Concern listed on the Inventory

BUILDING 218

I. Building History

Building 218 is actually two 10,000 gallon above-ground nitric acid storage tanks.

II. Processes Associated with Air Emissions

Nitric Acid

Acid Tank Farm. Building 218 consists of two stationary, 10,000-gallon HNO_3 storage vessels that have been in operation since 1952. Each tank is equipped with a single uncontrolled vent which protrudes vertically from the roof of each tank. Annual HNO_3 emissions for each tank are determined by summing the breathing and working/filling losses. Emission estimates are reported in tons per year. Annual uncontrolled and controlled air emissions for each tank are:

Uncontrolled and Controlled	8.97×10^{-3} tons/year
Total HNO_3 emissions	1.79×10^{-2} tons/year.

III. Inventory

No listings for this building on the 1988/89 inventory.

BUILDING 371
PLUTONIUM RECOVERY FACILITY

I. Building History

1968	A decision was made to replace the Plutonium Recovery Facility (Building 771) with a new building (Building 371) (ChemRisk, 1991; RE-891[65]).
1972	Construction began on Building 371 (ChemRisk, 1991; RE-891[65]).
1976	B-371 was originally scheduled for start-up (ChemRisk, 1991; RE-891[65]).
1978	Some equipment moved to Building 371 (ChemRisk, 1991; RE-891[65]).
1982	Pilot scale operations conducted. Due to engineering design problems production processes in this building never operated beyond pilot scale. The Plutonium Recovery (Pu electrorefining) operations remained in B-771 (ChemRisk, 1991; RE-891[9,49,65).
1982 - 1989	No accidents of any significance occurred in this building. In addition effluent emissions were most likely of little significance to the off-site population because this building only ran on a pilot scale basis. Monitoring data for radionuclides is available for the life of this building.

II. Processes Associated with Air Emissions

Beryllium

Building 371 does not process Be. However, some materials processed in Building 371 may contain Be. For this reason, Be is monitored at 2 discharge points from Building 371. The monitoring points are identified as 371-NNN and 371-SSS. They correlate respectively with vents #1 and #2.

Vent #1	2.5×10^{-7} tons/yr
Vent #2	1.8×10^{-7} tons/yr

It is believed that non-zero numbers are reported for Be release from these points due to the lack of pre-installation "blank" inspection of the filter (i.e., trace Be exists in new filters), and the magnification of analytical uncertainty, when multiplied by the large volume of air discharged from these vents.

Nitric Acid

The major function of Building 371 is to process and prepare dicesium hexachloroplutonate (DCHP) for use in molten salt extraction (MSE).

Plutonium Analytical Support Laboratory. The laboratory provides analytical support for process control. Processes include radiochemical, calorimetric, and X-ray analyses on feed materials and residues. Sample preparation and analysis can involve the use of HCl, nitric acid (HNO_3), cyclohexane, trioctyl phosphine oxide, and small amounts of HF as a catalyst. Emissions from the Plutonium Analytical Support Laboratory are minimal and would primarily occur from the dissolution processes during sample preparation of liquid and solid samples. Other potential emissions are from custom processes on heating and flaming of planchets containing waste solutions and reagents, such as HNO_3. The pollution control device for this process is a scrubber.

Emission estimates for nitric acid were based on the 10 lb NOx/ton HNO_3 from AP-42. Estimates for the Pu Analytical Support Laboratory Vent #2 are as follows:

Dissolution	
Uncontrolled	2.88×10^{-4} tons/yr NOx
Controlled	1.91×10^{-4} tons/yr NOx
Screening	
Uncontrolled	3.2×10^{-5} tons/yr NOx
Controlled	2.13×10^{-5} tons/yr NOx

Chemical Standards Laboratory. The Chemical Standards Laboratory is used to prepare standards for various users and to inspect standards that are used throughout the plant site. Emissions from the Chemical Standards Laboratory are negligible, with the exception of HCl and nitric acid used in dissolution. These emissions pass through utility scrubber 131, FP141, to System 1 exhaust (vent #1). Emissions for NOx from nitric acid were based on 11 lb NOx/ton nitric acid (AP-42).

Estimates are as follows:

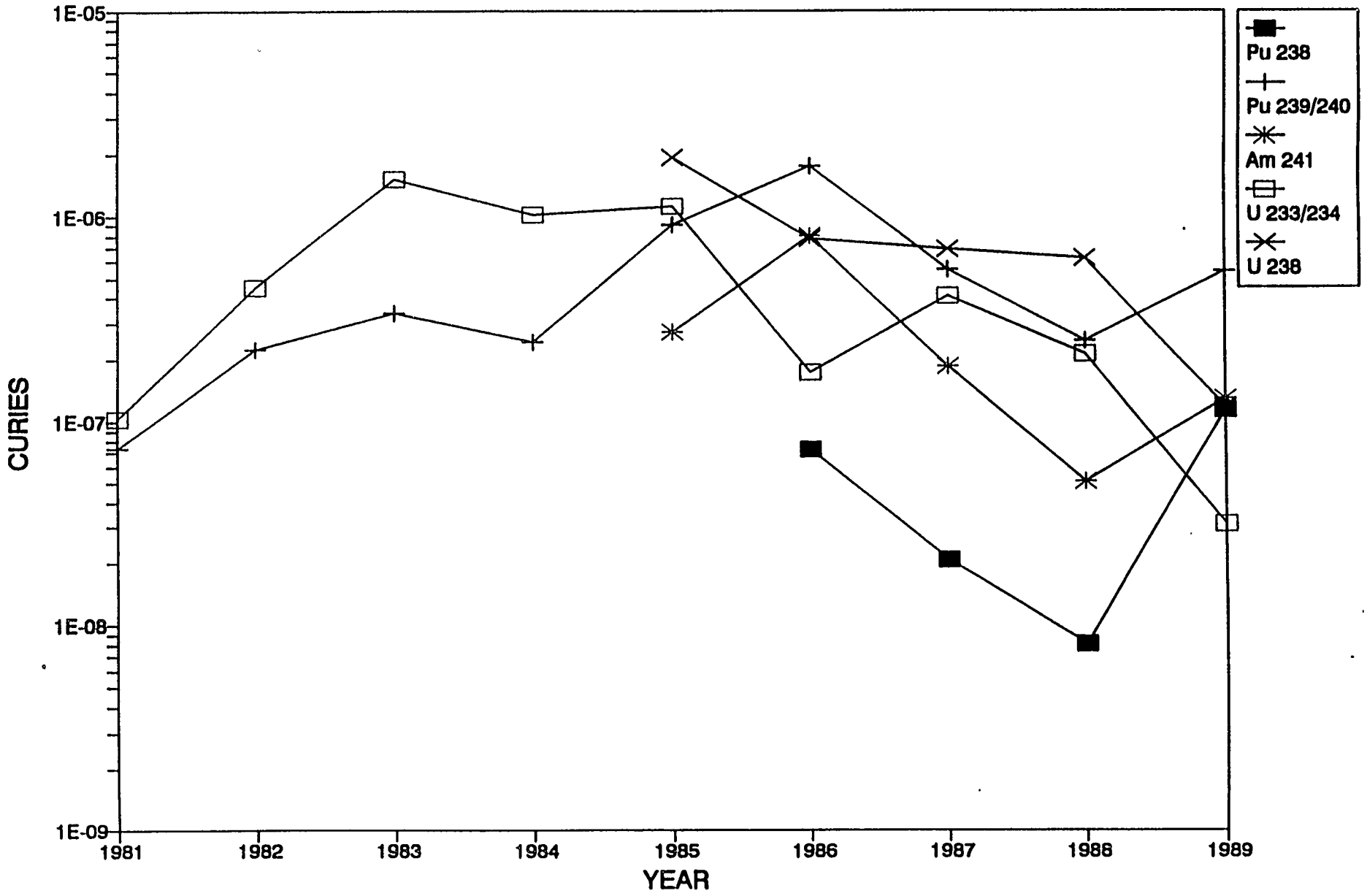
Uncontrolled	3.38×10^{-5} tons/yr NOx
Controlled	1.11×10^{-5} tons/yr NOx

III. Inventory

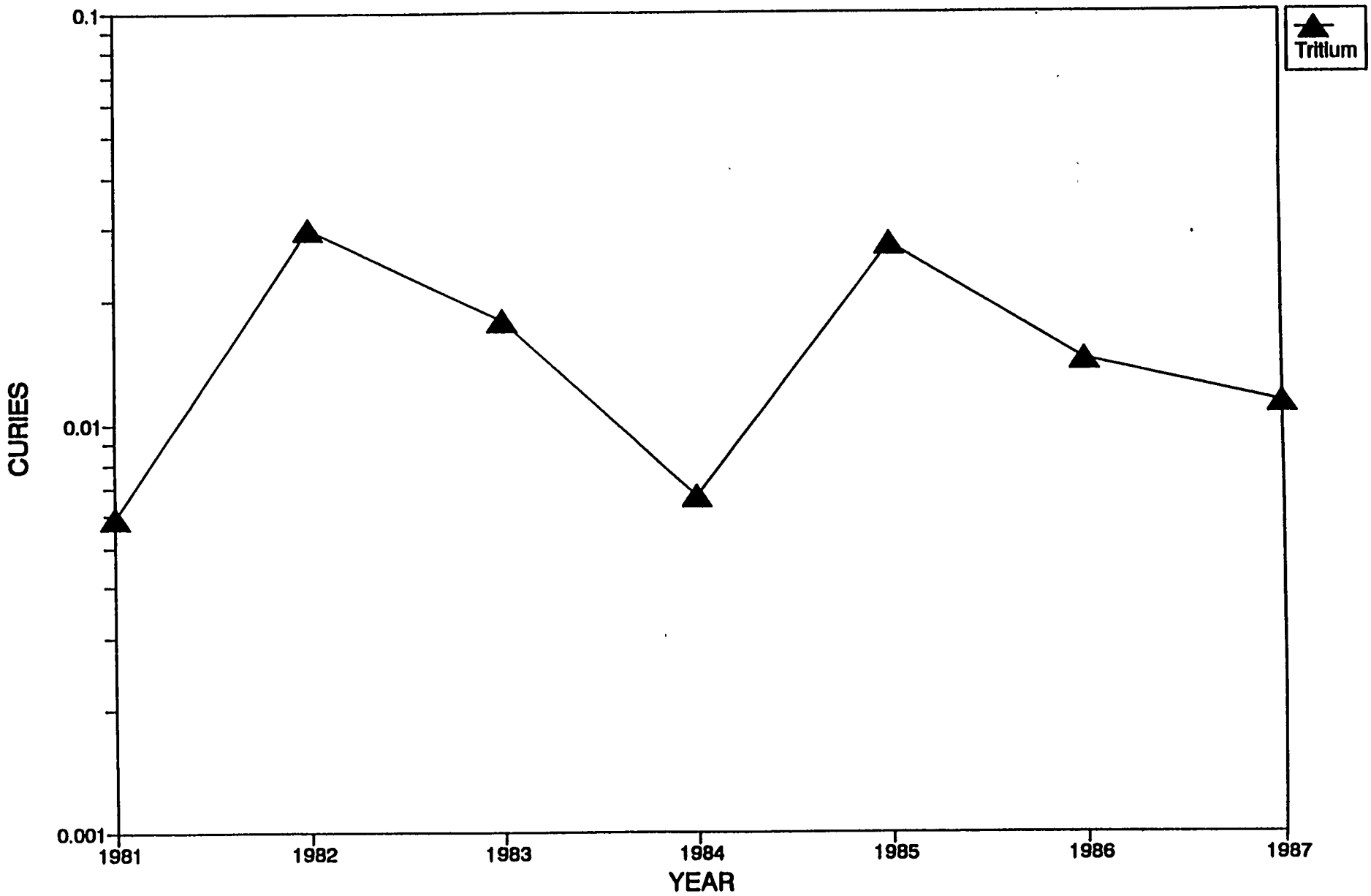
Inventory shows quantities of chloroform, nitric acid, and potassium chromate present. See table.

·adename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ILOROFORM	B371	R3412	LAB	NUL		12	LB
ITRIC ACID	B371	R3179	LAB	NUL		28	LB
)TASSIUM CHROMATE	B371	R3412	LAB	NUL		2	LB

Yearly Effluent Releases for Building 371



Yearly Tritium Releases for Building 371



BUILDING 374
PROCESS WASTE TREATMENT FACILITY

I. Building History

1978	Building brought on-line as the process waste treatment facility for many of the production buildings.
1980	Second stage of HEPA filters added (ChemRisk, 1991; RE-891[44]).
1986 - 1988	An increase in waste load (ChemRisk, 1991; RE-891[13]).
19?? - 1989	The condensate from the evaporator went to the cooling tower and then discharged to Pond B5. In 1989 this discharge was remedied by not allowing the cooling tower to overflow (ChemRisk, 1991; RE-891[44]).
1991	Presently the waste treatment facility is supporting the clean-up of the solar evaporation ponds and processing waste for Buildings 122, 123, 443, 444, 460. 559. 707, 774, 776, 778, 779, 865, 881, 883, and 889.

II. Processes Associated with Air Emissions

Chloroform

Exhausts through vents 7, 8, and 9. These vents serve the main exhaust plenum (2 stage HEPA) which is preceded by a scrubber. There are no controls for chloroform. Estimated emissions for chloroform:

Controlled 0.0014 t/y (almost all from B-778 and B-732)

Note: All VOC emissions are from neutralization processes. All organics are assumed to completely evaporate at some point in the treatment process.

Methylene Chloride

Exhausts through vents 7, 8, and 9. These vents serve the main exhaust plenum (2 stage HEPA) which is preceded by a scrubber. There are no controls for methylene chloride. Estimated emissions for methylene chloride:

Controlled 0.025 tons/yr

Nitric Acid

Exhausts through vents 7, 8, and 9. These vents serve main exhaust plenum (2 stage HEPA) which is preceded by a scrubber. Estimated emissions for nitric acid:

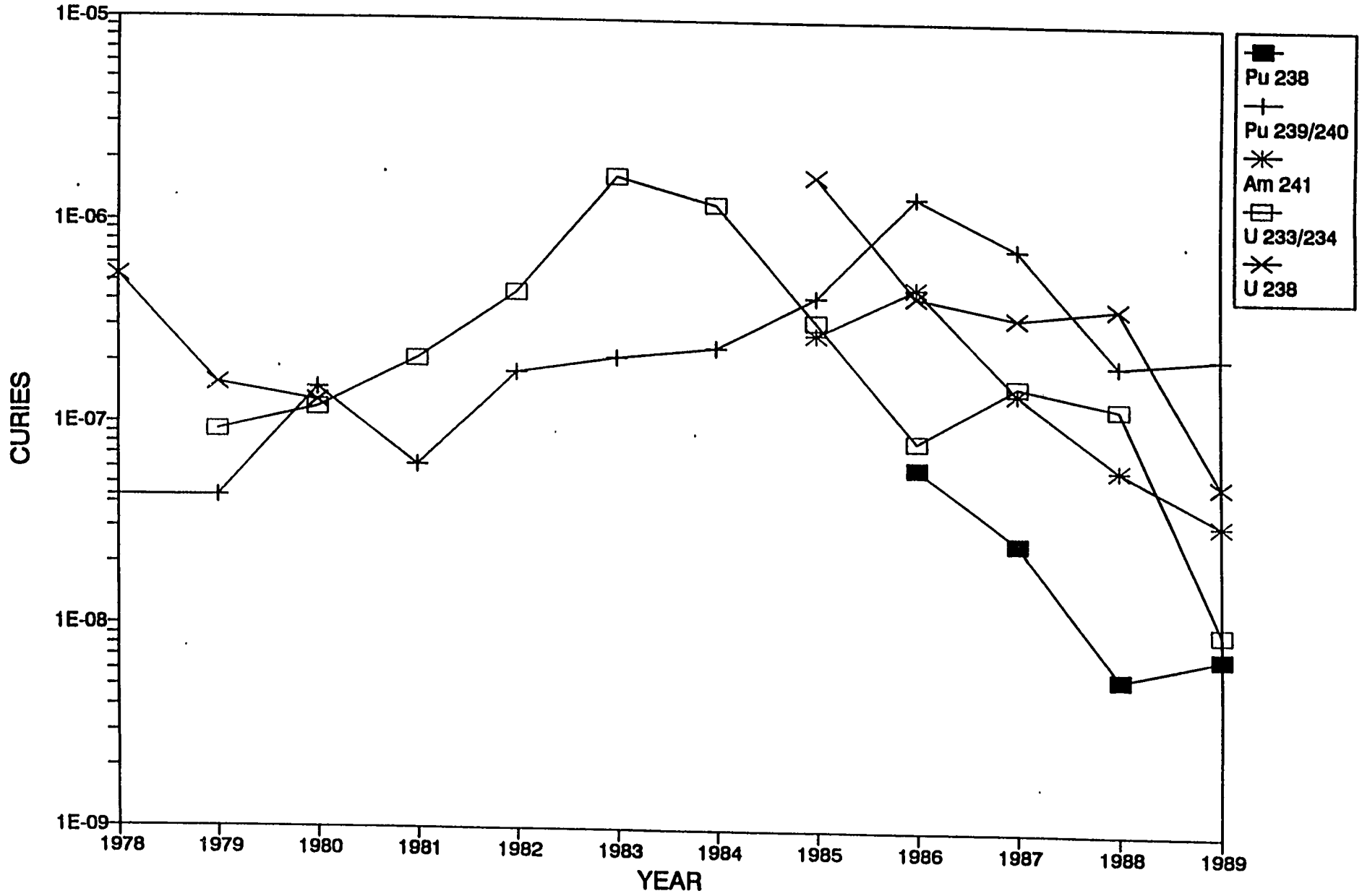
	Uncontrolled	0.46 tons/yr (reaction generates heat, therefore emissions)
	Controlled	1.92×10^{-2} tons/yr
1,1,1-TCA	Exhausts through vents 7, 8, and 9. These vents serve the main exhaust plenum (2 stage HEPA) which is preceded by a scrubber. There are no controls for 1,1,1-TCA. TCA emission estimate:	
	Uncontrolled	0.0022 t/y
Trichloroethylene	Exhausts through vents 7, 8, and 9. These vents serve the main exhaust plenum (2 stage HEPA) which is preceded by a scrubber. There are no controls for trichloroethylene. Emission estimate for trichloroethylene:	
	Uncontrolled	0.0015 tons/year
PCE	Exhausts through vents 7, 8, and 9. These vents serve the main exhaust plenum (2 stage HEPA) which is preceded by a scrubber. All VOC emissions are from neutralization. All organics are assumed to completely evaporate at some point in the treatment process. Emission estimate for tetrachloroethylene (PCE):	
	Uncontrolled	7.14×10^{-5} t/y

III. Inventory

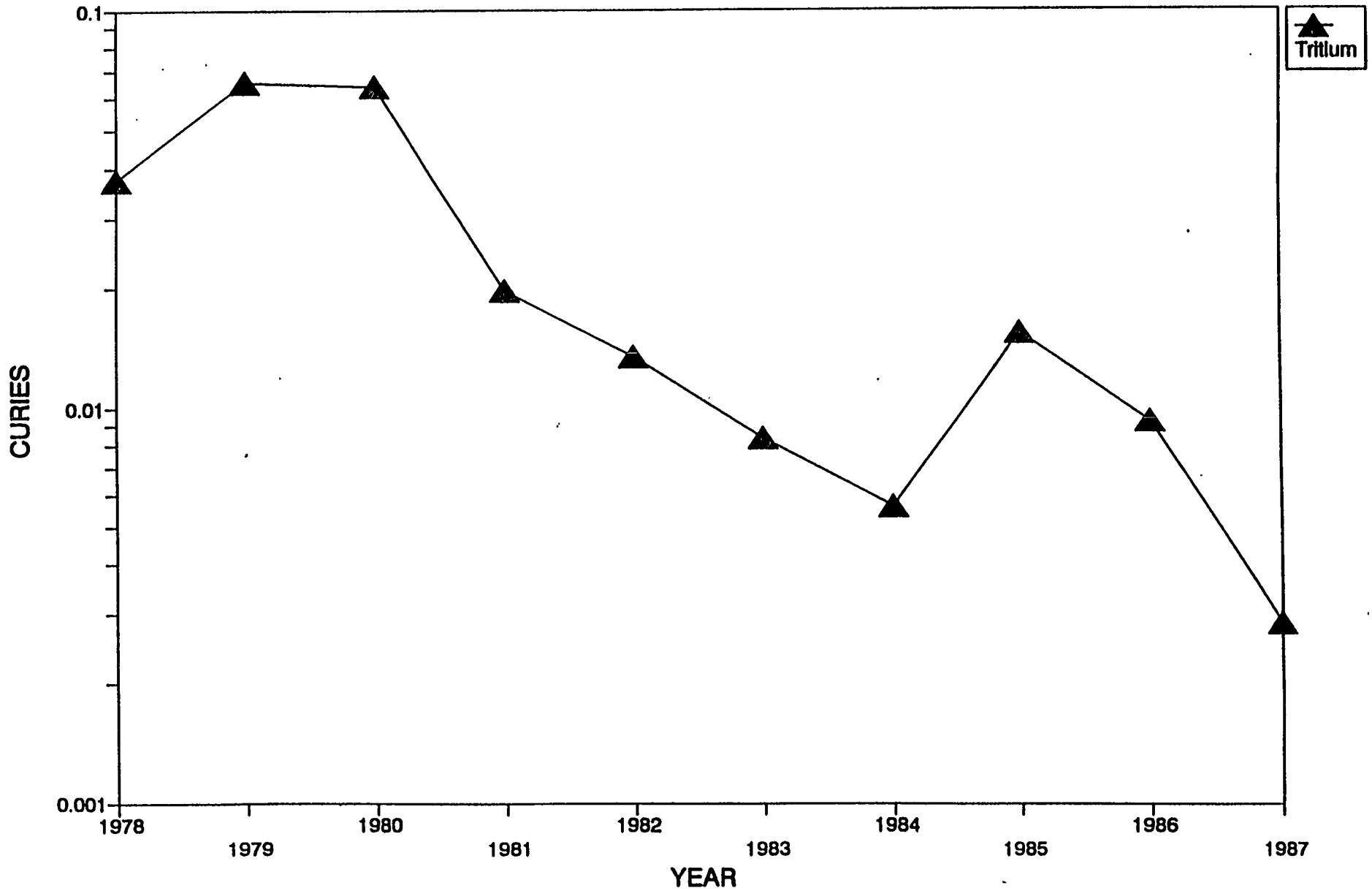
Nitric acid is the only chemical of concern listed on the 1988/89 inventory for Building 374.

radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ITRIC ACID	B374	OUTSIDE	TANK-NORTH	D222:NITRIC-ACID	EVAPORATORS, VACUUM FILTERS	4300	GL

Yearly Effluent Releases for Building 374



Yearly Tritium Releases for Building 374



BUILDING 439
MODIFICATION FACILITY

I. Building History

1971	Building constructed. Building 439 houses a machine shop, upholstery shop, battery maintenance, and office space for Building 439/440 support personnel.

II. Processes Associated with Air Emissions

No Chemicals or Radionuclides of Concern listed.

II. Inventory

No Chemicals of Concern were listed on the 1988/89 inventory.

BUILDING 440
FABRICATION FACILITY

I. Building History

1971 Building constructed. Building 440 is a fabrication facility in which rebuild and rework operations to modify and maintain DOE vehicles, and rail cars are performed. Operations in the building include metalworking, painting, electrical fabrication, and assembly.

II. Processes Associated with Air Emissions

No Chemicals or Radionuclides of Concern listed.

II. Inventory

One 55 gallon drum of methylene chloride was listed on the 1988/89 inventory.

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
METHYLENE CHLORIDE	B440	DR SHED	MOD CENTER/EAST SIDE	DRUM SHED		55	GL

BUILDINGS 444, 445, 450 and 455
DEPLETED URANIUM AND BERYLLIUM METALLURGY

I. Building History

1953	Building 444 came on line in August.
1957	Building 445 added.
1958	Be operations began in Building 444. Blanks received from commercial supplier were machined.
1968	Buildings 444 and 445 connected.
1968 - 1972	Tetrabromoethylene was used as a float-sink separation process media in conjunction with beryllium work (ChemRisk, 1991; RE-891[56]).
1980	Beryllium casting ceased (ChemRisk, 1991; RE-891[56]).
1981	Production plating lab began operations (ChemRisk, 1991; RE-891[56])
1983	Construction of new filter system for B-444.
1984/85	New filter system came on-line.
1987	Titanium Stripping began (ChemRisk, 1991; RE-891[56]).
1989	Uranium foundry shut-down (ChemRisk, 1991; RE-891[56]).
1990	Production plating lab shut down after a fire (ChemRisk, 1991; RE-891[56]).
B-450	Date of construction Unknown. Building 450 houses the exhaust filter plenum and exhaust fans that handle a major portion of the air exhausted from Building 444. The plenum is comprised of a demister section and two stages of HEPA filters. Each stage contains 192 HEPA filter units mounted 32 units wide by 6 units high. Three exhaust fans pull the exhaust air through the filter plenum and discharge the air through vent #200 to the atmosphere (EG&G Rocky Flats, 1991).

B-455

Date of construction unknown. This building is an exterior exhaust filter plenum consisting of a demister section and two stages of HEPA filtration. The plenum serves the production plating laboratory in Building 444. Each stage contains 16 HEPA filter units mounted 4 units high by 4 units wide. The exhaust fan for the plenum exhaust system is mounted on the roof of Building 444. The fan discharges through vent #82 to the atmosphere (EG&G Rocky Flats, 1991).

II. Processes Associated with Air Emissions

Beryllium

Beryllium Machining. Beryllium machining operations in Building 444 include sawing, milling, drilling, and lathe operations followed, if necessary, by polishing and abrading operations. Machining includes work on Be castings, rough pressings, sintered forms, and bar stock. Beryllium chips and dust are generated during dry Be machining operations. Chips and dust generated are collected from the immediate work area by two systems: 1) a low vacuum system consisting of hoods/plenums located above the machine that removes fine dust and small metal particles; and 2) a high vacuum system consisting of flexible hoses with suction heads located within a few inches of the cutting tools. This material is removed from the exhausted air stream by cyclone separators (one for the low vacuum system and one for the high vacuum system) followed by two stages of HEPA filtration. Beryllium chips and dust collect in 55-gallon drums located under each cyclone. Filled drums are sealed, inspected, and transported to Building 991 Waste Operations. For emission estimates an overall cyclone separator efficiency of 85 percent is assumed. Filtered air exits to the atmosphere through vent #122.

Be particulate air emissions are as follows:

Uncontrolled	1.88 tons/yr
Controlled	5.65×10^{-7} tons/yr

Nitric Acid

Production Plating. Building 444 production plating etches and plates War Reserve (WR) and special order parts fabricated from Cu, steel, and stainless steel. These processes are similar to standard industry plating processes, and are performed on a bench-scale basis. Air emissions from the production plating operations area discharge through the Building 445 exhaust filter plenum to vent #82. There are no air emission controls.

Emission estimates from the oxidation of HNO_3 to NOx (vent #86):

Uncontrolled NOx 7.02×10^{-2} tons/yr

Assembly Welding, Brazing, Etching, and Coating. In assembly welding, special order and WR parts fabricated from stainless steel are welded using a tungsten inert gas (TIG) welding process. In assembly brazing operations, Be and stainless steel parts are brazed in a vacuum furnace. Assembly etching is performed prior to assembly coating. Uranium parts are acid etched using an ultrasonic etching bath with a solution of HNO_3, hydrogen peroxide, and DI water. Air emissions from welding, brazing, etching, and coating operations discharge through the Building 450 exhaust filter plenum to vent #200. There are no emission controls.

Emission estimates from the oxidation of HNO_3 to NOx (vent #86):

Uncontrolled NOx 8.60×10^{-2} tons/yr

Titanium Stripping. WR products are coated with Ti in another process area. Stainless steel and ceramic fixtures used to hold WR parts during Ti coating also become coated with Ti. The build-up of Ti eventually makes the fixture unusable. Stripping restores the fixtures so that they can be reused. The Ti is removed by immersing the coated fixture in an acid solution from ten minutes to five hours. Air emissions from the Ti stripping discharge through the Building 450 exhaust plenum to vent #200. Fumes from the Ti stripping operations pass through a fume scrubber. The efficiency of this scrubber for removing NOx could not be determined. For this reason no reduction in NOx emissions was considered for this process. The reaction of HNO_3 with Ti generates NO_2.

Emission estimates of NO_2 are as follows:

Uncontrolled 7.93×10^{-2} tons/yr

Radionuclides

Foundry. Eight vacuum induction furnaces are used to produce ingots from scrap depleted U, depleted U alloys, Ag, Al, and Cu. Casting processes produce small quantities of particulates from mold coating compounds and metal oxidation reactions. All off-gases discharge through the Building 444 exhaust system to the Building 450 exhaust filter plenum vent #200 (Figure 2). Particulate emission control

consists of two stages of HEPA filtration. Particulate (including depleted U, depleted U alloys, Ag, Al, and Cu). Emission Estimates:

Uncontrolled	4.92×10^{-2} tons/yr
Controlled	9.84×10^{-8} tons/yr

Mold Cleaning. Graphite molds used in the foundry area in Building 444 for casting ingots are manually cleaned using wire brushes and other hand tools. The molds are recycled for reuse. Residual material in the mold after ingot removal includes Y_2O_3, depleted U oxide, graphite, and trace quantities of iron, silica, and other cast metals. This material is collected and transferred by house vacuum to a cyclone collector located in the Building 444 Utilities Area. The cyclone is 85 percent efficient in removing particles greater than 15 microns. According to plant personnel, approximately 5 percent of the material is less than 15 microns. Particulates from mold cleaning discharge through vent #200 after passing through a vacuum cyclone separator and two stages of HEPA filtration.

Particulate (including Y_2O_3, depleted U oxide, graphite, and trace quantities of iron, silica, and other cast metals) air emission estimates are as follows:

Uncontrolled	1.06 tons/yr
Controlled	4.06×10^{-7} tons/yr

Robot Crucible Cleaning. A robot device in Building 444 cleans the graphite crucibles used for heating and melting metals in foundry furnaces. The removed residue contains depleted U oxide with trace amounts of iron, silica, Y_2O_3, graphite, and other cast metals from the crucible. Controls consist of the cyclone separator and two stages of HEPA filtration.

Particulate (including depleted U oxide with trace amounts of iron, silica, Y_2O_3, graphite, and other cast metals) air emission estimates are as follows:

Uncontrolled	0.56 tons/yr
Controlled	2.16×10^{-7} tons/yr

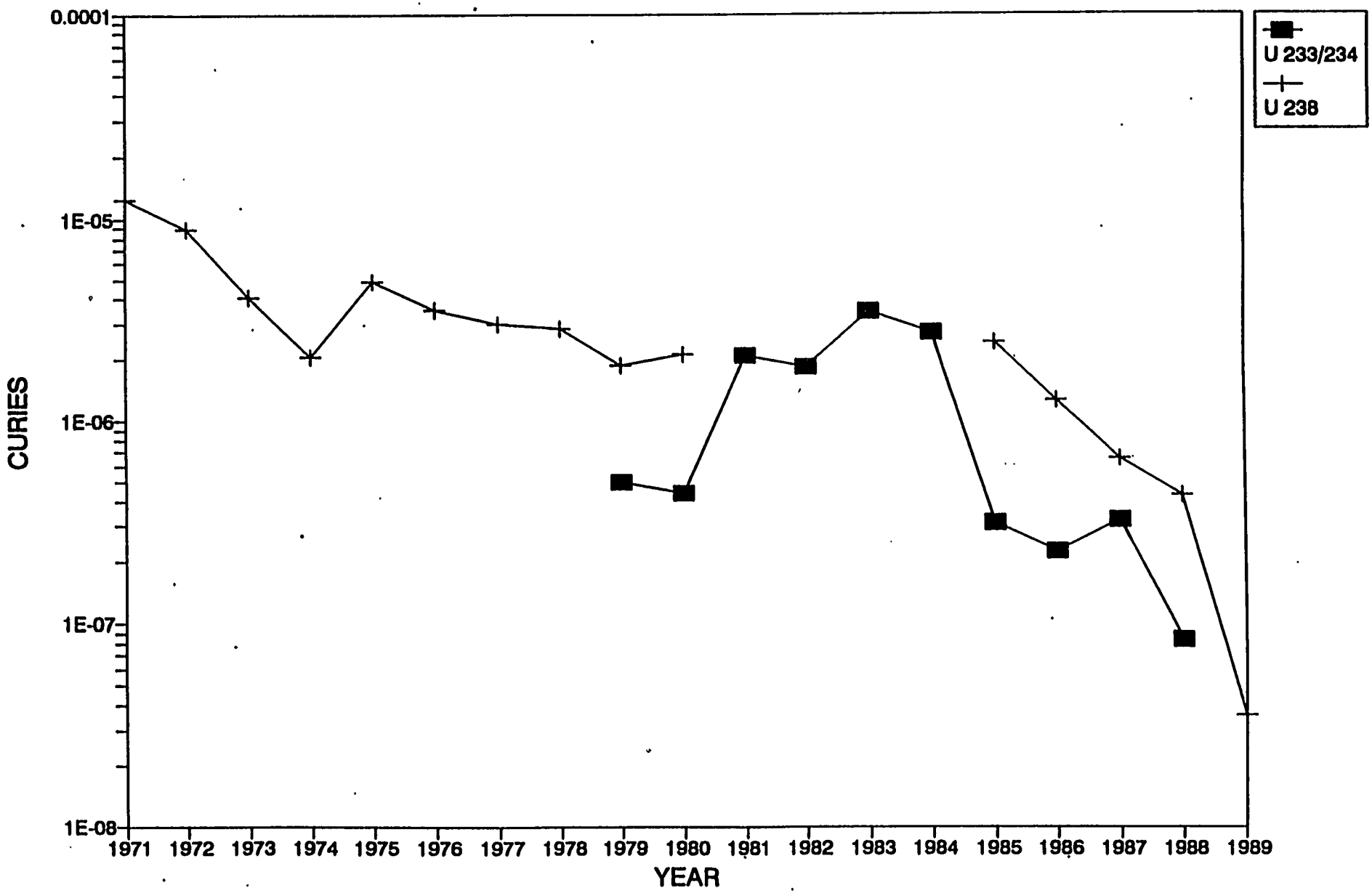
Depleted Uranium Machining. Depleted uranium machining operations in Building 444 include turning, facing, boring, milling, and sawing using numerically controlled lathes and conventional machine tools. Parts are fabricated from depleted U, depleted U alloy, depleted U with trace amounts of iron, silica, Ti, Al, and stainless steel. Air emission controls consist of two stages of HEPA filtration. Particulate air emission estimates are as follow:

Uncontrolled	1.38×10^{-3} tons/yr
Controlled	2.76×10^{-9} tons/yr

II. Inventory

Buildings 444/445 are listed as having some quantities of cadmium, chloroform, chromium, lead, mercury, and nickel. See table.

Yearly Effluent Releases for Building 444



BUILDINGS 447, 448, and 451

I. Building History

1956	Building 447 constructed. Manufacturing building
1962	Building 448 constructed. Shipping, receiving, and storage building
1983	Construction of a new filter system for Building 447.
B-451	Exhaust Filter Plenum Building which serves processes and facilities in Buildings 447 and 448. The exhaust plenum provides a demister and two stages of HEPA filtration. Three exhaust fans pull the air through the plenum and building exhaust ducts and discharge into a header that exhausts to the atmosphere through horizontal vent #201.

II. Processes Associated with Air Emissions

Beryllium

Electron Beam Welding. An electron beam welder is used for welding V, Be, Al, depleted U, and stainless steel. Welding operations are performed inside a vacuum chamber. The welding chamber vacuum pump connects to the Building 451 exhaust filter plenum. Exhaust from electron beam welding operations exits to vent #201 from the Building 451 exhaust filter plume, except during special cleanup operations after Be welding, when the chamber is vented to the Be exhaust plenum in Building 444. The calculated Be emissions from EB welding operations are 1.54×10^{-7} tons/yr.

Electrochemical Milling Operations (ECM). The ECM machine is used for a variety of production and special order jobs. Some work involves milling tungsten, brass, Cu, Al, Be, and depleted U.

ECM machining operations are performed in an enclosed chamber using aqueous electrochemical processing. Therefore, the process is not a significant source of air emissions.

Beryllium

Heat Treatment Operations. Some WR and special order depleted U, Be, and V parts produced in Manufacturing Buildings 444, 447, 883, and 460 require vacuum heat treatment to relieve internal stresses and "work hardening" induced by machining processes.

Heat treatment operations are performed inside vacuum furnaces where parts and assemblies are heated to a specified temperature under a vacuum. Therefore, there are no air emissions except ethyl alcohol used for cleaning the sealing surfaces on the vacuum chamber doors.

Methylene Chloride

Maintenance operations in B-447, B-448, B-451. Methylene chloride emitted during painting, paint stripping. Estimated air emission thru vent #201 in B-451:

Uncontrolled 5.31×10^{-4} tons/year

Radionuclides

Vacuum Arc Melt Furnace. The vacuum arc melt furnace is used to melt material for casting consumable electrodes in 6-inch and 8-inch diameter copper molds. The metals melted include depleted U, and depleted U alloy with six percent Nb. The molds may be up to 5 feet long. Off-gases from the furnace vacuum pump discharge to the 447 exhaust system, which vents to the Building 451 exhaust filter plenum. Metal melting operations are performed inside a vacuum chamber. Metal particulates may be exhausted from the chamber to the Building 451 exhaust plenum. These particulates would be collected on the vacuum pump filter. A combined emission factor of 5.7 pounds of particulate per ton of material processed is used from AP-42, Section 7.10, "Gray Iron Foundries". Actual vacuum arc melt furnace emissions are much lower than those presented below.

Emission estimates are:

Depleted U and U alloy part.	Uncont. 1.07×10^{-1} tns/yr
Depleted U and U alloy part.	Cont. 2.14×10^{-7} tns/yr

Controls: Particulate controls consist of two stages of HEPA filtration.

Chip Roaster. The chip roaster is used to oxidize depleted U scrap metal. The chip roaster is a 4-tier, single chamber, vertical roaster. Particulates and NOx gases are formed during the oxidation process. Particulate emission controls consist of two cyclone separators, a sintered metal filter, and two stages of HEPA filtration:. Air emissions from the chip roaster discharge to Building 451 exhaust filter plenum through vent #201.

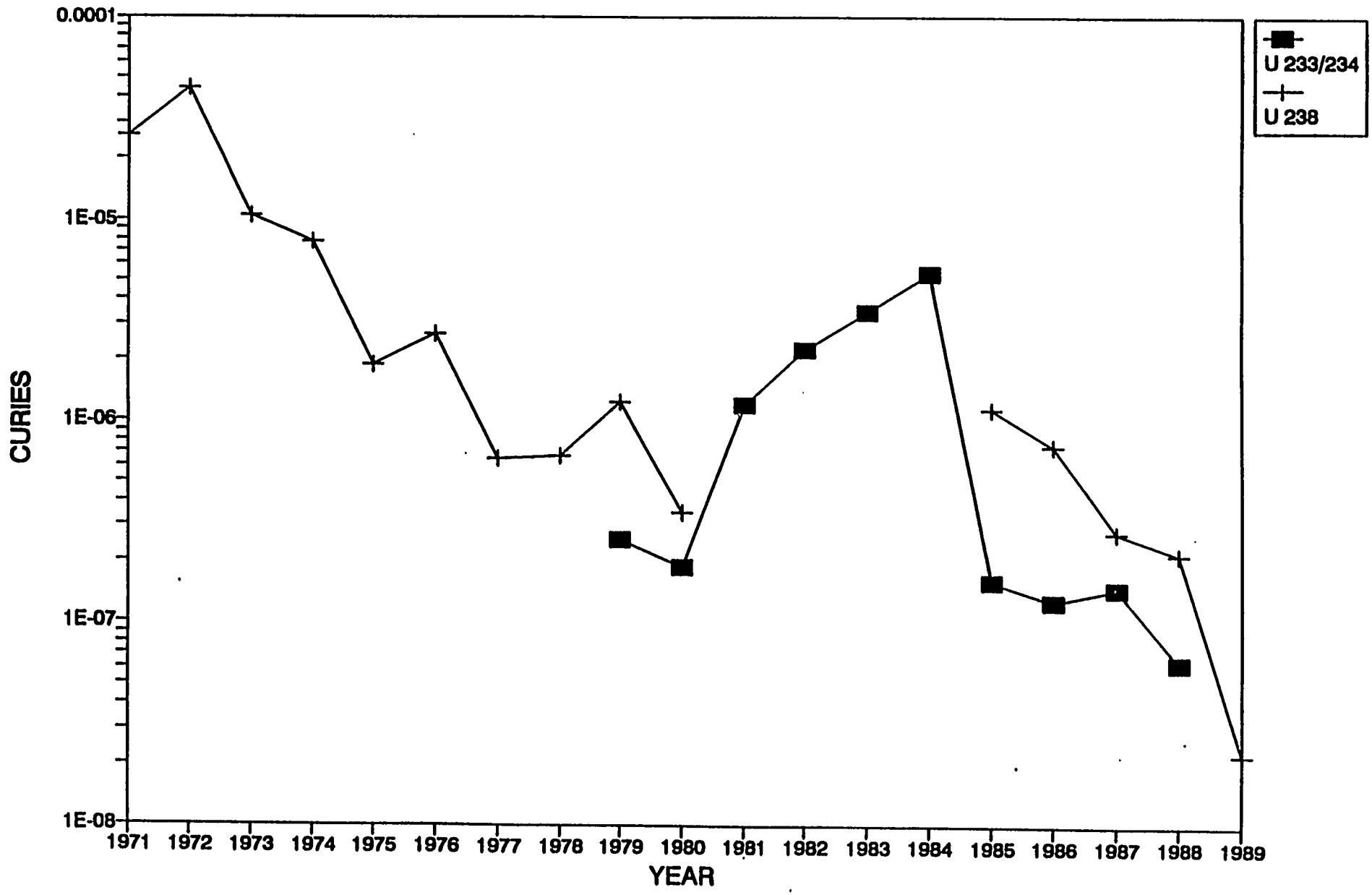
Emission estimates:

Depleted U and U alloy part.	Uncont. 2.98 tns/yr
Depleted U and U alloy part.	Cont. 8.5×10^{-7} tns/yr

III. Inventory

No Chemicals of Concern were listed on the 1988/89 inventory

Yearly Uranium Effluent Releases for Building 447



BUILDING 460
CONSOLIDATED MANUFACTURING FACILITY

I. Building History

1984	Building constructed. This building is a non-nuclear facility for war reserve and special order parts and assemblies. The stainless steel operations in this building were transferred from B-881 (ChemRisk, 1991; RE-891[35]).
1990	Eliminated the use of all chlorinated solvents (ChemRisk, 1991; RE-891[35]). .

II. Processes Associated with Air Emissions

Carbon Tetrachloride	**Materials Development Lab.** Eight gals/yr carbon tetrachloride is used to clean metal parts and is sent to B-881, distilled and returned to 460 for reuse. There are no emission controls, therefore uncontrolled and controlled emissions are the same. It is estimated that approximately 5% of the carbon tetrachloride evaporates and exhausted through vent #14. Uncontrolled 0.00266 tons/year
Chloroform	Ten vents are associated with the high bay (central manufacturing area). Chloroform emission estimates for vent #'s 2, 4, 5, 6, 35, 36, 38, 39, 40, 43 are: Uncontrolled 0.00625 tons/year
Lead	Used in non destructive testing. Radiographic testing (500 lb/yr no air emissions; lead is recycled or sent to an off-site metal processor)
Methylene Chloride	**Aqueous cleaning.** Estimated methylene chloride air emissions through vent #23: Uncontrolled 0.00162 tons/year Controlled 0.00137 tons/year
Nitric Acid	**Parts cleaning.** Acid wastewater goes to wastewater collection system. Spent acid is sent to waste treatment for disposal. Emissions go to an <u>inactive</u> fume scrubber and out vent #30. Estimated NOx air emissions from nitric acid: Uncontrolled 0.0119 tons/yr

1,1,1-TCA

Non-destructive testing (ultrasonic). Radiographic SKC developer/cleaner is 95% TCA. There are no emission controls. Estimated emissions through vent #54 are:

Uncontrolled	0.000241 tons/year

Aqueous cleaning. Ninety-five percent of 1,1,1-TCA is recovered as waste and 5% evaporates. Emissions are exhausted through an activated carbon filter to vent #23. Estimated emissions of 1,1,1-TCA:

Uncontrolled	0.00335 tons/year
Controlled	0.00285 tons/year

High Bay. Ten vents are associated with the high bay (central manufacturing area). 1,1,1-TCA emissions for vent numbers 2, 4, 5, 6, 35, 36, 38, 39, 40, 43 are:

Uncontrolled	0.00399 tons/year
Controlled	0.00399 tons/year

Inspection. 1,1,1-TCA is used to clean parts. There are no emission controls. 1,1,1-TCA emissions exhaust out the high bay vent group

Uncontrolled	0.15 tons/yr

III. Inventory

Chloroform and nitric acid were both listed on the 1988/89 inventory.

adename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
LOROFORM	B460	R150	MTCE CARPENTER SHOP	NUL	GLUE PLEXIGLASS	1	LT
TRIC ACID	B460	R158B	CLEANING	NUL	ACID CLEAN STAINLESS STEEL	280	LB

BUILDING 549

I. Building History

1957	Building constructed. This building contains the alarm systems.
1991	This building is used exclusively as an electrical maintenance shop and general staging support.

II. Processes Associated with Emissions

There are no processes associated with emissions of Chemicals of Concern from Building 549.

III. Inventory

No Chemicals of Concern were listed on the 1988/89 Inventory.

BUILDING 559 and 561
PLUTONIUM ANALYTICAL LABORATORY

I. Building History

1968 — Building Constructed. Plutonium Analytical Lab. The building contains laboratory facilities for conducting spectrochemical, chemical, and mass spectrometric analyses.

1973 — Building 561 constructed. This building houses the exhaust plenums for Building 559. Building 561 contains four separate filter plenums. Three of the plenums filter exhaust air from Building 559 and 561; the fourth plenum filters supply air for Building 561.

II. Processes Associated with Air Emissions

Beryllium — Building 559 does not process beryllium (Be). However, some materials processed in Building 559 may contain, or be contaminated with Be. For this reason, Be is monitored at Building 561 (the Building 559 glove box exhaust vent). The Be release data for 1988, is:

Controlled 1.45×10^{-7} tons/yr.

Chloroform — **Gallium Determination.** For the analysis of Pu metal samples for gallium content; Pu metal and turnings from the foundry in Building 707 foundry and the molten salt extraction in Building 776 are submitted for gallium determination. Chloroform is used to extract the gallium oxide complex. Emission estimates for vent #36 are:

Uncontrolled 0.74 tons/yr VOC

Nitric Acid — **Emissions Spectroscopy.** Emission spectroscopy analyses are performed on a variety of metal samples. Both direct reading spectrographs and Inductively Coupled Plasma are used. Acid emissions will result from the dissolution and evaporation of metal samples in acid. The acid fumes are passed through a bubbler -type scrubber before being exhausted to the filter plenum. Emission estimates (through vent #36) for the NOx generated from HNO_3 are:

Uncontrolled NOx 7.27×10^{-3} ton/yr
Controlled NOx 4.55×10^{-4} ton/yr

Uranium Analysis. Metals, liquids, oxides, oils, and sludges are analyzed for U content. Nitric acid is used during sample preparation for dissolution purposes. This results in a usage of 300 ml HNO_3/yr.

The NOx emission estimates from the evaporation of HNO_3 are:

Uncontrolled 4.97×10^{-4} ton/yr to vent #36.

Radionuclides

Plutonium Oxidation. Plutonium scraps and oxides remaining after sample analyses are oxidized in one of two glove boxes prior to shipping the PuO_2 to another process on the plant site. Scrap and oxide from all the processes are collected in these two glove boxes, and the oxidation process is run as needed (about once a month).

Emissions from Pu oxidation can be estimated by material balance. The HEPA filters on the glove box exhausts are changed approximately once every six months. These are assayed to determine Pu content. Typically each filter collects about 10 grams of particulate. The filters are more than 99% efficient. Therefore, it is assumed that all of the particulate generated during the oxidation process is collected on the prefilter. Controls include four stages of HEPA filtration in the filter plenum, the emissions vent to vent #36. The emission estimate for plutonium particulates follows:

Uncontrolled (On HEPA filters)	4.41×10^{-5} tons/yr
Controlled	3.53×10^{-16} tons/yr

1,1,1-TCA

Infrared Analysis (Infrared Spectroscopy Laboratory). 1,1,1-TCA may comprise some of the production samples undergoing acceptance testing by infrared analysis. However, no emissions are expected from this process, since the majority of organic compounds used are nonvolatile and collected in waste bottle.

III. Inventory

The 1988/89 inventory places a number of the Chemicals of Concern in this building. A complete list can be found on the attached table. The following is an abbreviated list:

Beryllium (oxide, sulfate)
Cadmium (acetate, chloride, iodide, nitrate, oxide, sulfate, and metal)
Carbon Tetrachloride
Chloroform
Chromium (chloride, nitrate, oxide, potassium sulfate, sulfate, trioxide)
Formaldehyde

Lead (acetate, chloride, metal, nitrate, oxide, powder)
Mercury (nitrate)
Methylene Chloride
Nickel (powder, nickelous chloride, nitrate, oxide, sulfate)
Nitric Acid
Tetrachloroethylene
Trichloroethylene

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radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ARIUM CHROMATE	B559	R129	UTILITY RM	NUL		1	LB
ERYLLIUM AQBE1	B559	R101D	CHEM PREP	NUL		500	ML
ERYLLIUM IN 2% HCL(HYDROCHLONC ACID	B559	R101	PU SPECT LAB	NUL		500	ML
ERYLLIUM OXIDE	B559	R101D	LAB	NUL		1	GM
ERYLLIUM OXIDE	B559	R129	UTILITY RM	NUL		5	OZ
ERYLLIUM PLBE2 2X	B559	R101D	CHEM PREP/SPECT	NUL		500	ML
ERYLLIUM SULFATE	B559	R101	LAB	NUL		10	GM
ERYLLIUM SULFATE	B559	R101	LAB	NUL		10	GM
ERYLLIUM SULFATE	B559	R129	UTILITY RM	NUL		1	LB
ADMIUM ACETATE	B559	R101	LAB	NUL		10	GM
ADMIUM ACETATE	B559	R101	LAB	NUL		10	GM
ADMIUM ACETATE	B559	R101	LAB	NUL		10	GM
ADMIUM ACETATE	B559	R101	LAB	NUL		10	GM
ADMIUM ACETATE	B559	R129	UTILITY RM	NUL		8	OZ
ADMIUM AQCD2 100	B559	R101D	CHEM PREP	NUL		500	ML
ADMIUM CHLORIDE	B559	R101	LAB	NUL		10	GM
ADMIUM CHLORIDE	B559	R101	LAB	NUL		10	GM
ADMIUM CHLORIDE	B559	R129	UTILITY RM	NUL		2	LB
ADMIUM IODIDE	B559	R129	UTILITY RM	NUL		4	OZ
ADMIUM NITRATE	B559	R101	LAB	NUL		10	GM
ADMIUM NITRATE	B559	R101	LAB	NUL		10	GM
ADMIUM NITRATE	B559	R129	UTILITY RM	NUL		4	OZ
ADMIUM OXIDE	B559	R101D	LAB	NUL		2	GM
ADMIUM OXIDE	B559	R101D	LAB	NUL		2	GM

radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ADMIUM OXIDE	B559	R129	UTILITY RM	NUL		6	LB
ADMIUM OXIDE	B559	R129	UTILITY RM	NUL		4	OZ
ADMIUM OXIDE	B559	R129	UTILITY RM	NUL		4	OZ
ADMIUM PLCD 2X	B559	R101D	CHEM PREP	NUL		500	ML
ADMIUM SULFATE	B559	R129	UTILITY RM	NUL		1	LB
ADMIUM, METAL	B559	R129	UTILITY RM	NUL		4	OZ
ARBON TETRACHLORIDE	B559	R101	PU SPEC LAB	NUL		12	LT
ARBON TETRACHLORIDE	B559	R101	PU SPEC LAB	NUL		12	LT
ARBON TETRACHLORIDE	B559	R101	PU SPECT LAB	NUL		1	PT
ARBON TETRACHLORIDE	B559	R101	PU SPECT LAB	NUL		4	LT
ARBON TETRACHLORIDE	B559	R101	PU SPECT LAB	NUL		4	LT
ILOROFORM	B559	R101	PU SPECT LAB	NUL		10	ML
ILOROFORM	B559	R102	PU CHEM LAB	NUL		4	LT
ILOROFORM	B559	R102	PU CHEM LAB	NUL		55	GL
IROMIUM	B559	R101D	LAB	NUL		20	GM
IROMIUM AQCR1 500	B559	R101D	CHEM PREP	NUL		700	ML
IROMIUM CHLORIDE	B559	R101	LAB	NUL		10	GM
IROMIUM CHLORIDE	B559	R101	LAB	NUL		10	GM
IROMIUM NITRATE	B559	R101	LAB	NUL		10	GM
IROMIUM NITRATE	B559	R101	LAB	NUL		10	GM
IROMIUM NITRATE	B559	R129	UTILITY RM	NUL		10	LB
IROMIUM OXIDE	B559	R101D	LAB	NUL		2	GM
IROMIUM PELLETS	B559	R103E	LAB-ANNEX	NUL		10	GM
IROMIUM PL SPORD	B559	R101D	CHEM PREP	NUL		1000	ML
IROMIUM PLCR2 3X	B559	R101D	CHEM PREP/SPECT	NUL		500	ML

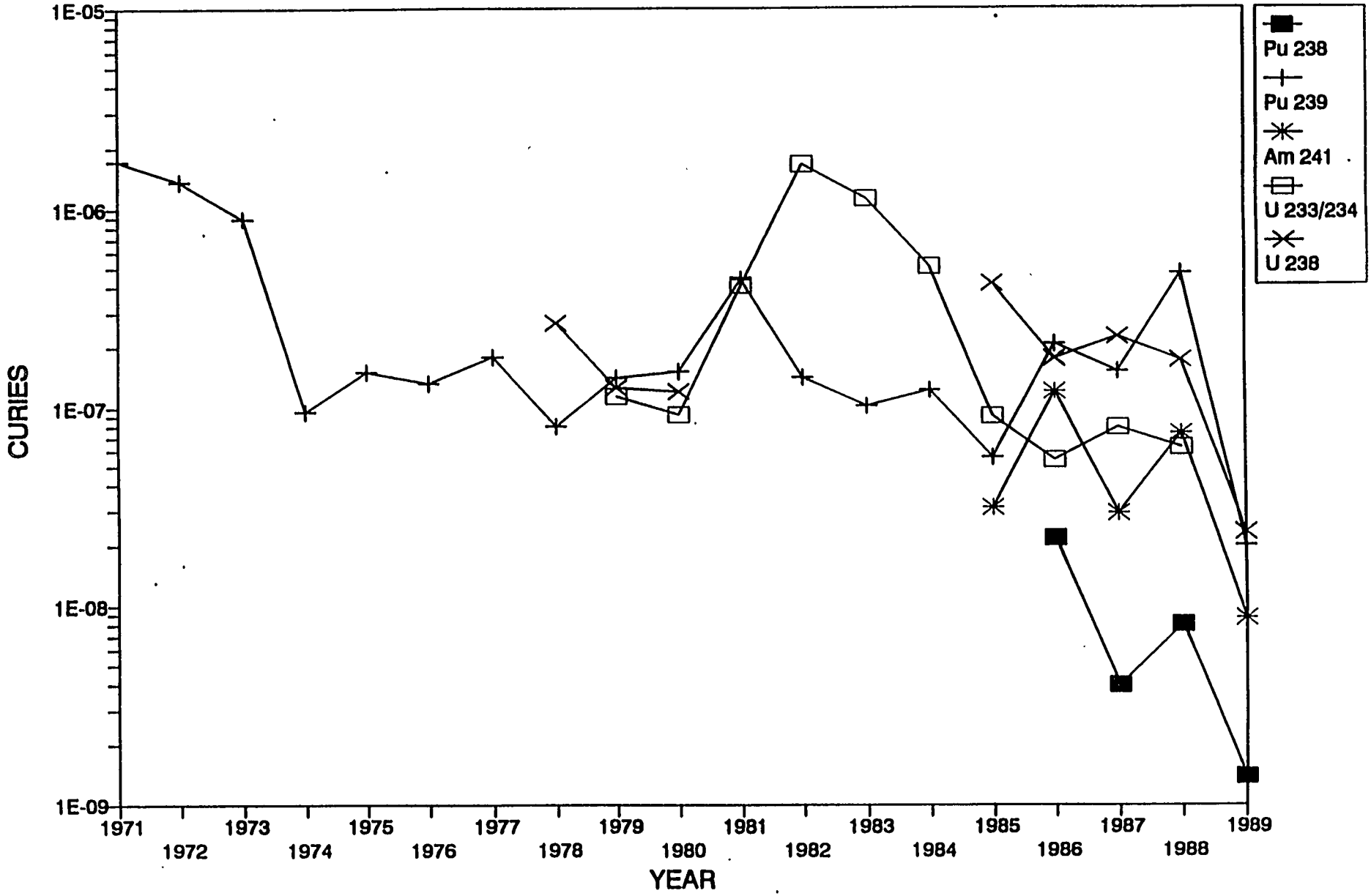
radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
HROMIUM POTASSIUM SULFATE	B559	R129	UTILITY RM	NUL		1	LB
HROMIUM SULFATE	B559	R129	UTILITY RM	NUL		5	LB
HROMIUM TRIOXIDE	B559	R101	LAB	NUL		10	GM
HROMIUM TRIOXIDE	B559	R101	LAB	NUL		10	GM
HROMIUM TRIOXIDE	B559	R129	UTILITY RM	NUL		1	LB
HROMIUM TRIOXIDE	B559	R129	UTILITY RM	NUL		2	LB
ORMALDEHYDE	B559	R101	PU SPECT LAB	NUL		10	ML
EAD	B559	R129	UTILITY ROOM	NUL		1	KG
EAD ACETATE	B559	R101	LAB	NUL		10	GM
EAD ACETATE	B559	R101	LAB	NUL		10	GM
EAD ACETATE	B559	R129	UTILITY RM	NUL		1	LB
EAD AQPB2 100	B559	R101D	CHEM PREP	NUL		200	ML
EAD CHLORIDE	B559	R101	LAB	NUL		10	GM
EAD CHLORIDE	B559	R101	LAB	NUL		10	GM
EAD CHLORIDE	B559	R129	UTILITY RM	NUL		1	LB
EAD METAL	B559	R129	UTILITY RM	NUL		24	KG
EAD METAL	B559	R129	UTILITY RM	NUL		29	KG
EAD NITRATE	B559	R101	LAB	NUL		10	GM
EAD NITRATE	B559	R101	LAB	NUL		10	GM
EAD NITRATE	B559	R129	UTILITY RM	NUL		1	LB
EAD NITRATE	B559	R129	UTILITY RM	NUL		1	LB
EAD OXIDE	B559	R101	LAB	NUL		10	GM
EAD OXIDE	B559	R101	LAB	NUL		10	GM
EAD OXIDE	B559	R101D	LAB	NUL		2	GM
EAD OXIDE RED	B559	R129	UTILITY RM	NUL		5	LB
EAD PLPB 3	B559	R101D	CHEM PREP	NUL		500	ML
EAD PLPB 3	B559	R101D	CHEM PREP	NUL		500	ML

rodoneme	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
EAD PLPB2 3X	B559	R101D	CHEM PREP/SPECT	NUL		500	ML
EAD POWDER	B559	R102	PU CHEM LAB	NUL		2	KG
EAD STANDARD	B559	R102	PU CHEM LAB	NUL		1000	ML
EAD WIRE	B559	R103E	LAB-ANNEX	NUL		50	GM
EAD,METAL	B559	R129	UTILITY RM	NUL		55	LB
ERCURY	B559	R102	PU CHEM LAB	NUL		1	LB
ERCURY	B559	R103	MS LAB	NUL		1	LB
ERCURY AGHG4 500	B559	R101D	CHEM PREP	NUL		1000	ML
ERCURY II NITRATE	B559	R103E	LAB-ANNEX	NUL		1	LB
ETHYLENE CHLORIDE	B559	R101	PU SPEC LAB	NUL		1	GL
ETHYLENE CHLORIDE	B559	R103	MS LAB	NUL		4	LT
ETHYLENE CHLORIDE	B559	R103	MS LAB	NUL		16	LT
ETHYLENE CHLORIDE	B559	R103	MS LAB	NUL		4	LT
ICKEL CHLORIDE	B559	R102	PU CHEM LAB	NUL		1000	ML
ICKEL ISOTOPE 60 NIO	B559	R103E	LAB-ANNEX	NUL		1	GM
ICKEL PLNI1 3X	B559	R101D	CHEM PREP/SPECT	NUL		500	ML
ICKEL POWDER	B559	R129	UTILITY ROOM	NUL		100	GM
ICKEL POWDER	B559	R129	UTILITY ROOM	NUL		4	OZ
ICKEL POWDER	B559	R129	UTILITY ROOM	NUL		500	GM
ICKEL, POWDER	B559	R101D	CHEM PREP/SPECT	NUL		1	LB
ICKEL, SHOT	B559	R101D	CHEM PREP/SPECT	NUL		1	LB
ICKELOUS ACETATE	B559	R101	LAB	NUL		10	GM
ICKELOUS ACETATE	B559	R101	LAB	NUL		10	GM

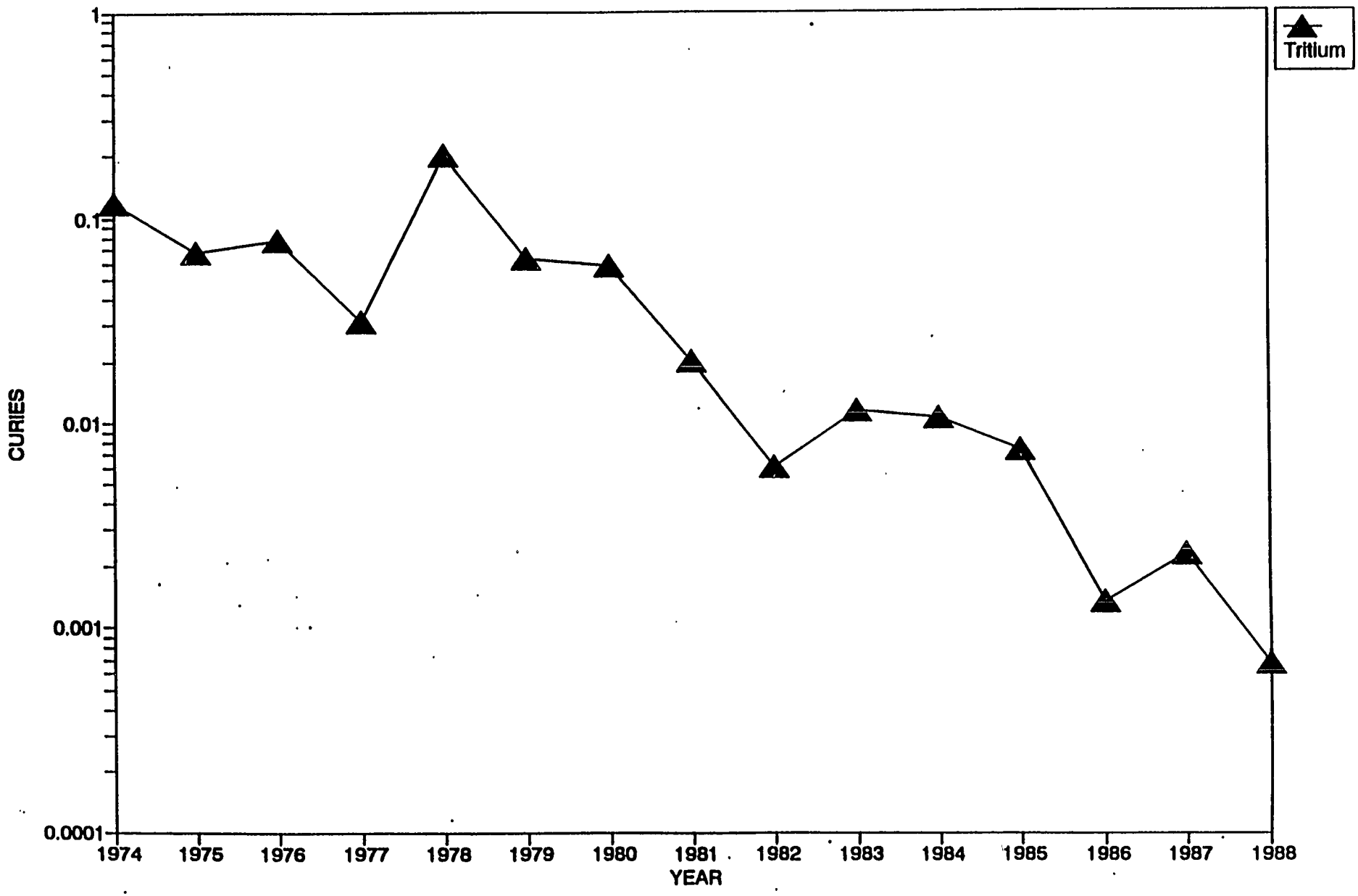
adename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
CKELOUS ACETATE	B559	R129	UTILITY RM	NUL		1	LB
CKELOUS CARBONATE	B559	R129	UTILITY RM	NUL		1	LB
CKELOUS CHLORIDE	B559	R101	LAB	NUL		10	GM
CKELOUS CHLORIDE	B559	R101	LAB	NUL		10	GM
CKELOUS CHLORIDE	B559	R129	UTILITY RM	NUL		3	LB
CKELOUS NITRATE	B559	R101	LAB	NUL		10	GM
CKELOUS NITRATE	B559	R101	LAB	NUL		10	GM
CKELOUS NITRATE	B559	R129	UTILITY RM	NUL		5	LB
CKELOUS OXIDE	B559	R101D	LAB	NUL		2	GM
CKELOUS OXIDE	B559	R129	UTILITY RM	NUL		113	GM
CKELOUS SULFATE	B559	R101	LAB	NUL		10	GM
CKELOUS SULFATE	B559	R101	LAB	NUL		10	GM
CKELOUS SULFATE	B559	R129	UTILITY RM	NUL		1	LB
CKELOUS SULFATE	B559	R129	UTILITY RM	NUL		1	LB
TRIC ACID	B559	R101D	CHEM PREP/SPECT	NUL		7	LB
TRIC ACID	B559	R102	PU CHEM LAB	NUL		7	LB
TRIC ACID	B559	R102	PU CHEM LAB	NUL		35	LB
TRIC ACID	B559	R102	PU CHEM LAB	NUL		50	ML
TRIC ACID	B559	R103D	LAB-	NUL		500	ML
TRIC ACID, RGT, 70%	B559	R103D	LAB-	NUL		7	LB
TRIC ACID, RGT, 70%	B559	R103E	LAB-ANNEX	NUL		12	LT
TASSIUM CHROMATE	B559	R101	LAB	NUL		10	GM
TASSIUM CHROMATE	B559	R101	LAB	NUL		10	GM
TASSIUM CHROMATE	B559	R129	UTILITY RM	NUL		1	LB
TASSIUM DICHROMATE	B559	R101	LAB	NUL		10	GM
TASSIUM DICHROMATE	B559	R101	LAB	NUL		10	GM
TASSIUM DICHROMATE	B559	R102	PU CHEM LAB	NUL		10	GM
TASSIUM DICHROMATE	B559	R103D	LAB-	NUL		2	LB
TASSIUM DICHROMATE	B559	R129	UTILITY RM	NUL		1	LB

·ndename	Location	Room	Workplace	Loc_Id	Operation	Pres_quant	Units
IDIUM CHROMATE	B559	R101	LAB	NUL		10	GM
IDIUM CHROMATE	B559	R101	LAB	NUL		10	GM
IDIUM DICHROMATE	B559	R101	LAB	NUL		10	GM
IDIUM DICHROMATE	B559	R101	LAB	NUL		10	GM
·TRACHLOROETHYLENE	B559	R101	PU SPECT LAB	NUL		10	ML
ICHLOROETHYLENE	B559	R101	PU SPECT LAB	NUL		10	ML

Yearly Effluent Releases for Building 559



Yearly Tritium Releases
for Building 559



BUILDING 566
LAUNDRY FACILITY

I. Building History

Construction date unknown. This building was designed as a laundry facility for clothing and respirators contaminated with radioactive materials; the present plan is that it will be used only for non-contaminated items.

II. Processes Associated with Air Emissions

Beryllium	No emissions listed. Asbestos and beryllium laundry, Room 127, has a supply air plenum and the dryers vent to an exhaust plenum then to the atmosphere.

No other chemicals of concern listed.

III. Inventory

No Chemicals of Concern were listed on the 1988/89 inventory.

BUILDING 701
WASTE TREATMENT RESEARCH AND DEVELOPMENT FACILITY

I. Building History

1965 Building constructed. Pilot Plant Development. Building 701 is a research and development facility that is used to design, build, and evaluate bench-scale and pilot-scale waste handling and treatment processes. Because this building is a Research and Development facility emissions of significant quantities of hazardous, toxic, or criteria air pollutants are not expected (EG&G Rocky Flats, 1991).

II. Processes Associated with Air Emissions

No Chemicals of Concern listed.

III. Inventory

The 1988/89 inventory places a number of the Chemicals of Concern in this building. A complete list can be found on the attached table. The following is an abbreviated list:

Benzene
Carbon Tetrachloride
Chloroform
Chromium (compounds)
Formaldehyde
Lead compounds
Nitric Acid

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radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
MMONIUM DICHROMATE	B701	R101	NUL	NUL	R & D	40	OZ
ENZENE	B701	R101	NUL	NUL	R & D	1	QT
ARBON TETRACHLORIDE	B701	NORTH SIDE	STORAGE CABINETS	NUL		3	QT
ARBON TETRACHLORIDE	B701	NORTH SIDE	STORAGE CABINETS	NUL	R & D	5	GL
HLOROFORM	B701	R107	NUL	NUL	R & D	4	LB
IROMIUM	B701	R101	NUL	NUL	R & D	1	LB
IROMIUM NITRATE	B701	R101	NUL	NUL	R & D	1	LB
IROMIUM OXIDE	B701	R101	NUL	NUL		1	LB
IROMIUM OXIDE	B701	R101	NUL	NUL	R & D	1	OZ
IROMIUM TRIOXIDE	B701	R101	NUL	NUL		24	OZ
IROMIUM TRIOXIDE	B701	R101	NUL	NUL	R & D	1	LB
ORMALDEHYDE	B701	R107	NUL	NUL	R & D	4	OZ
EAD BASE BEARING METAL	B701	R101	NUL	NUL	R & D	4	OZ
EAD OXIDE RED	B701	R101	NUL	NUL	R & D	1	LB
EAD,METAL	B701	R101	NUL	NUL	R & D	5	LB
ITRIC ACID	B701	R101	NUL	NUL	R & D	1	GL
ITRIC ACID	B701	R107	NUL	NUL	R & D	6	LB
OTASSIUM CHROMATE	B701	R101	NUL	NUL		9	OZ
OTASSIUM CHROMATE	B701	R101	NUL	NUL		1	LB
OTASSIUM CHROMATE	B701	R101	NUL	NUL	R & D	1	LB

BUILDING 705
COATINGS LABORATORY

I. Building History

1966 Building Constructed. Coatings Laboratory. This building consists of coatings laboratories and associated offices. Currently, the following processes are conducted in Building 705 at a reduced rate as compared to previous years of operation:

Vapor Deposition
Be Vapor Deposition
Parts Cleaning
Be Parts Cleaning
Polishing
Sand Blasting
Water Cooling

The primary operations in Building 705 involve vapor deposition. In the past, metallography was also performed in Building 705, but this process is no longer conducted.

II. Processes Associated with Air Emissions

Beryllium Beryllium Vapor Deposition, Room 100A-- Be is vaporized and used to coat metal parts. The Be particulate emission through Vent #11 is:

Uncontrolled	6.61E-08 tons/yr
Controlled	1.32E-13 tons/yr

III. Inventory

No Chemicals of Concern were listed on the 1988/89 inventory.

BUILDING 707
PLUTONIUM FABRICATION/PYROCHEMICAL OPERATIONS

I. Building History

1972 — Construction completed. This building provides metallurgical support in the form of foundry and casting operations, as well as product assembly. The machining and foundry operations of Plutonium came from 776 after the 1969 fire. The buildings main ventilation system consists of seven separate exhaust plenums.

1972-1989 — Building 707 was the major user of carbon tetrachloride and 1,1,1-TCA at Rocky Flats.

II. Processes Associated with Air Emissions

Beryllium — Building 707 does not process beryllium (Be). However, some materials processed in Building 707 may contain Be. For this reason Be is monitored at 15 discharge points from Building 707. The monitoring points are identified as 707-101, 707-102, 707-105, 707-106, 707-1072, 707-108, 707-R21, 707-R22, 707-R23, 707-R25, 707-R26, 707-R27, 707-R45, and 707-R46. They correlate respectively with vents #36, #9/10, #28, #55, #65, #75, #38/39, #40/41, #42/43, #44/45, #76/77, #78/79, #80/81, #1/2, and #3/4. The controlled release data for the entire building is 1.9×10^{-7} tons/yr. Individual vent information is as follows:

Vent #9/10	6.9×10^{-9}
Vent #28	2.5×10^{-8}
Vent #36	1.9×10^{-9}
Vent #44/45	7.2×10^{-9}
Vent #55	1.7×10^{-8}
Vent #65	2.6×10^{-8}
Vent #75	4.1×10^{-8}
Vent #78/79	8.8×10^{-9}
Vent #80/81	9.0×10^{-9}
Vents #1/2, #3/4, #38/39, #40/41, #42/43, #76/77	4.4×10^{-8}

Carbon Tetrachloride

Plutonium Fabrication/Pyrochemical Operations. This building contains foundry and casting operations and products assembly. carbon tetrachloride is used as a cleaning agent. Waste carbon tetrachloride is drained to tanks located in the basement of the building. Carbon tetrachloride exhausts thru vents #9/10, #28, and #36. Total carbon tetrachloride emission estimates for each vent are:

Vents #9/10	3.36 tons/yr
Vent #28	0.11 tons/yr
Vent #36	28.83 tons/yr
TOTAL	32.30 tons/yr

Module A - Casting Operations. Carbon tetrachloride is used to clean interior glove box walls where casting furnaces are located in which Pu ingots are made. Carbon tetrachloride is also used to clean the furnaces. Carbon tetrachloride emissions estimate through vent #36:

Uncontrolled 1.68 tons/yr

Module J - Casting Operations. Pu ingots are made. Carbon tetrachloride is used to clean the glove boxes. Carbon tetrachloride emission estimate through vents #9/10:

Uncontrolled 1.68 tons/yr

Module K - Casting Operations and Stacker Retriever. This operation stores and retrieves Pu metal for distribution to other processes. Metal is weighed, melted in furnace, formed into ingots. Carbon tetrachloride is used for cleaning inside of glove boxes. Carbon tetrachloride emission estimates through vents #9/10:

Uncontrolled 1.68 tons/yr

Module B - Rolling and Forming. This process involves the forming and thermal treatment of Pu metal ingots. Carbon tetrachloride is used to clean the rollers. Carbon tetrachloride emission estimates through vent #36:

Uncontrolled 4.39 tons/yr

Module C - Briquetting. Metal turnings from Module C machining process and Module B scrap cutters are put in metal baskets and dipped in five carbon tetrachloride baths. Filtered carbon tetrachloride is piped directly to pencil tanks in the C-pit. Carbon tetrachloride emission estimates to vent #36:

Uncontrolled 0.10 tons/yr

Module C - Machining Operations. Pu parts are machined. After machining, parts are weighed and cleaned with carbon tetrachloride, which is pumped to the C-pit. Carbon tetrachloride emission estimates to vent #36:

Uncontrolled 22.62 tons/yr

Modules C and D - Inspection. Parts are cleaned with carbon tetrachloride. Emission estimates:

Uncontrolled 0.11 tons/yr thru vent #28
Uncontrolled 4.2E-02 tons/yr thru vent #36.

Radionuclides

Casting Operations - Module A. Plutonium ingots are cast into feed or production ingots in Casting Operations. Ingots are transported by enclosed, interconnected chain conveyors from storage to the foundry glove boxes. The ingots are placed in crucibles and melted in electric induction furnaces, which operate under vacuum. Metal is poured through a funnel into the molds which are then allowed to cool. Crucibles and funnels are scraped clean and reused until worn. Emissions from this process exhaust through vent #36 and include carbon tetrachloride and particulates. While details of certain process emissions are classified, the total radionuclide emissions for the building are reflected in the graphs that follow.

Casting Operations - Module J. Emissions from this process exhaust through vents #9/10. Two types of particulate emissions result from operations in this module. The first is from Pu oxidation and the second is from casting operations. Uncontrolled emissions of 8.0×10^{-3} tons/yr of Pu particulate from Pu oxidation operations were estimated. Particulate emissions from both of these sources pass through five stages of HEPA filters. For Pu oxidation particulates, this results in a controlled emission of 1.3×10^{-16} tons/yr. Controlled emission estimates for casting operations are classified, but the total radionuclide emission for the building are reflected in the graphs that follow.

Casting Operations and Stacker Retriever - Module K. Module K contains the stacker retriever also known as the X-Y retriever, and casting furnaces. These operations are performed in an inert nitrogen atmosphere. The stacker retriever is used to store and retrieve Pu metal for distribution to other processes in Building 707. Particulate emissions are those resulting from casting. While details of certain process emissions are classified, the total radionuclide emissions for the building are reflected in the graphs that follow.

1,1,1-TCA

B-707 is the **Plutonium Fabrication/Pyrochemical Operations** building, which has foundry and casting operations and product assembly. TCA is used as a cleaning and degreasing agent. TCA is gravity drained to tanks in the basement of the building. All emissions are uncontrolled. 1,1,1-TCA exhausts thru vents #28 (1.48 tons/yr), #36 (8.5×10^{-3} tons/yr), #44/45 (7.4×10^{-3} tons/yr), #55 (6.7×10^{-2} tons/yr), #65 (2.11 tons/yr), #80/81 (0.13 tons/yr). The total emission estimate for B-707 is:

Uncontrolled 3.80 tons/yr

Module E, Assembly Operations. TCA is component of ultrasonic cleaner used to clean Pu parts. When the TCA reaches a designated level of impurities, it is pumped into tank V100 in the C-pit; from C-pit, the TCA waste is piped to B-777 then to B-774 for treatment. TCA emissions from the 3 ultrasonic cleaners exhaust to vent #28. The emission estimates are included in the above total.

Module F, Assembly-Superdry. TCA is used to clean Pu parts before they are assembled and welded into a weapons product. Emissions exhaust through vent #55 and are uncontrolled. The emission estimate is included in the above total.

Module G, Assembly-Welding and Cleaning. TCA is a component of the ultrasonic cleaner used to clean Pu parts following welding. TCA emissions from the 2 ultrasonic cleaners pass thru vent #65 and are included in the above total.

Module G, Assembly-Electron Bombardment Brazing/ Scanning. TCA 2 is a used (1) to clean waste materials deposited on the walls of a bell jar during brazing of metals in the jar, and (2) during fluorescent dye penetration (quality control to detect surface flaws in Pu parts -- fluorescent dye is applied to a part, then the part is cleaned with TCA and viewed under black light). Emission estimate (through vent #80/81) is included in the above total.

Module H, Assembly Testing. TCA is used to clean parts prior to testing. The emission estimate (through vents 65 and 80/81) is included in the above total.

Modules D, E, and G, Assembly Ultrasonic Cleaners. Tanks containing the ultrasonic cleaners used in B-707 and B-777 and described above. Emission estimates through vents 28 and 65 are included in the above total.

Room 173, Radiography. TCA is used to clean Pu parts prior to radiography (X-ray examination of parts). The emission estimate through vent 44/45 is included in the above total.

Module D, Weighing. TCA is used for cleaning prior to weighing of parts. The emission estimate through vent 28 is included in the above total.

Module E, Eddy Current Testing. To check the depth of weld penetration on Pu parts which are moved to and from glove boxes; TCA is used to clean glove boxes. The emission estimate through vent 28 is included in the above total.

Weld Scanners and Fluorescent Penetrant Operations. Area used to qualify welds on Pu parts. TCA is used to clean off fluorescent dye. The emission estimate through vent 65 is included in the above total.

Module D, Production Control Operations. TCA is used to clean parts following grit blasting. The emission estimate through vent 28 is included in the above total.

Modules D and G, Calibration Laboratory. TCA is used to clean gauges before precision measurements. The quantity of TCA used is so small it does not add appreciably to the total emissions from the associated vents and therefore was not calculated.

Carbon Tetrachloride, TCA, and Freon Systems. TCA feed tanks (V-36A, B, C) located in B-707, room 200, provide solvents to Buildings 707 and 777. Working losses for all three tanks were calculated:

Uncontrolled 7.6×10^{-3} tons/yr thru vent #36

Working loss from waste tank throughput was calculated to be:

Uncontrolled 9.0×10^{-4} tons/yr thru vent #36

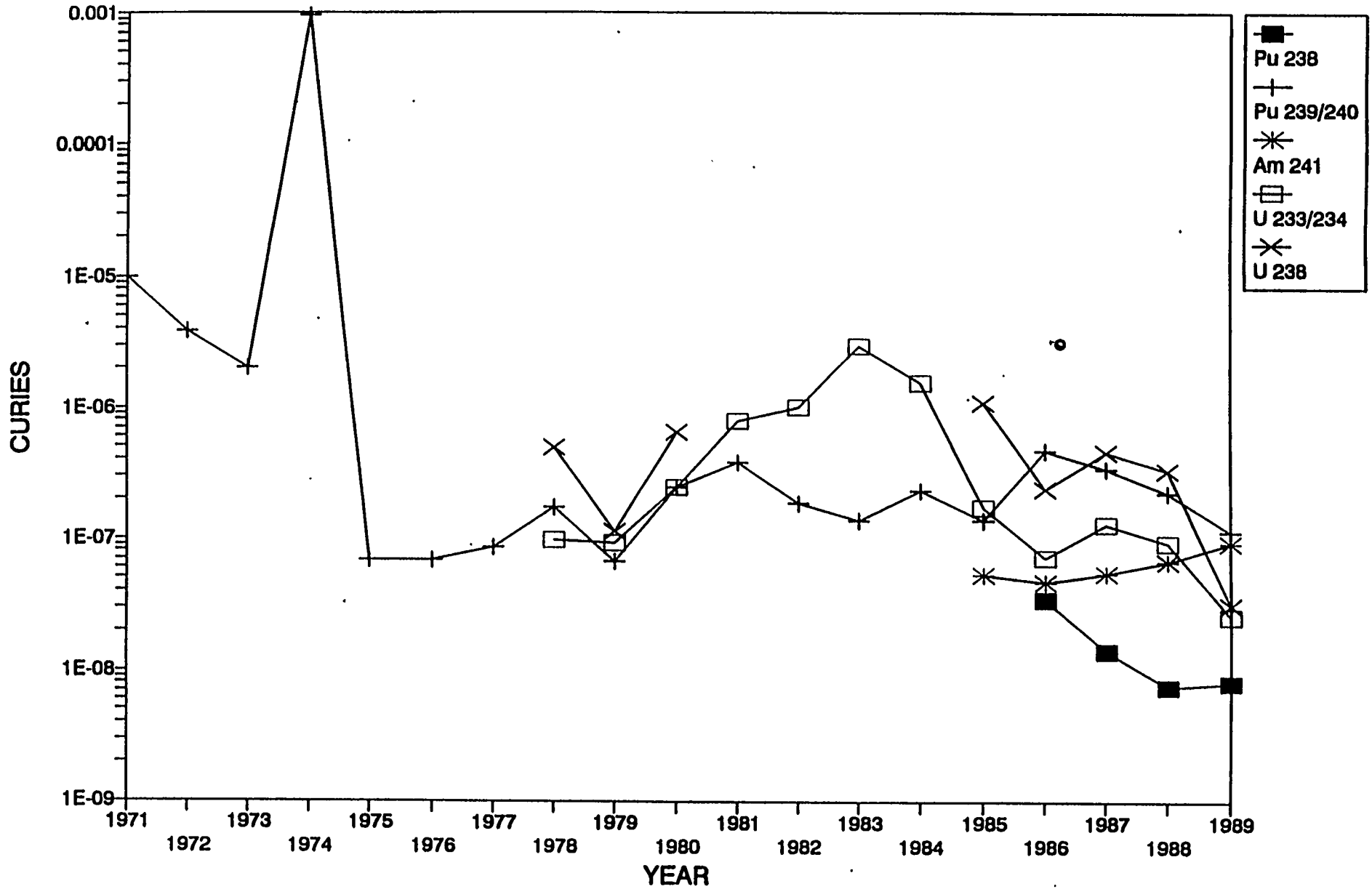
Both of these estimates are included in the above total.

III. Inventory

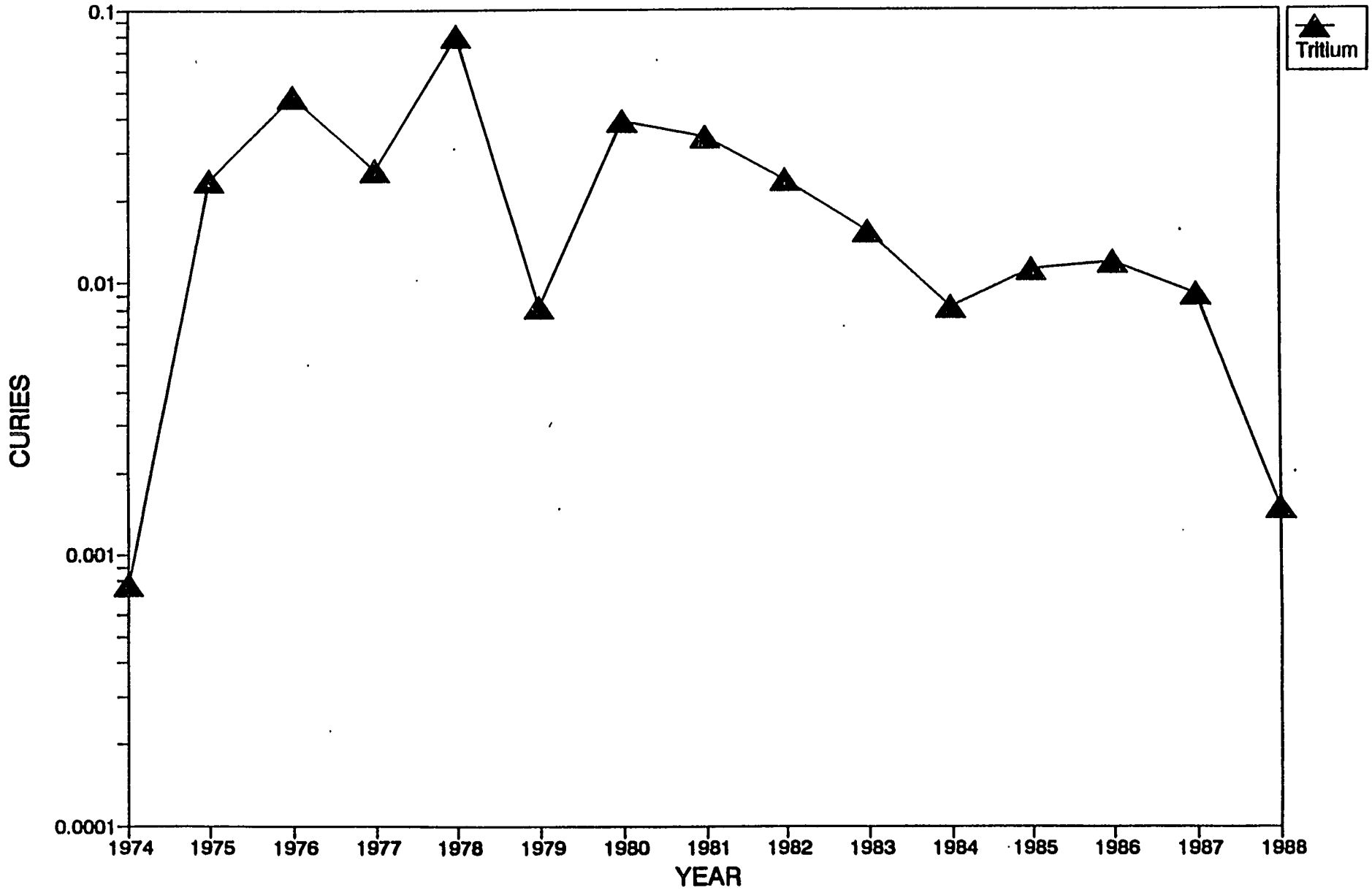
Building 707 is listed on the 1988/89 inventory as having some quantities of lead, chromium, 1,1,1-TCA, TCE, and mercury. See table.

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
CARBON TETRACHLORIDE	B707	OUTSIDE	TANK-NORTH	NUL	STORAGE-BLDG 707	1800	GL
CHROMIUM	B707	R171	NUL	NUL	REMOVED FROM AREA	1	PT
CHROMIUM NITRATE	B707	R130A	NUL	NUL	REMOVED FROM AREA	15	LB
CHROMIUM NITRATE	B707	R171	NUL	NUL	REMOVED FROM AREA	134	LB
LEAD OXIDE RED	B707	R130A	NUL	NUL	REMOVED FROM AREA	7	OZ
MERCURY	B707	R130	MODULE-G	NUL	GROUND FOR WELDERS	3	ML
TRICHLOROETHANE,1,1,1-	B707	R115	MODULE-D	NUL	CLEANING	1	LT
TRICHLOROETHANE,1,1,1-	B707	R120	MODULE-E	NUL	CLEANING	250	ML
TRICHLOROETHANE,1,1,1-	B707	R130A	NUL	NUL	CLEAN MATERIAL	1	GL
TRICHLOROETHANE,1,1,1-	B707	R210	TANK	TRICHLOROETHANE	CLEANING OF WR PRODUCT	133	GL
TRICHLOROETHANE,1,1,1-	B707	R210	TANK	TRICHLOROETHANE	CLEANING OF WR PRODUCT	133	GL
TRICHLOROETHANE,1,1,1-	B707	R210	TANK	TRICHLOROETHANE	CLEANING OF WR PRODUCT	133	GL
TRICHLOROETHENE	B707	R120	MODULE-E	NUL	N/A	100	ML
TRICHLOROETHENE	B707	R130	MODULE-G	NUL	N/A	25	GL
TRICHLOROETHENE	B707	R135	MODULE-H	NUL	N/A	12	GL

Yearly Effluent Releases for Building 707



Yearly Tritium Releases for Building 707



BUILDING 771
PLUTONIUM RECOVERY OPERATIONS

I. Building History

1953	Building constructed. The principal operation of Building 771 is the recovery of plutonium from plutonium bearing residues.
1957	Americium line started.
1958	Carbon tetrachloride distilled out of the cutting oil and Pu recovered from the solids. The cutting oil, carbon tetrachloride mixture came from the Pu machining in B-776.
1958 - 1988	Incinerator used for the recovery of fissile material (ChemRisk, 1991; RE-891).
1953 - 1959	Purex process used for Pu purification (ChemRisk, 1991; RE-891).
1959	Began using ion exchange for Pu purification (ChemRisk, 1991; RE-891).
1968	Caustic scrubber installed (ChemRisk, 1991; RE-891).
1963-1975	Ammonium thiocyanate used for recovery of americium (ChemRisk, 1991; RE-891).
1975 - 1980's	Oxalate precipitation process used for recovery of americium (ChemRisk, 1991; RE-891).
Early 1980's	Discontinued americium purification but not recovery (ChemRisk, 1991; RE-891).

II. Processes Associated with Air Emissions

Beryllium

Building 771 does not process Be. However some materials processed in Building 771 may contain, or be contaminated with Be. For this reason, Be is monitored at four air discharge points from Building 771. Three of these monitored discharge points are from Building 771C (vents 2, 8 and 9). Vents 2 and 8 are combined and designated as discharge point 771-CRM. Vent 9 is designated discharge point 771-CMA. Vent #86, the main exhaust stack for Building 771, is designated as 771-MAI. The Be release data from these vents for 1988, the last year of nearly full-time operation for Building 771 are given below:

771-CRM	2.74×10^{-9} tons/yr
771-CMA	2.90×10^{-9} tons/yr
771-MAI	2.46×10^{-9} tons/yr

Methylene Chloride

Maintenance Operations. Methylene chloride is present in paints, paint strippers (e.g. methylene chloride is an ingredient of KS-3 paint remover at 85 % wt). Estimated air emissions through vent #86 (main B-771 exhaust stack).

Controlled 0.70 tons/year

Nitric Acid

Dissolution. Dissolution processes are all similar in concept. The equipment consists of a series of cascade dissolver vessels. Plutonium-bearing material is fed into the first dissolver at a controlled rate by a special screw feeder. Nitric acid (12N), aluminum nitrate, calcium fluoride, and water are fed into the first dissolver, also at a controlled rate. Nitric acid is the primary chemical used in dissolution. Solids are kept in suspension in the dissolvers by the agitation provided by an air lift. Vapors from the dissolvers are collected by an off-gas system. A portion of the gases are condensed and returned to the process. The remaining vapors are drawn to the Building 771 large fume scrubber, which removes any acids from the air stream. The Building 771 large fume scrubber consists of two packed tower scrubbers in series.

Emissions Estimate:

Uncontrolled NOx	0.33 tons/yr
Controlled NOx	1.69×10^{-2} tons/yr

Note: These emission estimates include the NOx released from the oxidation of both aluminum nitrate and nitric acid.

Feed Evaporation. Feed evaporation is used to concentrate some solutions coming from previous operations. Concentration of these solutions is necessary in order to yield precipitation feed of an acceptable Pu concentration. The off-gas from the evaporation step is collected and routed through a moisture condenser and large fume scrubber.

Emission estimates from the oxidation of HNO_3 to NOx (vent #86):

Uncontrolled NOx	8.23×10^{-2} tons/yr
Controlled NOx	4.21×10^{-3} tons/yr

Peroxide Precipitation. The peroxide precipitation process converts the Pu in solution to a solid form. The precipitation process itself should not contribute significantly to air emissions. However, some emissions will be associated with the evaporation of the filtrate from the precipitation step. The off-gases are passed through a condenser and then through the Building 772 large fume scrubber.

Emissions Estimate from oxidation of HNO_3 to NOx (vent #86):

Controlled NOx emissions	1.68×10^{-2} tons/yr

Chemical Technology. Plutonium chemistry technology in Building 771 supports and develops improved methods for recovering, separating, and purifying actinides from acidic streams. Off-gases from this operation are passed through a bubble-type acid scrubber that is assumed to be 50% efficient. The controlled emissions are released into booster plenum FU-2C, which discharges to the main filter plenum.

Emission Estimate from oxidation of HNO_3 to NOx (vent #86)

Uncontrolled	2.54×10^{-3} tons/yr
Controlled	1.27×10^{-3} tons/yr

Radionuclides

Calcination. The calcination process converts PuO_4 to PuO_2 and drives out residual water and HNO_3, leaving a dry, powdered product. The primary contaminant released from calcination is PuO_2 particulates. The off-gas from this operation is passed through a HNO_3 scrubber (50% efficient for PuO_2 removal) and six HEPA filters in series.

Pu particulate Emission Estimates (vent #86):

Uncontrolled	4.21×10^{-2} tons/yr PuO_2 particulate
Controlled	6.74×10^{-19} tons/yr PuO_2 particulate

Hydrofluorination. Plutonium oxide is converted to plutonium tetrafluoride (PuF_4) in a continuous rotary-tube hydrofluorinator. The off-gas from the hydrofluorination process is routed through an emissions control system consisting of a venturi-type KOH scrubber. The off-gas is then routed through six stages of HEPA filtration.

Pu particulate Emission Estimates:

Uncontrolled	4.30×10^{-2} tons/yr
Controlled	2.06×10^{-19} tons/yr

Plutonium Oxidation. Plutonium oxidation converts pure Pu metal, which is pyrophoric, to a more stable PuO_2. The PuO_2 is then used as a feed to the dissolution operation. The off-gases are passed through six HEPA filter stages.

Emission Estimates for Pu particulates (vent #86):

Uncontrolled	3.47×10^{-5} tons/yr
Controlled	1.11×10^{-21} tons/yr

Plutonium Metallurgy and Research and Air Emissions. The Pu metallurgy group assists the design agency and plant production in the development of processes that require metallurgical production of materials and related manufacturing techniques. All Pu metallurgy operations are conducted in glove boxes. Off-gases from these operations are passed through an exhaust filter plenum (FU-1 and main plenum) consisting of six HEPA filters.

Pu particulate Emission estimates:

Uncontrolled	4.83×10^{-3} tons/yr
Controlled	1.55×10^{-19} tons/yr

III. Inventory

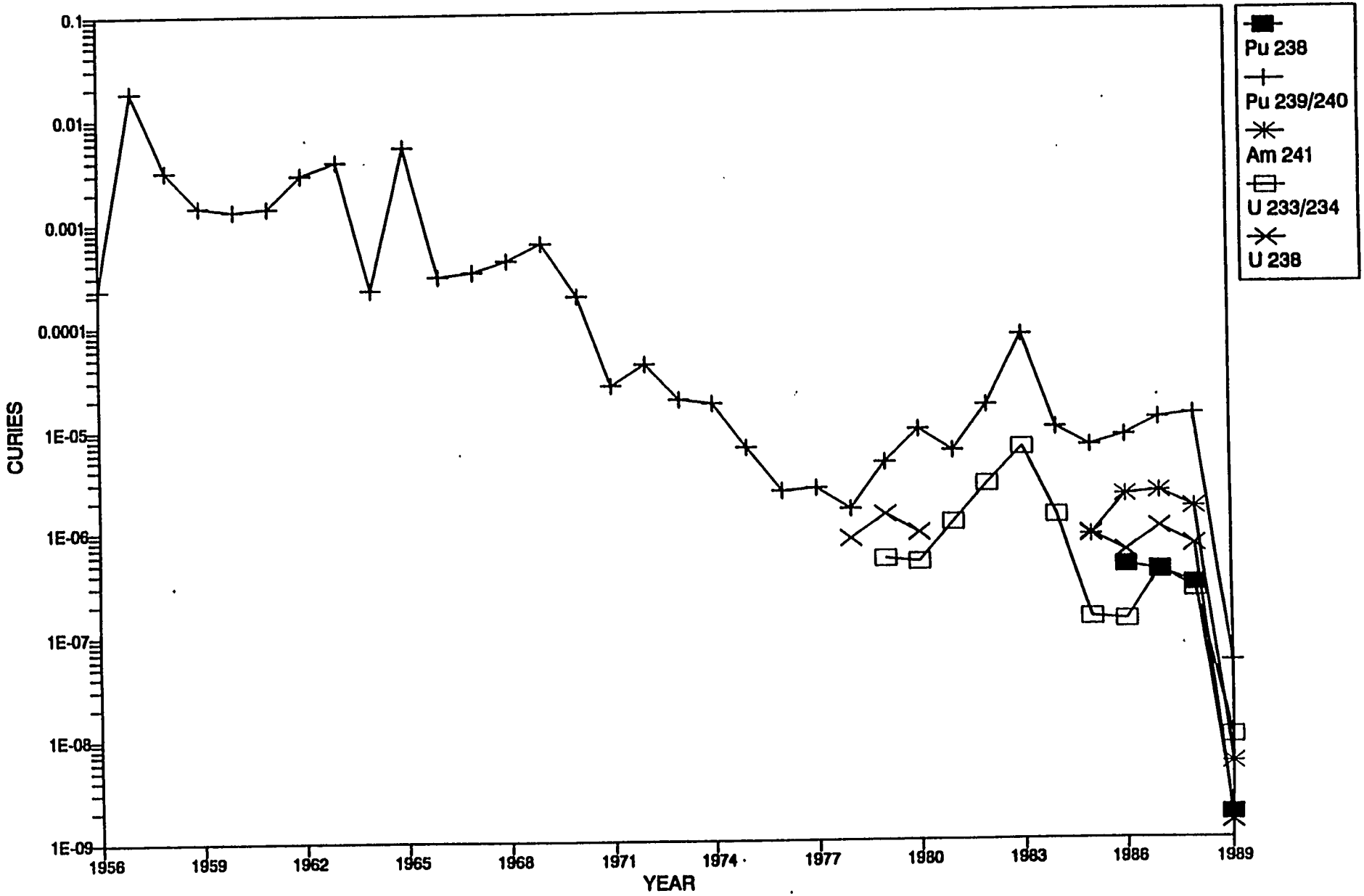
The 1988/89 inventory places a number of the Chemicals of Concern in this building. A complete list can be found on the attached table. The following is an abbreviated list:

Beryllium Compounds	Formaldehyde	Nitric Acid
Cadmium Compounds	Lead Compounds	
Carbon Tetrachloride	Mercury	
Chloroform	Methylene Chloride	
Chromium Compounds	Nickel Compounds	

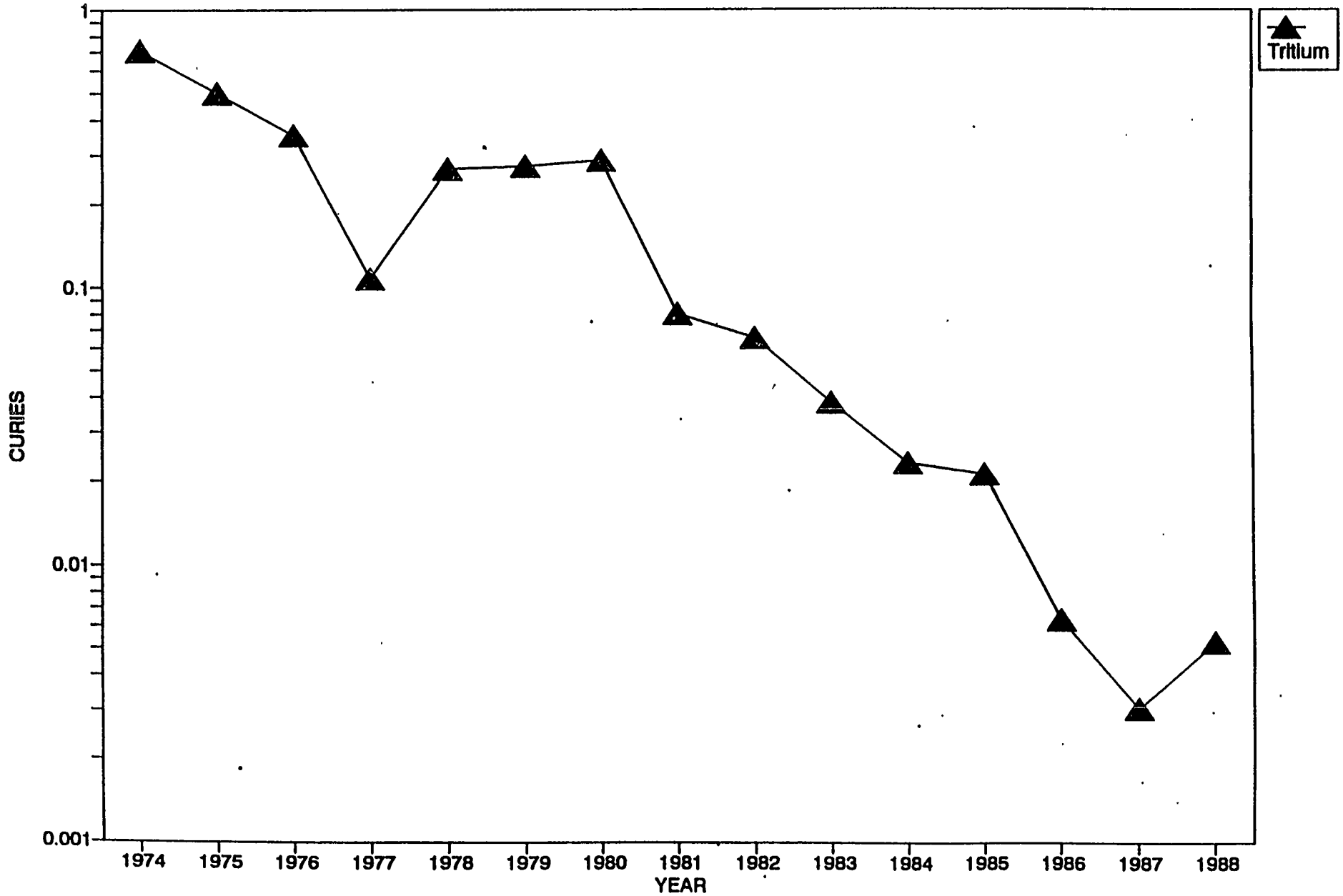
adename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
RIUM CHROMATE	B771	R180F	LAB	NUL		1	LB
RYLLIUM CARBONATE	B771	R180F	LAB	NUL		1	OZ
DMIUM	B771	R162	LAB	NUL		1	LB
DMIUM ORTHOPHOSPHATE	B771	R187	LAB	NUL		100	GM
DMIUM, METAL	B771	R162	LAB	NUL		1	LB
RBON TETRACHLORIDE	B771	R137	LAB-FLAM-LOCKER	WEST-DOCK		4	LT
RBON TETRACHLORIDE	B771	R137	LAB-FLAM-LOCKER	WEST-DOCK-1		1	GL
RBON TETRACHLORIDE	B771	R137	LAB-FLAM-LOCKER	WEST-DOCK-1		4	LT
LOROFORM	B771	R137	LAB-FLAM-LOCKER	WEST-DOCK		8	LT
ROMIUM CHLORIDE	B771	R158	LAB-	NUL		5	LB
ROMIUM OXIDE	B771	R158	LAB-	NUL		1000	GM
ROMIUM TRIOXIDE	B771	R180F	LAB	NUL		2	LB
ROMIUM, METAL	B771	R162	LAB	NUL		1	LB
IMALDEHYDE	B771	R156A	PHOTO LAB	NUL		2	PT
IMALDEHYDE	B771	R180E	SPCL ISOTOPE LAB	NUL		1	LB
IMALDEHYDE SOLUTION	B771	R137	LAB-FLAM-LOCKER	WEST-DOCK-1		1	GL
ID CHLORIDE	B771	R180F	LAB	NUL		2	LB
ID CITRATE AR	B771	R156A	PHOTO LAB	NUL		100	GM
ID DIOXIDE	B771	R164	LAB-	NUL		113	GM
ID FLUORIDE	B771	R180F	LAB	NUL		1	LB
ID METAL	B771	R180E	SPCL ISOTOPE LAB	NUL		1	LB

radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
EAD METAL	B771	R187	LAB	NUL		25	LB
EAD POWDER	B771	R162	LAB	NUL		1	KG
EAD, METAL POWDER	B771	R162	LAB	NUL		2	LB
EAD, METAL POWDER	B771	R180E	SPCL ISOTOPE LAB	NUL		1	LB
EAD, METAL POWDER	B771	R187	LAB	NUL		2	LB
RCURY (METAL)	B771	R156B	DARKROOM	NUL		4	OZ
THYLENE CHLORIDE	B771	R129	MTCE PIPE/SHEET	NUL		1	PT
CKEL NITRATE	B771	R164	LAB	NUL		1	LB
CKEL OXIDE	B771	R158	LAB-	NUL		1000	GM
CKEL, METAL	B771	R180E	SPCL ISOTOPE LAB	NUL		1	LB
CKEL, METAL POWDER	B771	R180E	SPCL ISOTOPE LAB	NUL		2	LB
CKELOUS CHLORIDE	B771	R158	LAB-	NUL		5	LB
CKELOUS FLUORIDE	B771	R180F	LAB	NUL		1	LB
CKELOUS NITRATE	B771	R180F	LAB	NUL		5	LB
CKELOUS OXIDE	B771	R164	LAB	NUL		4	OZ
CKELOUS OXIDE	B771	R180F	LAB	NUL		1	LB
CKELOUS SULFATE	B771	R187	LAB	NUL		1	LB
RIC ACID	B771	OUTSIDE	TANK-PORTABLE-SOUTH	DOOR-21	NUMEROUS	200	GL
RIC ACID	B771	OUTSIDE	TANK-PORTABLE-SOUTH	DOOR-21	DO NOT USE	420	GL
RIC ACID	B771	R159	LAB-	NUL		7	LB
RIC ACID	B771	R159	LAB-	NUL		100	ML
RIC ACID	B771	R164	LAB	NUL		5	LT
RIC ACID	B771	R164	LAB	NUL		49	LB
RIC ACID	B771	R180F	LAB	NUL		7	LB
RIC ACID	B771	R247	NUL	CHEM-MAKEUP		1000	LT

Yearly Effluent Releases for Building 771



Yearly Tritium Releases for Building 771



ıdename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
'RIC ACID	B771	R247	NUL	CHEM-MAKEUP		390	GL
'RIC ACID	B771	R247	NUL	CHEM-MAKEUP	DISSOLUTION, ION EXCHANGE, PRECIPITATI	7	LT
'RIC ACID	B771	R247	NUL	CHEM-MAKEUP		440	LT
RIC ACID	B771	R247	NUL	CHEM-MAKEUP	DISSOLUTION, ION EXCHANGE, PRECIPITATI	750	LT
'RIC ACID	B771	R247	NUL	NUL	ACID BATCHING	166	LB
'RIC ACID, RGT, 70%	B771	R180F	LAB	NUL		7	LB
RIC ACID, RGT, 70%	B771	R180F	LAB	NUL		7	LB
RIC ACID, RGT, 70%	B771	R187	LAB	NUL		56	LB
ASSIUM CHROMATE	B771	R156B	DARKROOM	NUL		1	LB
ASSIUM DICHROMATE	B771	R164	LAB	NUL		1	LB
ASSIUM DICHROMATE	B771	R164	LAB	NUL		4	OZ
ASSIUM DICHROMATE	B771	R180F	LAB	NUL		1	LB
IUM BICHROMATE	B771	R180F	LAB	NUL		4	OZ
IUM CHROMATE	B771	R187	LAB	NUL		1	LB
IUM CHROMATE	B771	R246	NUL	NUL	PROCESS COOLING WATER	75	LB

BUILDING 774
PROCESS WASTE TREATMENT FACILITY

I. Building History

1953	Building constructed to support B-771. Originally designed as a nuclear waste packaging facility. Modifications and additions in 1963, 1965, 1966, 1967, 1970, and 1974.
1981	Converted to storage for Building 771 (Drums).

II. Processes Associated with Air Emissions

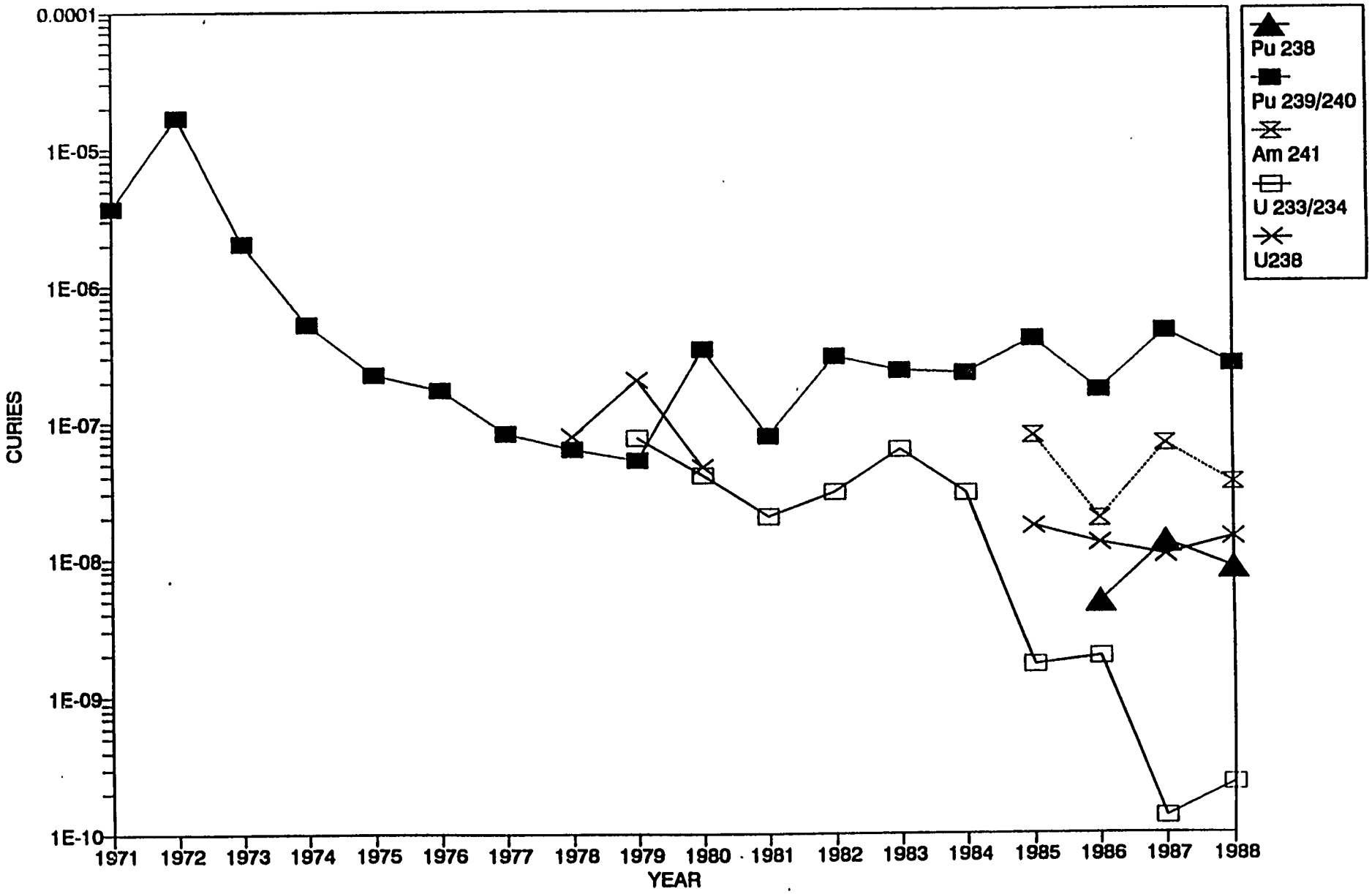
Nitric Acid	**Radioactive Decontamination Treatment.** Nitric Acid is used in the first stage of this process. This caustic precipitation process reduces the plutonium and americium concentrations. The acidic distillate waste is neutralized and transferred to caustic system. There are no air emissions of NOx because no heat is applied to the solution.
Radionuclides	**Caustic Precipitation.** This process is the first stage in radioactive decontamination treatment it is designed to reduce the Pu and Am concentrations. Pressure control zones 1,2 and 3; 1 has three stages HEPA, 2 and 3 have two stages HEPA; all 3 go to main exhaust plenum, which has two more stages of HEPA.
1,1,1-TCA	**OASIS (organic and sludge immobilization system).** TRU waste from 707 and 776/777. TCA, oils mixed with carbon tetrachloride are solidified with gypsum cement in a glove box. Process and tanks all vent to #4. There are no Air Pollution Control Devices, therefore estimated emissions:

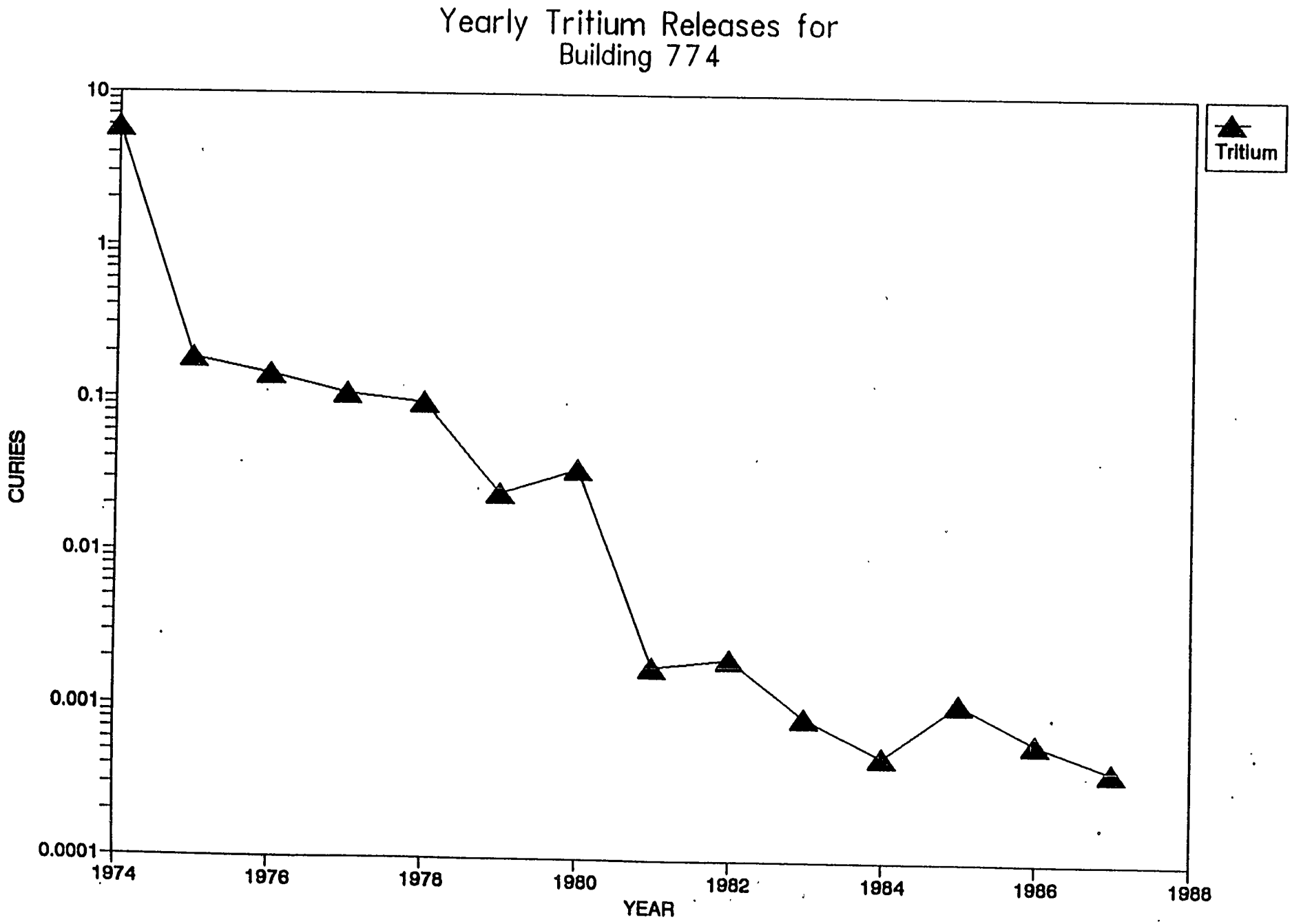
Uncontrolled 8.26 tons/yr

III. Inventory

No chemicals of concern listed on 1988/89 inventory.

Yearly Airborne Effluent Releases for Building 774




Yearly Tritium Releases for
Building 774
10
1
0.1
0.01
0.001
0.0001
CURIES
1974
1976
1978
1980
1982
1984
1986
1988
YEAR
Tritium

BUILDINGS 776 AND 777
ASSEMBLY AND MANUFACTURING BUILDINGS

I. Building History

1957	Buildings 776 and 777 constructed. B-776: Manufacturing building; B-777: Assembly Building. Assembly operations transferred from B-991.
1958	First significant machining of Pu begins using cutting oil, followed by a washing with carbon tetrachloride.
1969	Fire in B-776 on May 11, 1969.
1972	Operations in B-776 transferred to B-707. B-776 converted to waste storage and waste size reduction.
1957-1969	B-776 was the major user of carbon tetrachloride and TCE at Rocky Flats

Buildings 776 and 777 are connected by a common wall and share building ventilation systems.

II. Processes Associated with Air Emissions

Beryllium

Buildings 776/777 do not process Be. However, some materials processed in these buildings may contain Be. For this reason Be is monitored at nine plenum discharge points from Buildings 776/777, which exhaust to the atmosphere through five vents. The monitoring points are identified as plenums 201, 202, 204, 205, 206, 207, 250, 251, and 252. Plenum 202 exhausts through vent #17. Plenums 201, 204, and 250 exhaust through vent #24. Plenums 205, 206, and 207 exhaust through vent #32, Plenums 251 and 252 exhaust through vents #45 and #44, respectively. The Be releases for Buildings 776/777 from these vents are given below:

#17	1.9×10^{-8} tons/yr
#24	2.0×10^{-7} tons/yr
#32	1.6×10^{-7} tons/yr
#44	1.1×10^{-8} tons/yr
#45	1.5×10^{-8} tons/yr
TOTAL	4.0×10^{-7}

Carbon Tet.

B-776

CCl4 emitted from vents #24, #32, and #45. These vents serve the main building HEPA filter plenums.

Uncontrolled	8.10 tons/yr through vent #24
TOTAL	8.10 tons/yr (All three vents).

Baler. The baler is used to reduce volume of low-level combustible waste. CCl4 is solvent present in wet low-level waste at 750 lb CCl4/10E+06 lb waste; Emissions estimate for vent #24:

Uncontrolled	2.32 tons/yr (This is included in the above total)

B-777

Briquetting. The pressing of Pu metal machine turnings into pucks using hydraulic press. Turnings are cleaned in metal baskets that are dipped into four CCl4 baths. Emissions estimate for vent #24:

Uncontrolled	8.0×10^{-2} tons/yr (This is included in the above total)

Machining, Rooms 131 and 134A. Parts are cleaned with CCl4 on towels prior to machining.

Uncontrolled	5.65 tons/yr through vent #24 (This is included in the above total).

Inspection, Rooms 130 and 430. Parts are cleaned with CCl4.

Uncontrolled	5.5×10^{-2} tons/yr thru vent #24 (This is included in the above total).

Carbon Tetrachloride System. Waste CCl4 from briquetting and machining operations in B-777 are collected in 5 pencil tanks. When full, the CCl4 is pumped through filtration system to larger storage tank. When full, this tank is filtered and tested and transferred to B-774 for waste treatment. Emissions are calculated with other outdoor tanks in a separate APEN.

Methylene Chloride

Baler, Room 144. The baler is used to reduce volume of low-level combustible waste. Methylene chloride is present in wet low-level waste at 750 lb/10E+06 lb waste this is equal to an air emissions estimate (through vent #24) of:

Uncontrolled	2.32 tons/year

Radionuclides

Disassembly Operations. Disassembly occurs in room 430 and involves the disassembling of Pu parts for further processing in the Molten Salt Extraction (MSE) Operation. No controls are listed in the APEN document. While details of certain process emissions are classified, the total radionuclide emissions for the building are reflected in the graphs that follow.

Special Weapons Projects. Special weapons projects perform R&D for fabricating classified parts and fitting specialty parts and materials. Plutonium oxidation is conducted to convert pyrophoric Pu residues to non-pyrophoric PuO_2. The particulate passes through four stages of HEPA filters.

Pu particulate emission estimates (vent #32):

Uncontrolled	2.7×10^{-6} tons/yr
Controlled	2.2×10^{-17} tons/yr

Tritium Environmental Control. Tritium is generated from the disassembly of some types of contaminated parts. The tritium environmental control system removes tritium from gas sampling and glove box exhausts by converting it to tritiated water and desiccating the air stream. Tritium contaminated water is collected in special containers for further processing. The gettering process has not been used for over two years. If this process becomes operational, particulate emissions will be generated from the disassembly of parts by standard machining operations. While details of certain process emissions are classified, the total radionuclide emissions for the building are reflected in the graphs that follow.

1,1,1-TCA

B-776

Baler, Room 144. The baler is used to reduce volume of low-level combustible waste. TCA is present in wet low-level waste. TCA is assumed to evaporate 100%. All emissions are uncontrolled. Emission estimate:

Uncontrolled 6.19 tons/yr thru vent #24

B-777

Foundry Operations, Coatings. TCA is used in coatings facility in Rooms 437 and 463 to remove oils from substrates to be coated with U or Pu. Waste TCA is piped directly to Building 777 waste TCA collection system. Emission estimate:

Uncontrolled 0.20 tons/yr thru vent #32

Disassembly Operations, Room 430. Pu parts are disassembled for further processing. Following disassembly, TCA is used to clean parts. Emission estimate:

Uncontrolled 5.6×10^{-3} tons/yr thru vent #24

Assembly Superdry, TCA Wash, Room 430, Glove box 465 Process Description. Parts are cleaned in a 10-gallon TCA bath prior to ultrasonic cleaning. Emission estimate:

Uncontrolled 0.18 tons/yr thru vent #24

Ultrasonic Cleaning System, Room 430. Ultrasonic vapor degreaser containing TCA is used to clean parts from various modules in B-707. Emission estimate:

Uncontrolled 0.69 tons/yr thru vent #24

Ultrasonic Cleaning System, Room 440. Ultrasonic vapor degreaser containing TCA used to clean metal filters from module H in B-707. Emission estimate:

Uncontrolled 0.46 tons/yr thru vent #32

Downdraft Rooms 430, 432, 432B, 433, and 440 Assembly and Cleaning Process Description. TCA is used to assemble parts in a moisture-free airlock chamber. Emissions estimate:

Uncontrolled 1.1×10^{-2} tons/yr thru vent #32

Radiography. TCA used for general cleaning of radiography instrument. Emission estimate:

Uncontrolled 7.4×10^{-3} tons/yr thru vent #24

Weighing. Prior to weighing, parts are cleaned with TCA = 3.0×10^{-3} tons/yr thru vent #24

Plutonium Metallography Laboratory. TCA is used as a cutting agent for grinding with carbide grit to cut Pu. Emissions estimate

Uncontrolled 0.13 tons/yr thru vent #32

Special Weapons Projects. R&D for fabricating classified parts and fitting specialty parts and materials. Parts are immersed in ultrasonic cleaner which contains TCA. Emission estimates for the three different cleaners are:

Uncontrolled	0.14 tons/yr vent #32
Uncontrolled	0.25 tons/yr vent #32
Uncontrolled	8.4×10^{-2} tons/yr vent #32

TCA Collection and Filtration System. Collects TCA from storage systems in B-707 and B-776/777 and pumps the TCA to tank V-100 in B-707 C-pit and then to tank T-1 in B-777. Waste TCA from B-776/777 ultrasonic cleaners and vapor degreasers is pumped to tank T-1. If Pu, Am, and U are below the transfer limit is pumped to T-2; if not, is circulated through a filter system and sent back to Tank T-1. Emission estimates:

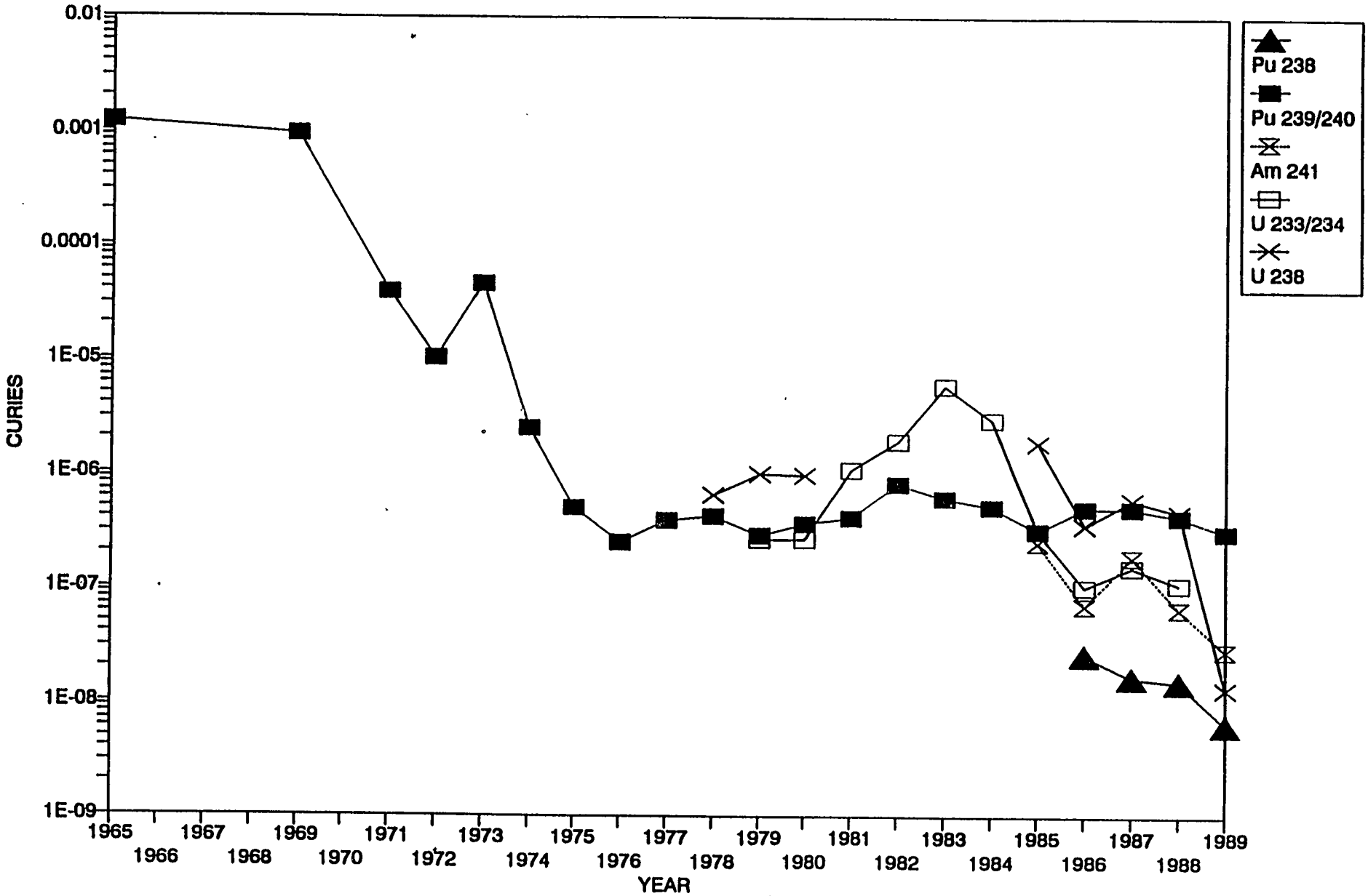
Uncontrolled	4.94×10^{-3} tons/yr thru vent #32 from T-1
Uncontrolled	4.94×10^{-3} tons/yr thru vent #32 from T-2

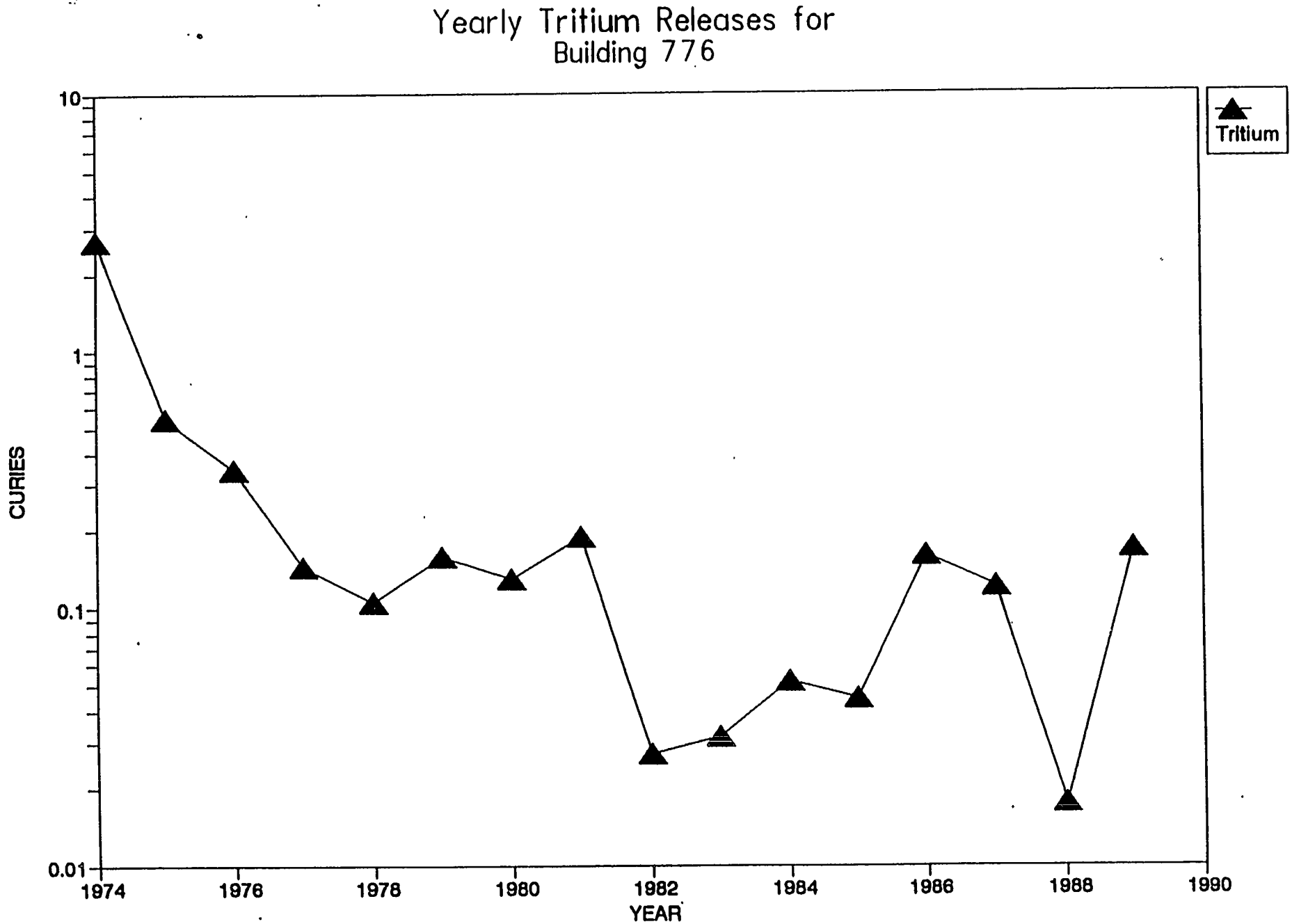
III. Inventory

Buildings 776/777 are listed as having some quantities of chromium and nitric acid. See table.

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
CHROMIUM OXIDE	B776	R159	PILOT-PLANT	NUL		2	KG
LITHIUM CHROMATE	B776	R201	NUL	UTILITIES	KATHENE ADDITIVE	15	GL
NITRIC ACID	B776	R159	NUL	NUL		21	LB
NITRIC ACID, RGT	B776	R159A	NUL	NUL		42	LB

Yearly Effluent Releases for Building 776




Yearly Tritium Releases for
Building 776
Tritium
CURIES
10
1
0.1
0.01
1974
1976
1978
1980
1982
1984
1986
1988
1990
YEAR

BUILDING 779
PLUTONIUM DEVELOPMENT BUILDING

I. Building History

1965 Building constructed. Building 779 is a research and development facility that supports production.

II. Processes Associated with Emissions

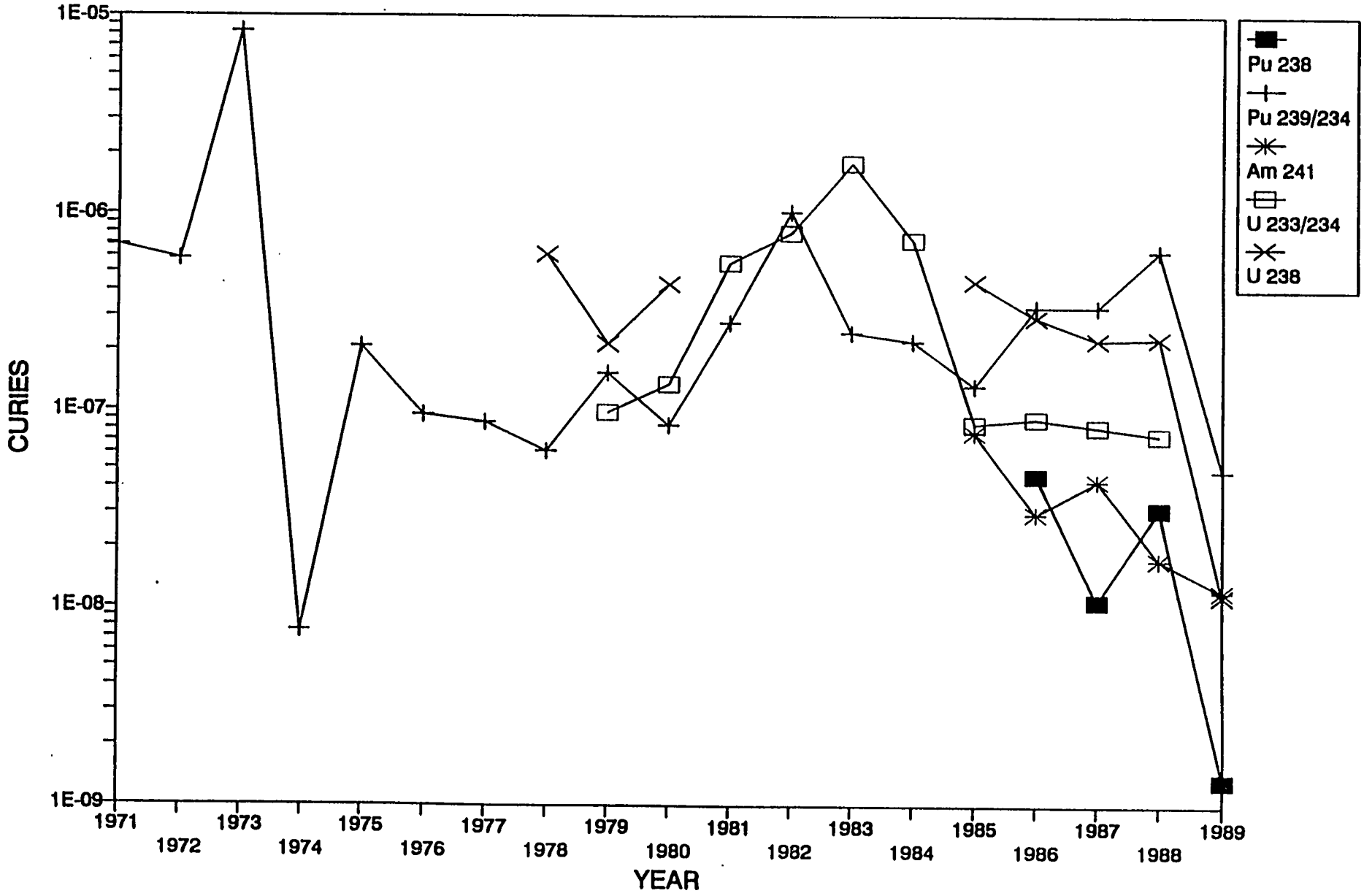
Although there are no specific processes associated with emissions of Chemicals of Concern from Building 779, some radonuclides are emitted from the research and development operations in the building. The following graphs reflect the radionuclide emissions from the building.

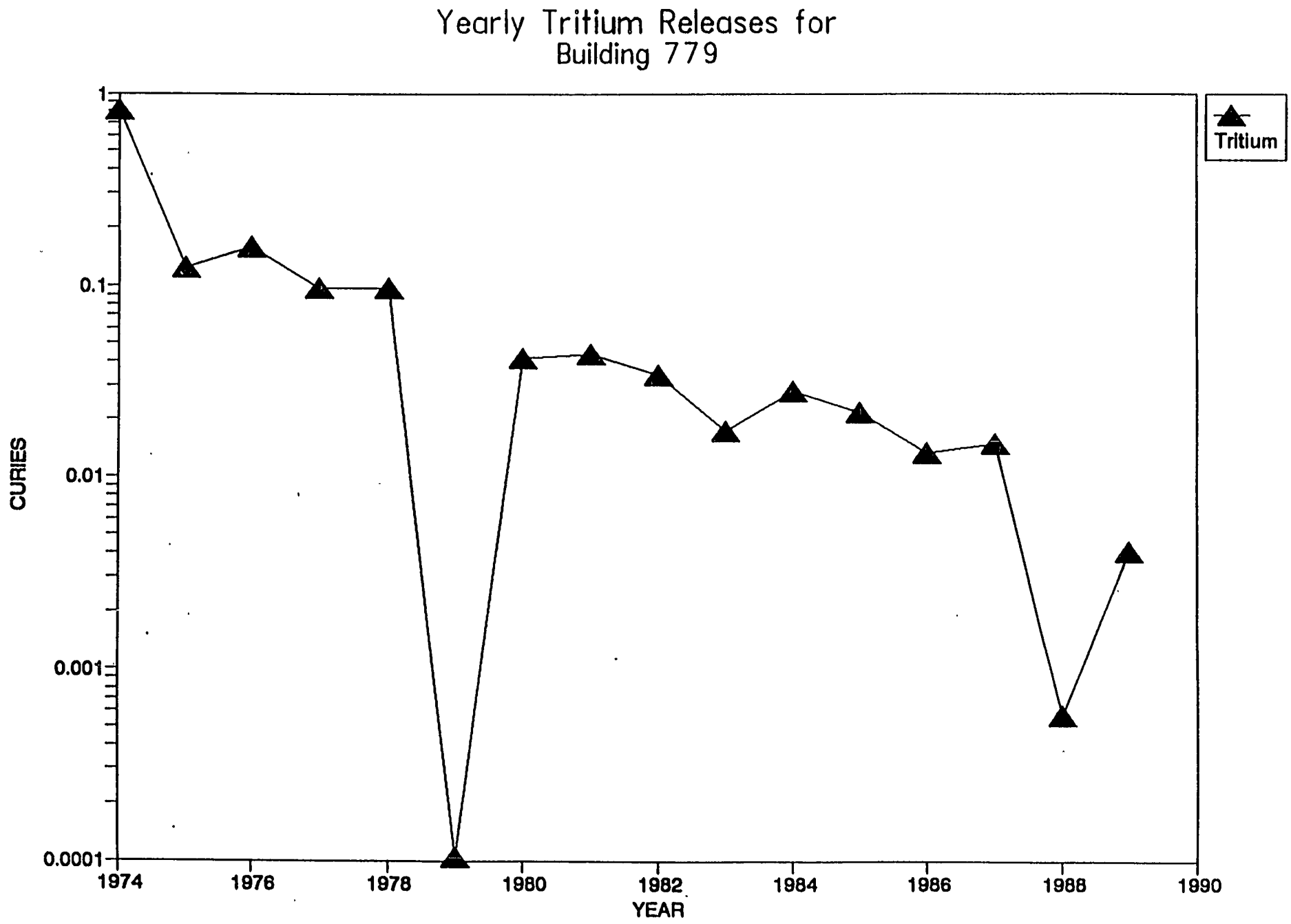
III. Inventory

The 1988/89 inventory of the chemicals and radionuclides of concern is provided in the following table.

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
BERYLLIUM	B779	R140	LAB-PHYSICAL-MET	NUL		85	GM
CARBON TETRACHLORIDE	B779	R137	LAB-AQ-REC-TECH	NUL		4	LT
CARBON TETRACHLORIDE REAGENT, A C S	B779	R137	LAB-AQ-REC-TECH	NUL		1	QT
CHLOROFORM	B779	R137	LAB-AQ-REC-TECH	NUL		12	LB
CHROMIUM INTENSIFIER	B779	R234B	LAB-PHYSICAL-MET	NUL		50	GM
CHROMIUM OXIDE	B779	R222	NUL	NUL		1	LB
CHROMIUM TRIOXIDE	B779	R152	LAB-PHYSICAL-MET	NUL		1	LB
CHROMIUM TRIOXIDE	B779	R155	NUL	NUL		8	OZ
CHROMIUM TRIOXIDE	B779	R155	NUL	NUL	ETCHING METALLURGICAL SAMPLES	12	OZ
HYDRAZINE 95%	B779	R137	LAB-AQ-REC-TECH	NUL		500	GM
LEAD CHLORIDE	B779	R131	NUL	NUL		1	LB
NICKEL SULFATE CRYSTALS	B779	R139	LAB-AQ-REC-TECH	NUL		1	LB
NITRIC ACID	B779	R137	LAB-AQ-REC-TECH	NUL		21	LB
NITRIC ACID	B779	R155	NUL	NUL	ETCHING METALLURGICAL SAMPLES	350	ML
NITRIC ACID	B779	R223	LAB-COATINGS	NUL		7	LB
NITRIC ACID, RGT, 70%	B779	HALLWAY	2ND-FLOOR	NUL		14	LB
NITRIC ACID, RGT, 70%	B779	R137	LAB-AQ-REC-TECH	NUL		7	LB
POTASSIUM CHROMATE	B779	R131	NUL	NUL		1	LB
POTASSIUM CHROMATE	B779	R131	NUL	NUL		1	LB
POTASSIUM DICHROMATE	B779	R131	NUL	NUL		5	LB
POTASSIUM DICHROMATE	B779	R155	NUL	NUL	ETCHING METALLURGICAL SAMPLES	142	GM
SODIUM DICHROMATE	B779	R139	LAB-AQ-REC-TECH	NUL		4	OZ

Yearly Effluent Releases for Building 779




Yearly Tritium Releases for
Building 779
Tritium
CURIES
1
0.1
0.01
0.001
0.0001
1974
1976
1978
1980
1982
1984
1986
1988
1990
YEAR

BUILDING 865, 867, AND 868
RESEARCH AND DEVELOPMENT OF URANIUM AND BERYLLIUM

I. Building History

1972	Building Constructed. Material and Process Development Lab.
B-867	Date of construction unknown. Contains filter plenums for process exhaust routed from Building 865.
B-868	Date of construction unknown. Contains filter plenums for process exhaust routed from Building 865.

Process exhausts are routed through an exhaust plenum to the dedicated filter plenums located in filter plenum Buildings 867 and 868. There are no raw chemical storage tanks or process waste storage tanks located in Building 865.

II. Processes Associated With Emissions

Beryllium

Beryllium Powder Work. Rooms 144, 148, 153. Be powder is mixed with other metals, placed in molds, and compressed into shapes. Be emissions are from powder pressing, drying operations, and spills in glove boxes. Be particulate emissions for vents #58/59 and 63/64:

Uncontrolled	2.50×10^{-3} tons/vent pair
Controlled	6.12×10^{-10} tons/vent pair

High Bay. Production through R&D of metalworking processes. Be particulate emissions from casting and heat treating furnaces. Be particulate emissions for vents #58/59 and 63/64:

Uncontrolled	4.88×10^{-5} tons/vent pair/year
Controlled	9.76×10^{-11} tons/vent pair/year.

Beryllium Electrorefining. Production of ultra-pure Be metal electrolytically. In operation from 1983 through 1986; exhausts were routed through scrubber, then through B-865 plenum system. Process discontinued in 1986. Currently no emissions.

Nitric Acid

High Bay. The High Bay area of Building 865 supports production through the research and development of metalworking processes. Most work is done with depleted U, Be, copper, tungsten, stainless steel and other steel alloys. Processes include metal casting, machining, rolling, heat-treating, and isostatic pressing. Chemical etching and cleaning are also performed to prepare the part for inspection and to remove oily residues, respectively. Nitric acid is used in the etching process. The air emission controls in the Building 865 complex do not reduce the uncontrolled emissions of nitric acid. Therefore, emission estimates for nitric acid assume that 100 percent evaporation occurs. Reported uncontrolled emissions for vent pairs #58/#59 and #63/#64 follow:

Uncontrolled 1.62×10^{-3} tons/vent pair/year

Metallography Laboratory. The Metallography Laboratory, located in Rooms 102, 106, and 108, conducts quality control analyses on metal samples. Nitric acid is used in the etching step of the quality control process. Nitric acid air emissions are based on the annual usage. It is assumed that 100 percent of the nitric acid evaporates during use. The emissions are directed into the building ventilation system where flow is assumed to be split evenly between vent pairs #58/#59 and #63/#64. Uncontrolled nitric acid emissions are not reduced by building control equipment; therefore, reported uncontrolled and controlled emissions are identical.

Uncontrolled 6.50×10^{-4} tons/vent pair/year

Radionuclides

High Bay. Production through R&D of metalworking processes. Uranium particulate emissions from casting and heat treating furnaces. Emission estimates for vents #58/59 and 63/64

Uncontrolled 9.52×10^{-4} tons/vent pair/year
Controlled 1.90×10^{-9} tons/vent pair/year.

Grit Blasters, Room 172. Surface cleaning of parts containing depleted U. Air emission estimates for all particulates including various metals are (for vent pairs #58/59 and #63/64):

Uncontrolled emissions 6.25×10^{-3} tons/pair/year
Controlled emissions 5.00×10^{-10} tons/pair/year

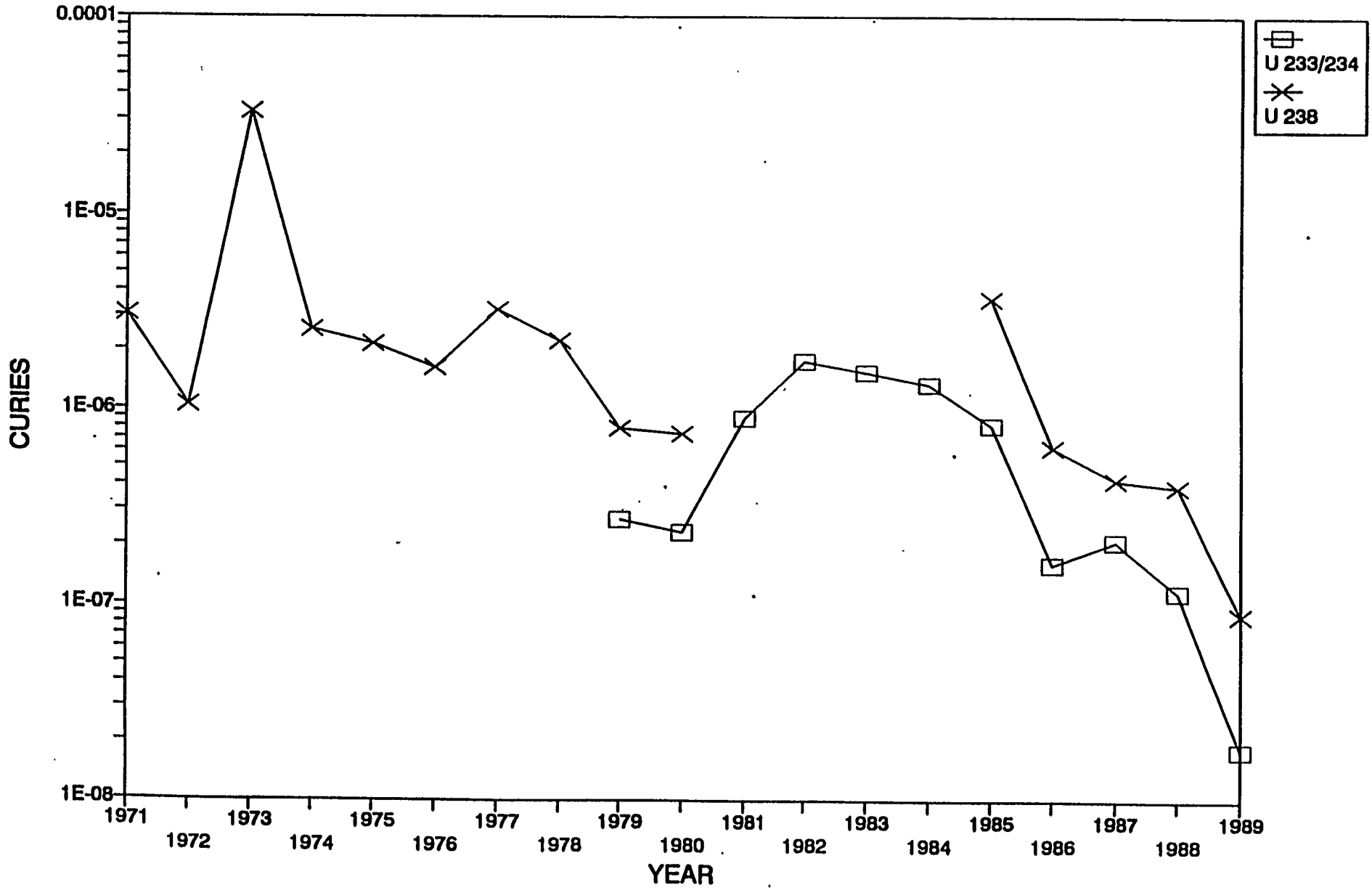
III. Inventory

The 1988/89 inventory places a number of the Chemicals of Concern in this building. A complete list can be found on the attached table. The following is an abbreviated list:

Chromium compounds
Lead compounds
Nickel compounds
Nitric Acid

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
:HROMIUM BORIDE	B865	145	HIGH BAY	NUL		1	LB
:HROMIUM CARBIDE	B865	145	HIGH BAY	NUL		8	OZ
:HROMIUM SILICIDE	B865	145	HIGH BAY	NUL		1	LB
:HROMIUM TRIOXIDE	B865	R106	LAB-METALLOGRAPHY	NUL		2	LB
'HROMIUM TRIOXIDE	B865	R106	LAB-METALLOGRAPHY	NUL		5	LB
EAD, METAL POWDER	B865	145	HIGH BAY	NUL		10	LB
EAD, METAL POWDER	B865	145	HIGH BAY	NUL		1	LB
EAD, METAL POWDER	B865	R145	HIGH BAY	NUL		50	LB
ICKEL METAL (325)	B865	145	HIGH BAY	NUL		10	LB
ICKEL, METAL	B865	R145	HIGH BAY	NUL		4	OZ
ICKEL, PELLETS	B865	R145	HIGH BAY	NUL		21	LB
ITRIC ACID	B865	R106	LAB-METALLOGRAPHY	NUL		7	LB
ITRIC ACID	B865	R145	HIGH BAY	NUL		35	LB
)TASSIUM DICHROMATE	B865	R106	LAB-METALLOGRAPHY	NUL		1	LB

Yearly Uranium Effluent Releases for Building 865



BUILDING 866

I. Building History

Date of construction unknown.

Building 866 is a transfer station. It receives wastes from Building 865 and 889 and transfers them to Building 374.

II. Processes Associated with Air Emissions

Beryllium	No emissions listed. No quantities are provided because emissions that occur during waste transfer in 866 are included in the B-374 APEN emissions.
Radionuclides	Two of the four vents are sealed (physically capped) and two have 2 stages of HEPA filters. Waste from B-865 includes 3 1200-gal tanks containing metals, acids, bases, uranium 238, beryllium. Wastes from B-889 include two 400-gal tanks containing detergent, U238, and Be. No emission estimates were derived because emissions that occur during waste transfer in 866 are in B-374 APEN.

III. Inventory

No Chemicals of Concern were listed on the 1988/89 inventory for Building 866.

BUILDING 881

I. Building History

1953 — Building constructed. Building 881 contains laboratories, maintenance shops, and plant support facilities. The original building was designed and built for processing uranium 235. Small quantities of other radioactive materials such as uranium 233 and plutonium (Pu) were also historically handled in the building.

II. Processes Associated with Air Emissions

Benzene

No information on the use of benzene was provided in the APENS.

Controlled 3.87×10^{-3} tons/yr

Beryllium

Beryllium is not processed in B-881. However, some materials processed in the building may contain beryllium. The following emission estimate is based on stack effluent monitoring data for 1990.

Controlled 7.32×10^{-8} tons/yr

Carbon Tet.

Carbon tetrachloride is used in small quantities in several laboratories and processes it is most commonly used at room temperature as a rinse. The liquid waste is transferred to a satellite collection container. The emission estimate is based on an assumption that five percent of the carbon tetrachloride will volatilize.

Controlled 8.92×10^{-4} tons/yr

Chloroform

No information on the use of chloroform was provided in the APENS.

Controlled 9.68×10^{-2} tons/yr

Methylene Chloride

Methylene chloride is used in several laboratories and process areas for sample preparation and analysis. The emission estimate is based on the assumption that 50 percent of the methylene chloride evaporates in the hood.

Controlled 0.28 tons/yr

Nitric Acid

Per building personnel approximately 5 gallons/yr of HNO_3 is used in the laboratories. Eighty percent of the laboratory acid is used at room temperature in various baths, rinses, and sample preparation, and approximately five percent of this evaporates. The remaining 20 percent of the nitric acid is boiled to dryness under acid scrubber hoods. All of this acid evaporates and 90 percent is recovered by the acid scrubbers.

Uncontrolled	0.16 tons/yr
Controlled	4.16×10^{-2} tons/yr

1,1,1-TCA

No information on the use of 1,1,1-TCA was provided in the APENS.

Controlled	6.16×10^{-2} tons/yr

II. Inventory

The 1988/89 inventory of the chemicals and radionuclides of concern is provided in the following table.

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
BENZENE	B881	R227	LAB-STANDARDS	NUL		5000	ML
BERYLLIUM 1000 PPM	B881	R131	LAB-GEN-CHEM	NUL		500	ML
BERYLLIUM 5000PPM (WT)	B881	R139	NUL	NUL		2	OZ
BERYLLIUM SOLUTION 3105	B881	R227	LAB-STANDARDS	NUL		25	ML
CADMIUM	B881	R227	LAB-STANDARDS	NUL		1	LB
CADMIUM 1000 PPM	B881	R131	LAB-GEN-CHEM	NUL		500	ML
CADMIUM ACETATE I-28	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CADMIUM CHLORIDE	B881	R227	LAB-STANDARDS	NUL		500	GM
CADMIUM CHLORIDE I-29	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CADMIUM NITRATE I-30	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CADMIUM ROD STANDARD	B881	R227	LAB-STANDARDS	NUL		1	LB
CADMIUM SOLUTION 3108	B881	R227	LAB-STANDARDS	NUL		25	ML
CARBON TETRACHLORIDE	B881	R227	LAB-STANDARDS	NUL		1	GL
CARBON TETRACHLORIDE	B881	R227	LAB-STANDARDS	NUL		4	LT
CARBON TETRACHLORIDE	B881	R255	NUL	NUL		4	LT
CARBON TETRACHLORIDE	B881	R255	NUL	NUL		4	LT
CARBON TETRACHLORIDE	B881	R266	LAB-FRIG	NUL		3	ML
CARBON TETRACHLORIDE	B881	R267	LAB-PROC DEV	NUL		4	LT
CARBON TETRACHLORIDE PURITY-98% O-620	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CHLOROFORM	B881	R255	NUL	NUL		37	LB
CHLOROFORM	B881	R255	NUL	NUL		4	LT
CHLOROFORM	B881	R266	LAB-FRIG	NUL		1	ML
CHLOROFORM	B881	R266	LAB-FRIG	NUL		1	ML
CHLOROFORM	B881	R283	PRODUCT-LAB	NUL	DISSOLVING PLASTICS AND PHOTO RESISTS	2	GL

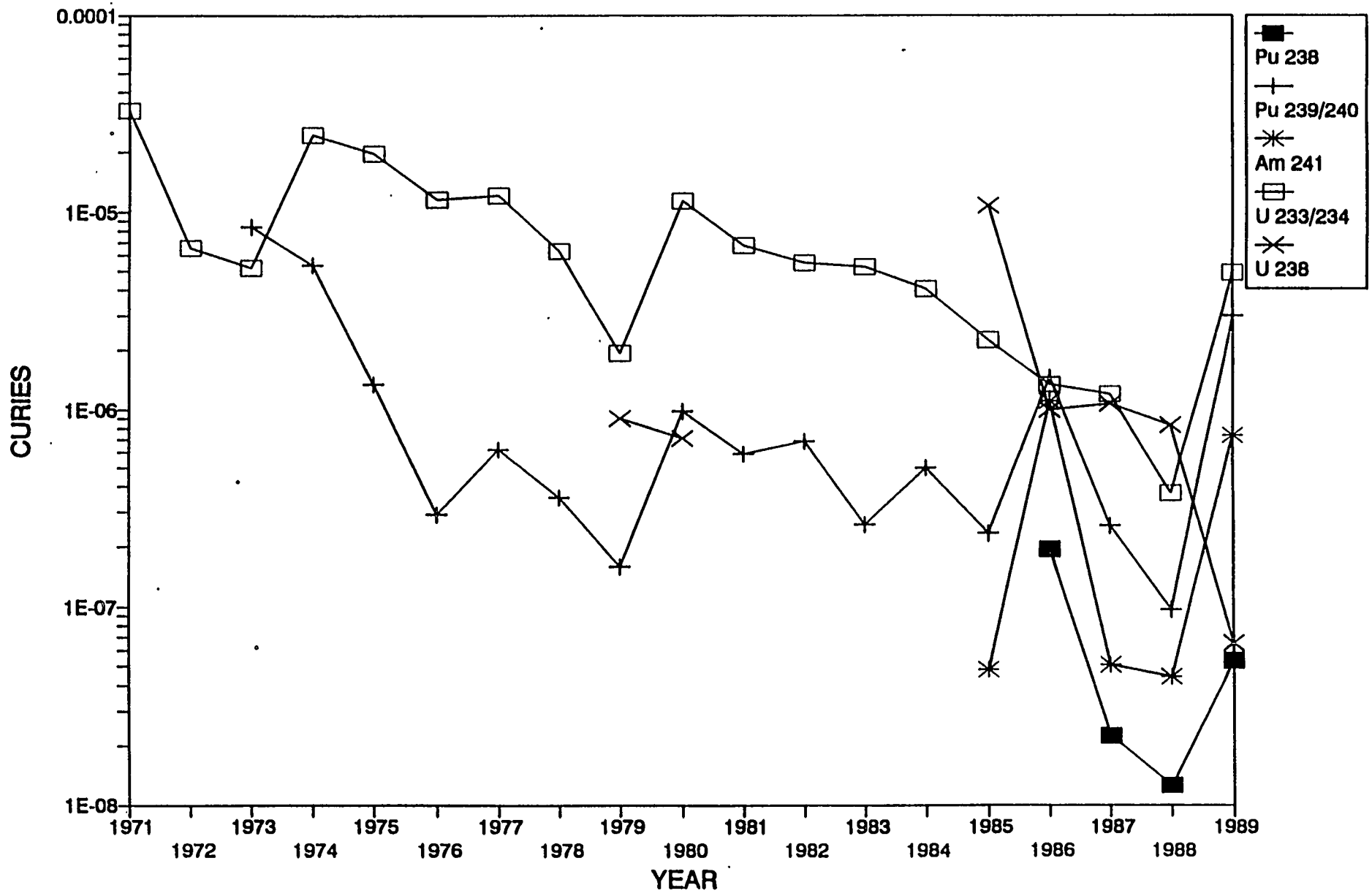
Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
CHLOROFORM PURITY-99% O-623	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CHLOROFORM, RGT	B881	R191	LAB	NUL	STRIPPING OF PLASTICS AND PHOTO RESIST	2	GL
CHROMIUM 1000 PPM	B881	R131	LAB-GEN-CHEM	NUL		500	ML
CHROMIUM CHLORIDE I-40	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CHROMIUM DIOXIDE	B881	R227	LAB-STANDARDS	NUL		10	GM
CHROMIUM NITRATE I-41	B881	R255	LAB-GEN-CHEM	NUL		10	GM
CHROMIUM OXIDE	B881	R227	LAB-STANDARDS	NUL		5	GM
CHROMIUM POWDER	B881	R227	LAB-STANDARDS	NUL		25	GM
CHROMIUM SOLUTION 3112	B881	R227	LAB-STANDARDS	NUL		25	ML
CHROMIUM TOTAL AND TRIVALENT	B881	R139	NUL	NUL		2	ML
CHROMIUM TRIOXIDE	B881	245	LAB-R+D	NUL		1	LB
CHROMIUM TRIOXIDE	B881	R267	LAB-PROC DEV	NUL		500	GM
CHROMIUM TRIOXIDE	B881	R267	LAB-PROC DEV	NUL		3	LB
CHROMIUM TRIOXIDE I-42	B881	R255	LAB-GEN-CHEM	NUL		10	GM
HYDRAZINE SULFATE	B881	R137	LAB-GEN-CHEM	NUL		24	OZ
HYDRAZINE SULFATE	B881	R137	LAB-GEN-CHEM	NUL		500	GM
HYDRAZINE SULFATE	B881	R227	LAB-STANDARDS	NUL		125	GM
LEAD	B881	R227	LAB-STANDARDS	NUL		1000	GM
LEAD 1000 PPM	B881	R131	LAB-GEN-CHEM	NUL		500	ML
LEAD ACETATE	B881	R267	LAB-PROC DEV	NUL		1	LB
LEAD BASE BEARING METAL	B881	R131D	LAB-GEN-CHEM	NUL		4	OZ

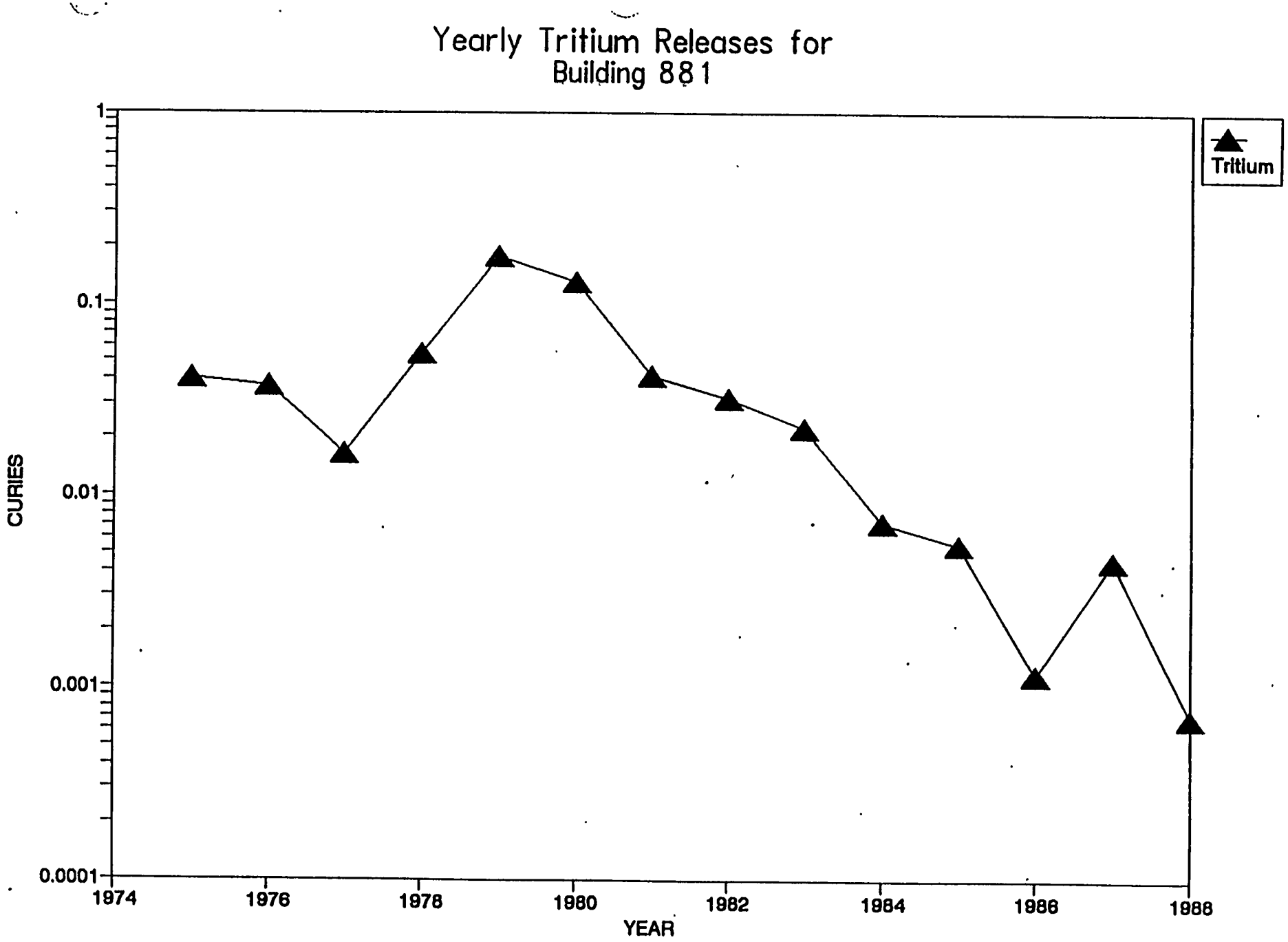
Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
LEAD CARBONATE	B881	R224	LAB	NUL		1	LB
LEAD CHLORIDE	B881	R224	LAB	NUL		1	LB
LEAD IODIDE	B881	R224	LAB	NUL		4	OZ
LEAD METAL	B881	R224	LAB	NUL		1	LB
LEAD METAL	B881	R227	LAB-STANDARDS	NUL		1	LB
LEAD NITRATE	B881	R267	LAB-PROC DEV	NUL		2	LB
LEAD NITRATE	B881	R267	LAB-PROC DEV	NUL		113	GM
LEAD OXIDE	B881	R227	LAB-STANDARDS	NUL		10	GM
LEAD SHOT	B881	R227	LAB-STANDARDS	NUL		50	GM
LEAD SOLUTION 3128	B881	R227	LAB-STANDARDS	NUL		25	ML
LEAD STANDARD	B881	R131C	LAB-GEN-CHEM	NUL		475	ML
LEAD SULFATE	B881	R224	LAB	NUL		1	LB
LEAD, METAL POWDER	B881	R227	LAB-STANDARDS	NUL		1	LB
MERCURY 100 PPM (WT.)	B881	R139	NUL	NUL		4	OZ
MERCURY 1000 PPM	B881	R131	LAB-GEN-CHEM	NUL		500	ML
MERCURY SOLUTION 3133	B881	R227	LAB-STANDARDS	NUL		25	ML
METHYLENE CHLORIDE	B881	R224	LAB	NUL		36	LT
METHYLENE CHLORIDE	B881	R227	LAB-STANDARDS	NUL		1	GL
METHYLENE CHLORIDE PURITY-99+% O-648	B881	R255	LAB-GEN-CHEM	NUL		10	GM
NICKEL 1000 PPM	B881	R131	LAB-GEN-CHEM	NUL		500	ML
NICKEL CATALYST	B881	R266	LAB-GEN-CHEM	NUL		25	GM

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
NICKEL CHLORIDE	B881	R267	LAB-PROC DEV	NUL		1	LB
NICKEL CHLORIDE	B881	R267	LAB-PROC DEV	NUL		500	GM
NICKEL CHROMIUM CASTING ALLOY 161 64 NICKEL	B881	R131D	LAB-GEN-CHEM	NUL		12	OZ
NICKEL COPPER ALLOY 162 66 NICKEL 29 COPPER	B881	R131D	LAB-GEN-CHEM	NUL		4	OZ
NICKEL COPPER ALLOY 162A 64 NICKEL 31 COPPER	B881	R131D	LAB-GEN-CHEM	NUL		4	OZ
NICKEL METAL POWDER	B881	R227	LAB-STANDARDS	NUL		4	OZ
NICKEL NITRATE	B881	R139	NUL	NUL		500	GM
NICKEL NITRATE	B881	R255	NUL	NUL		1	LB
NICKEL NITRATE HEXAHYDRATE GR	B881	R139	NUL	NUL		500	GM
NICKEL OXIDE	B881	R227	LAB-STANDARDS	NUL		10	GM
NICKEL POWDER	B881	R127A	LAB GEN-CHEM	NUL		100	GM
NICKEL SOLUTION 3136	B881	R227	LAB-STANDARDS	NUL		25	ML
NICKEL WIRE	B881	R227	LAB-STANDARDS	NUL		10	GM
NICKELOUS CHLORIDE	B881	R227	LAB-STANDARDS	NUL		1	LB
NICKELOUS SULFATE	B881	R267	LAB-PROC DEV	NUL		10	LB
NITRIC ACID	B881	245	LAB-R+D	NUL		7	LB
NITRIC ACID	B881	R131C	LAB-GEN-CHEM	NUL		7	LB
NITRIC ACID	B881	R139	NUL	NUL		49	LB
NITRIC ACID	B881	R227	LAB-STANDARDS	NUL		1	LT
NITRIC ACID	B881	R283	PRODUCT LAB	NUL	ETCHING METAL	1	LT
NITRIC ACID	B881	R299	LAB-CORROSION	NUL		14	LB
NITRIC ACID	B881	R299	LAB-CORROSION	NUL		8	LB
NITRIC ACID, RGT, 70%	B881	245	LAB-R+D	NUL		21	LB
NITRIC ACID, RGT, 70%	B881	R267	LAB-CHEM-PROC-DEV	NUL		7	LB

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
POTASSIUM CHROMATE	B881	R131C	LAB-GEN-CHEM	NUL		1	LB
POTASSIUM DICHROMATE	B881	R224	LAB	NUL		4	OZ
POTASSIUM DICHROMATE	B881	R227	LAB-STANDARDS	NUL		1	LB
POTASSIUM DICHROMATE	B881	R267	LAB-PROC DEV	NUL		1	LB
POTASSIUM DICHROMATE STANDARD	B881	R227	LAB-STANDARDS	NUL		100	GM
SODIUM BICHROMATE	B881	R227	LAB-STANDARDS	NUL		1	LB
SODIUM CHROMATE	B881	R137	LAB-GEN-CHEM	NUL		500	GM
SODIUM CHROMATE	B881	R267	LAB-PROC DEV	NUL		1	LB
SODIUM DICHROMATE	B881	R267	LAB-PROC DEV	NUL		2	LB
TETRACHLOROETHYLENE PURITY-99+% O-663	B881	R255	LAB-GEN-CHEM	NUL		10	GM
TRICHLOROETHANE, 1,1,1	B881	R255	NUL	NUL		12	LT
TRICHLOROETHANE, 1,1,1	B881	R267	LAB-PROC DEV	NUL		16	KG
TRICHLOROETHANE, 1,1,1 PURITY-96.4% O-652	B881	R255	LAB-GEN-CHEM	NUL		10	GM
TRICHLOROETHYLENE	B881	R266	LAB-FRIG	NUL		3	ML

Yearly Effluent Releases for Building 881




Yearly Tritium Releases for
Building 881
Tritium
CURIES
1
0.1
0.01
0.001
0.0001
1974
1976
1978
1980
1982
1984
1986
1988
YEAR

BUILDINGS 883 and 879
BERYLLIUM AND URANIUM MACHINING FACILITY

I. Building History

1957	Building constructed as a rolling and forming (more commonly referred to as machining) facility for both enriched and depleted uranium. The building was divided into two sides: A side and B side. The A side rolled enriched uranium while the B side rolled depleted uranium (ChemRisk, 1991; RE-891[36]).
1966	Enriched uranium operations curtailed at Rocky Flats. The A side of Building 883 was converted to beryllium rolling (this process was not enclosed). Depleted uranium rolling continued on the B side (ChemRisk, 1991; RE-891[36]).
Mid-1970s	Beryllium machining stopped (ChemRisk, 1991; RE-891[36]).
1957-1988	Perchloroethylene, trichloroethylene and freon commonly used solvents (Quantity used is unknown). In November of 1988 the use of chlorofluorocarbons in B-883 was curtailed (ChemRisk, 1991; RE-891[36]).
Late 1970s or Early 1980s	Nitric acid fume scrubber added (ChemRisk, 1991; RE-891[36]).
1957-1989	Nitric acid commonly used in a 50:50 water/nitric acid mixture for pickling uranium (No estimate of quantity given) (ChemRisk, 1991; RE-891[36]).
1980-1985	Increased processing of depleted uranium. See graphs indicating missing monitoring data during this time period (ChemRisk, 1991; RE-891[36]).
Early 1980s	Modification of the ventilation system (ChemRisk, 1991; RE-891[36]).
B-879	Date of construction unknown. Building 879 houses the exhaust plenums and particulate emission controls for the Building 883 heating, ventilation, and air conditioning (HVAC) system.

II. Processes Associated with Air Emissions

Beryllium

Beryllium has not been fabricated in these buildings since late 1970s. The building has undergone decontamination since the discontinuation of Be processing. However, Be is still monitored at 3 plenum discharge points from the building. These are vents #34, 44, 45 (883-AAA, 883-BBB, 883-CCC).

Controlled emissions 2.02×10^{-4} lb/yr

Radionuclides

Vents #34, Room 139 plenum exhaust
Vents #44 and #45, Building 879 plenum exhaust

Rolling. Metal ingots, including uranium, are rolled in a rolling mill to reduce thickness and establish desirable grain structures. No emissions.

Shearing. Uranium plates are mechanically cut into smaller pieces before being shaped in other mechanical processes. Uranium scrap is recycled by sending it to B-444 for recasting.

Blanking/Trepanning. Uranium is cut from a sheet with a press and die, and desired shapes are cut with trepanning tool. Uranium turnings are placed in a drum and sent to B-444 for U chip roasting.

Forming. Uranium parts are formed into useful shapes. No emissions.

Heat Treating. Process used to anneal uranium parts-- are heated to high temp in a salt bath or furnaces; oxidation of uranium to uranium oxide may occur in furnaces. Amount of U accumulating in furnaces = 6 lb/yr Amount of U in uncontrolled and controlled release of U particulates are:

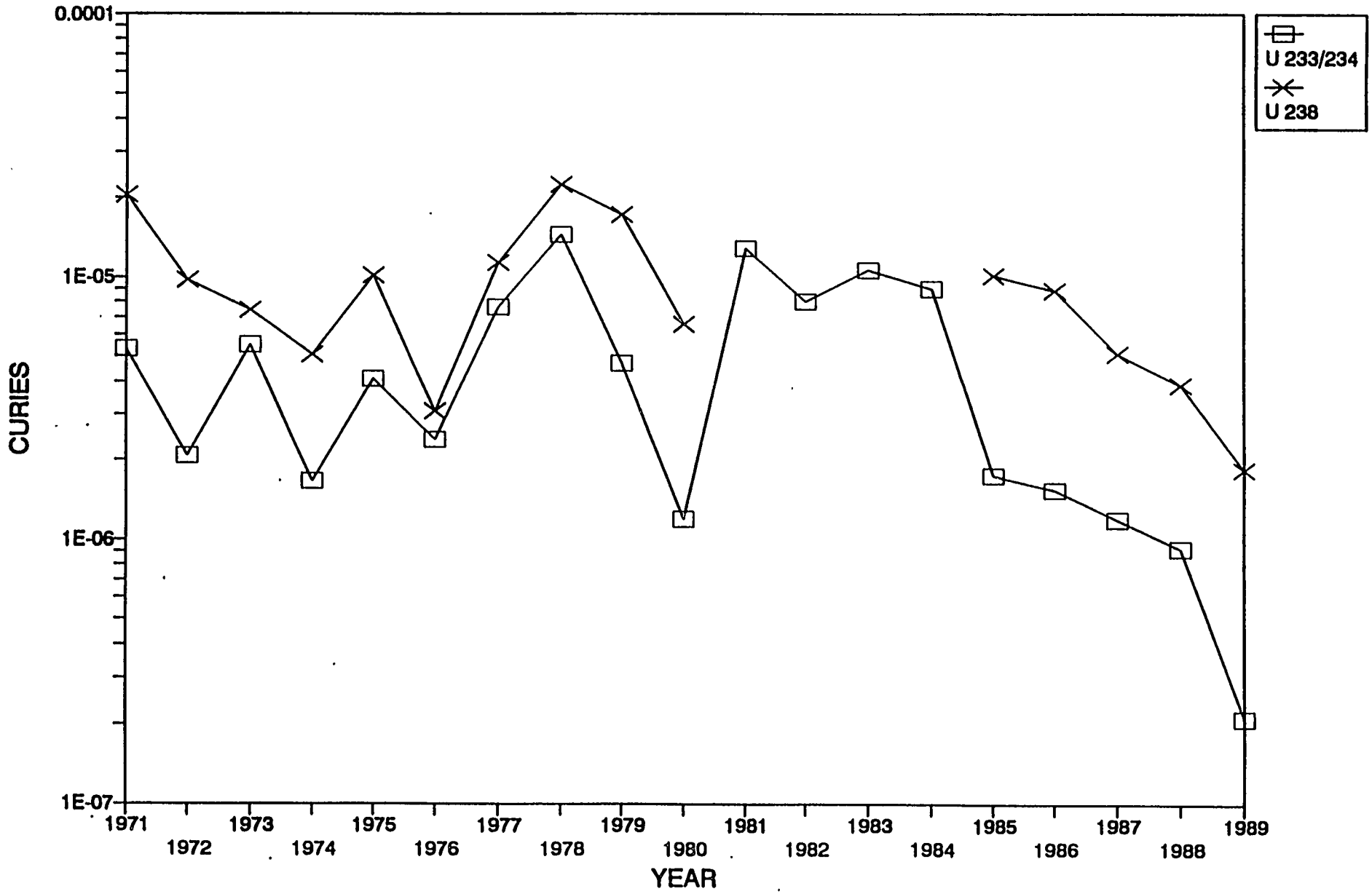
Uncontrolled	6 lb/yr
Controlled	1.20×10^{-5} lb part/yr

III. Inventory

The 1988/89 inventory places two 500 gallon storage tanks of nitric acid outside of B-883. See table.

radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ITRIC ACID	B883	OUTSIDE	TANK-DAY-WEST	NITRIC-ACID	CLEANING OF URANIUM (ACID BATH)	500	GL
ITRIC ACID	B883	OUTSIDE	TANK-PORTABLE-WEST	NITRIC-ACID	CLEANING OF URANIUM (ACID BATH)	500	GL

Yearly Uranium Effluent Releases for Building 883



BUILDINGS 886 AND 875
NUCLEAR SAFETY FACILITY

I. Building History

1965	Building 886 constructed. This building contains 13 interior storage tanks. Nine tanks contain uranyl nitrate in dilute nitric acid and four of the tanks are utility tanks and are empty. The function of the operations in this building was to perform safety experiments for equipment design.
1965-Present	Over 1600 criticality experiments have been performed. The materials used in the experiments (uranyl nitrate metal powder) are re-used. Very little waste fission products are produced and none are released. The products decay rapidly and are contained until stable (ChemRisk, 1991; RE-891[53]).
B-875	Date of construction unknown. B-875 Contains two filter plenums for air exhaust from three vents in B-886, an air supply fan and two tanks (one tank is empty, it is used to collect fire water, and one is an insulated steam condensate tank).

Building 886 is connected to B-875 by an underground passageway. The interior of the building is divided into offices, an electronics/machine shop, and laboratory spaces.

II. Processes Associate with Air Emissions

Nitric Acid	Nine storage tanks of uranyl nitrate in 0.5 N and 0.16 N nitric acid (approx. 4000 liters) are located in Rooms 103 and 101. Because the solution is not heated, no emissions of NOx from the oxidation of nitric acid are expected to occur.

III. Inventory

One pound of mercury in storage is listed on the 1988/89 inventory. See table.

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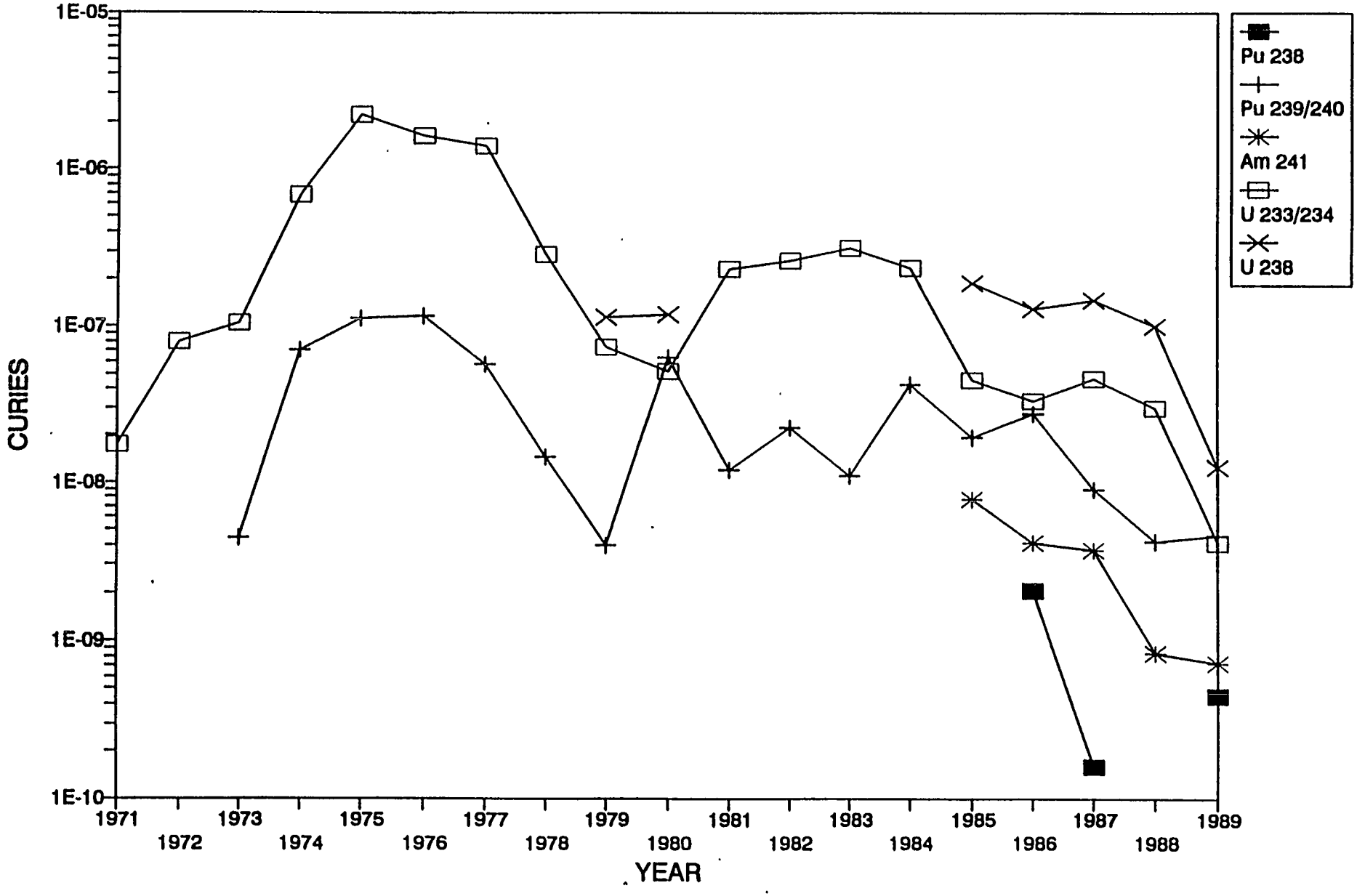
radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ERCURY	B886	R106	STORAGE	NUL		1	LB

Yearly Effluent Releases for Building 886



BUILDING 910 AND SOLAR PONDS 207A, B, AND C

I. Building History

1957	Solar evaporation pond 207A put into use (asphalt-planked pond).
1960	Solar Evaporation Ponds 207B and C put into service (asphalt-planked).
1961	Pond 207B relined with asphalt concrete over the planking.
1963	Pond 207A relined with asphalt concrete over planking.
1967	Pond 207B receives several treatments to repair cracks.
1968	Nigrosine dye used in solar evaporation ponds. Pond 207B cracked side walls repaired with burlap and asphalt.
1977	Building 910 (Reverse Osmosis facility) constructed. This building originally contained the equipment required for a reverse osmosis (RO) operation to treat effluent from the sanitary wastewater treatment plant. The RO units separated dissolved solids from the wastewater streams. This process has not been in operation for about the last five years. Building 910 is presently used to house portable evaporator units and support services for the evaporation of liquids from the solar ponds.

II. Processes Associated with Emissions

Methylene Chloride	Ponds 207A and the three 207B ponds detected methylene chloride at levels above zero but below the specified detection limit. Methylene chloride was also detected in the blank sample and the results are, therefore suspect. Therefore no emissions were calculated.
Nickel	In Ponds 207A and the three 207B ponds, **nickel** was above the detection limit in June 1990, but will remain with the sludge and not contribute to air emissions

III. Inventory

The 1988/89 inventory places formaldehyde in this building. See table.

radename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
ORMALDEHYDE	B910	NUL	NUL	UTILITIES (PSZ)-MAIN	MEMBRANE STERILIZATION	30	GL

BUILDING 985
AIR HANDLING SYSTEM

I. Building History

1974 — Building constructed. Building 985 houses the air handling system that supports the underground storage vaults 996, 997, and 999. These underground storage vaults are tunnels that extend out from Building 991. Air is supplied to the underground storage vaults by Building 985 via the supply air intake vent. The exhaust air leaving the underground storage vaults 996, 997, and 999 is drawn into the filter plenum in Building 985. The exhaust passes through a metal mesh demister screen and two stages of high efficiency particulate air (HEPA) filters before exiting through the exhaust vent.

II. Processes Associated with Air Emissions

Beryllium — Beryllium is not processed in Building 985 or in the underground storage vaults. However, some materials in the vaults may contain beryllium. For this reason beryllium is monitored at the plenum discharge point.

Controlled 3.15×10^{-8} tons/yr (particulates)

The above emission estimate is the value for beryllium releases from B-985 during 1990. It is believed that the non-zero number reported for beryllium releases is a combination of the lack of pre-installation "blank" assays of the filters (i.e., trace beryllium exists in new filters) and the magnification of analytical uncertainty when multiplied by the large volume of air discharged from these points.

II. Inventory

No Chemicals of Concern were listed on the 1988/89 inventory.

BUILDINGS 990, 990A, 995, 988, 228A, 228B

I. Building History

1953 — Buildings 990, 995, and 988 constructed. B-990 - Pre-Aeration Building; B-995 - Sewage Treatment Facility; B-988 - Tertiary Treatment Pump House.

Buildings 228A and 228B are sludge drying beds located east of B-995. Date of construction is unknown. When the reverse osmosis (RO) process was in operation, these drying beds were used to dry sludge from the precoat filters. The drying beds are presently used to dry sludge from the sanitary waste treatment plant.

II. Processes Associated with Emissions

Methylene Chloride

In sludge drying beds, B-228A and B-228B, methylene chloride was detected in one bed at a level of 160 μg/kg and was not detected in the other bed. The emissions estimate was based upon 80 μg/kg in the drying bed and 100% volatilization.

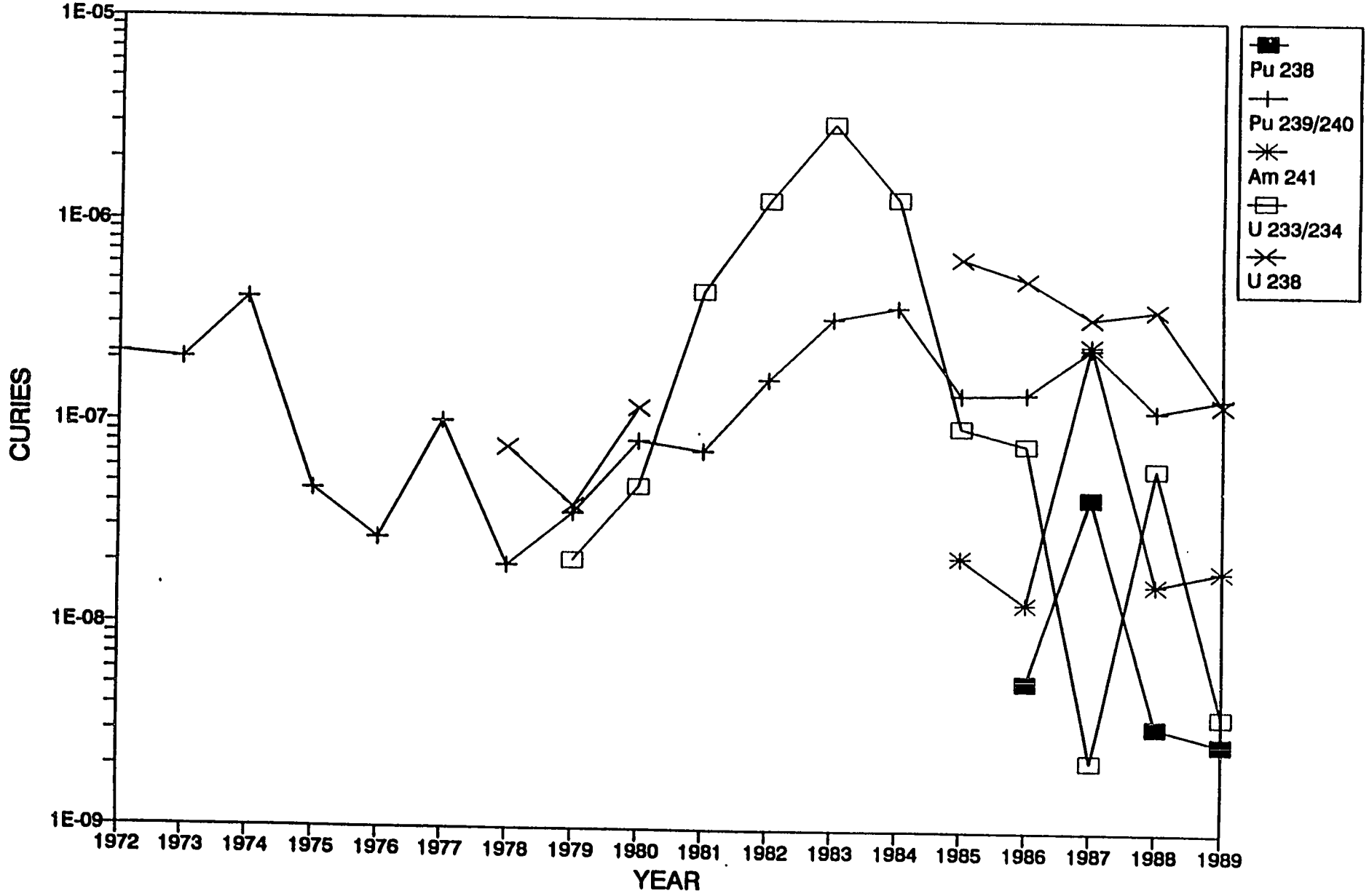
Uncontrolled	0.00014 tons/yr

III. Inventory

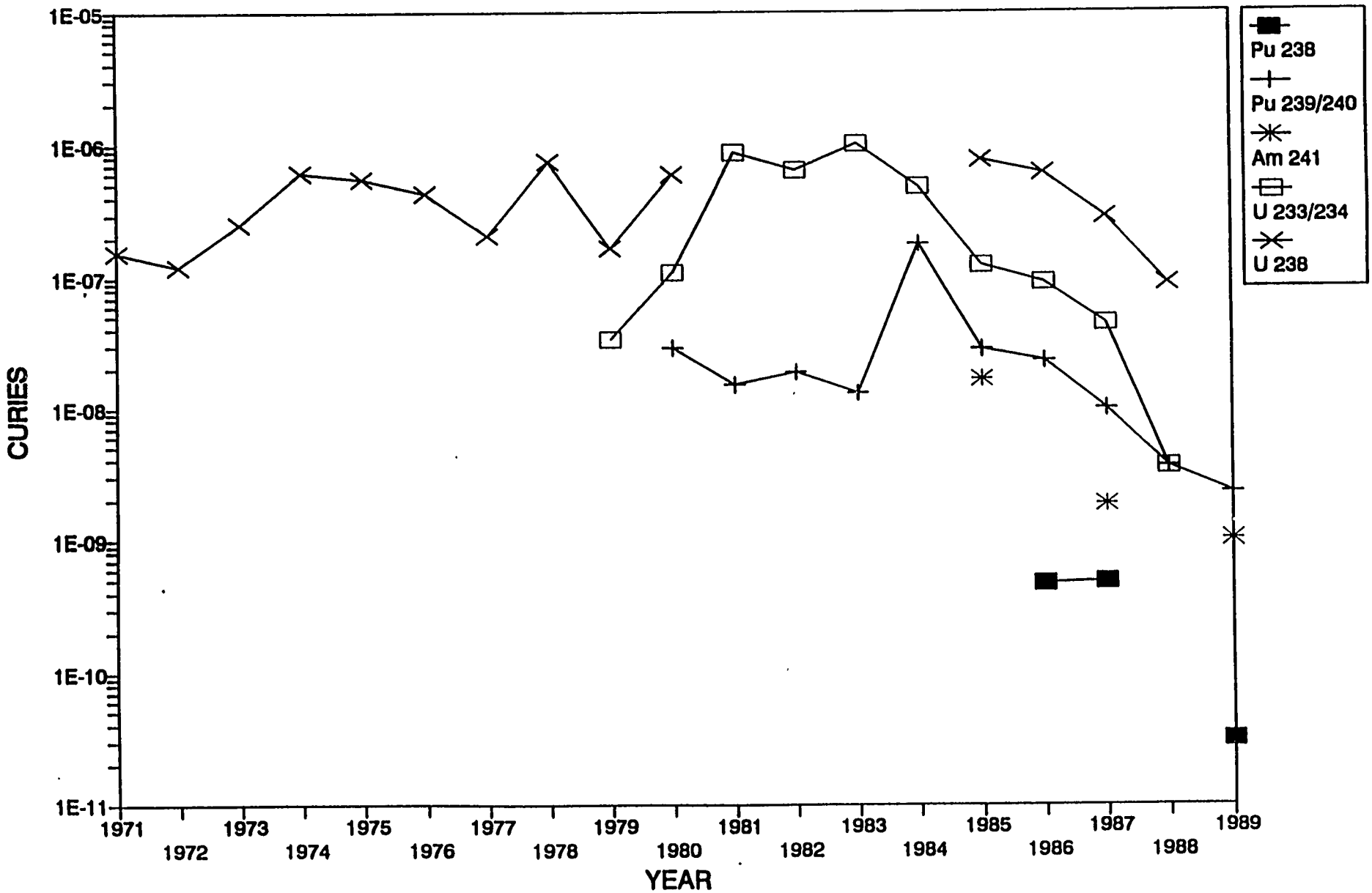
No chemicals of concern were listed on the 1988/89 inventory.

GRAPHS FOR BUILDINGS WITHOUT APENS
(Data from the EIS)

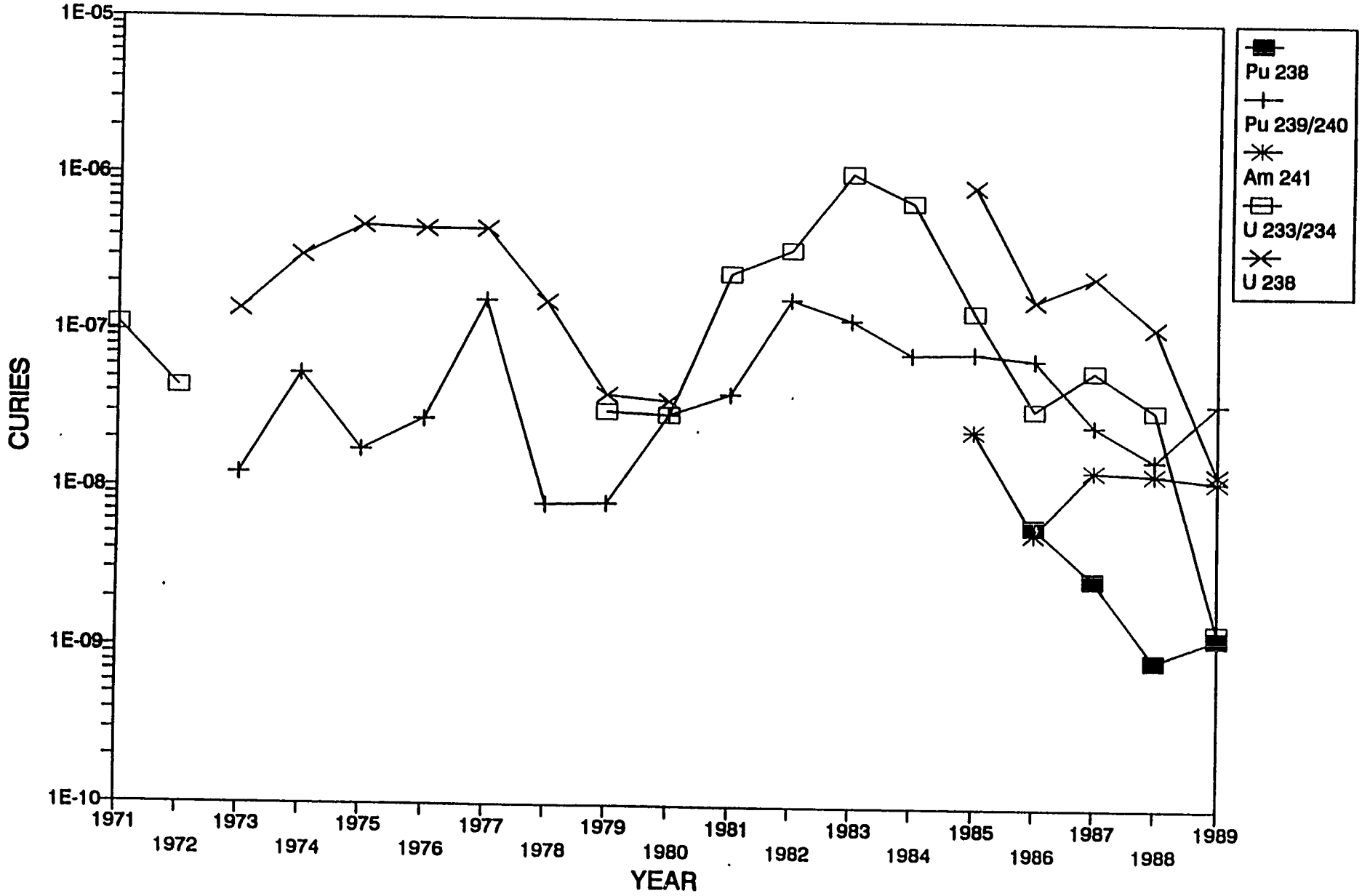
Yearly Effluent Releases for Building 778



Yearly Effluent Releases for Building 889



Yearly Effluent Releases for Building 991



BUILDINGS WITHOUT APENS BUT CONTAINING CHEMICALS OF CONCERN ON THE 1988/89 CHEMICAL INVENTORY

	Pres_quant	Units		Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
				B123	R105	LAB	NUL		300	GM
	25	ML		B123	R126	LAB	NUL		1	PT
	100	ML		B123	R126	LAB	NUL		1	GL
	500	GM		B123	R125	LAB	NUL		4	LT
				B123	R125	LAB	NUL		4	LT
	5	GM		B123	R126	LAB	NUL		1	QT
	25	ML		B123	R105	LAB	NUL		1	LB
	25	ML		B123	R109B	STORAGE	NUL		1	PT
				B123	R109B	STORAGE	NUL		2	GL
	500	GM		B123	R109B	STORAGE	NUL		2	GL
				B123	R109B	STORAGE	NUL		1	PT
				B123	R126	LAB	NUL		1	GL
	7	LB		B123	R109B	STORAGE	NUL		1	GL
	180	LB		B123	R109B	STORAGE	NUL		1	GL
			D SOLUTION	B123	R105	LAB	NUL		50	ML
				B123	R105	LAB	NUL		1	LB
				B123	R126	LAB	NUL		3	LT
				B123	R103	LAB	NUL		12	LT
				B123	R112	LAB	NUL		2	LT
				B123	R124	LAB	NUL		1	GL
				B123	R125	LAB	NUL		4	LT
				B123	R127	LAB	NUL		7	LB
				B123	R156	LAB	NUL		1	GL
				B123	R157	LAB	NUL		24	LB
				B123	R156	LAB	NUL		2	LB

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
CHLOROFORM	B334	R106	TOOL-CRIB	NUL		3	QT
CHLOROFORM	B334	R106	TOOL-CRIB	NUL	ADHESIVE - SOLVENT	6	QT
LEAD OXIDE RED	B334	R106	TOOL-CRIB	NUL	MACHINE REBUILDING	8	OZ
LEAD OXIDE RED	B334	R106	TOOL-CRIB	NUL		16	OZ
CARBON TETRACHLORIDE	B551	R101	WAREHOUSE	NUL		40	GL
CHROMION TRIOXIDE	B551	R101	WAREHOUSE	NUL		1400	LB
NITRIC ACID	B551	R101	WAREHOUSE	NUL		400	LB
BENZENE	T452B	NORTH SIDE	FLAM CABINET	NUL		10	GM
CARBON TETRACHLORIDE	T452B	NORTH SIDE	FLAM CABINET	NUL		5	ML
CHLOROFORM	T452B	NORTH SIDE	FLAM CABINET	NUL		10	GM
METHYLENE CHLORIDE	T452B	NORTH SIDE	FLAM CABINET	NUL		5	ML
TETRACHLOROETHYLENE	T452B	NORTH SIDE	FLAM CABINET	NUL		5	ML
TETRACHLOROETHYLENE	T452B	NORTH SIDE	FLAM CABINET	NUL		5	ML
TRICHLOROETHANE, 1,1,1	T452B	NORTH SIDE	FLAM CABINET	NUL		5	ML
BERYLLIUM ATOMIC ABSORPTION STD. SOLN	T452F	WEST END	LAB-MEDICAL	NUL		100	ML
BERYLLIUM STANDARD SOLUTION	T452F	WEST END	LAB-MEDICAL	NUL		25	ML

Tradename	Location	Room	Workplace	Loc_id	Operation	Pres_quant	Units
CADMIUM STANDARD SOLUTION	T452F	WEST END	LAB-MEDICAL	NUL		25	ML
CHROMIUM ATOMIC ABSORPTION STD. SOLN	T452F	WEST END	LAB-MEDICAL	NUL		100	ML
CHROMIUM POTASSIUM SULFATE	T452F	WEST END	LAB-MEDICAL	NUL		500	GM
LEAD IN BLOOD	T452F	WEST END	LAB-MEDICAL	NUL		5	GM
LEAD STANDARD SOLUTION	T452F	WEST END	LAB-MEDICAL	NUL		25	ML
MERCURY STANDARD SOLUTION	T452F	WEST END	LAB-MEDICAL	NUL		25	ML
POTASSIUM DICHROMATE	T452F	WEST END	LAB-MEDICAL	NUL		500	GM
NITRIC ACID	T690J	ALL	LAB-SOIL	NUL		7	LB
NITRIC ACID, RGT, 70%	T690J	ALL	LAB-SOIL	NUL		180	LB

APPENDIX C

INTERVIEW QUESTIONS

INTERVIEW QUESTIONS

The Toxicological Review and Dose Reconstruction project has identified a number of **chemicals from inventories** generated by the plant in 1974 and in 1988/89 which are of interest for investigations of potential off-site health impacts. A list of 20 chemicals and 5 radioactive elements is attached. ChemRisk is interested in identifying the way these chemicals were used and released from the site historically, between 1950 and 1989.

Some of the chemicals have been identified as being stored or released from buildings. Air pollution emission notification (APEN) documents have been prepared by the plant which estimate emissions of chemicals for normal operation of the plant based on current processes and facilities. ChemRisk has reviewed all available APEN documents.

1. Pleas describe your complete work history at the plant, including years worked in building(s) and job title(s)/duties.

2. ChemRisk is interested in knowing about **historical changes to processes, buildings, or effluent treatment systems** that would have affected air emissions.

   - Do you know of any **process changes** that may have increased/decreased air emissions? (e.g., any processes which have been added or eliminated over the lifetime of the plant)

   - Do you know of any major **additions, eliminations or substitutions** in the types of chemicals used in the buildings? Do you know of any chemicals used in large quantities at the plant that are **not** on the enclosed list?

   - Do you know of any significant additions, eliminations or changes in **ventilation or emission controls** that could change emissions?

   - Can you suggest any methods for estimating historical **changes in the volumes** of chemical use and emissions that might have resulted from different rates of production (e.g., higher direct measurements of radioactive effluents might be associated higher production years). How might chemical emissions have varied?

3. Little historical information is available with regards to contaminants in **liquid effluents** from the plant, with the exception of the limited monitoring of the holding ponds.

- Do you have any knowledge of the historical **disposal practices** for the attached list of chemicals and radioactive elements?

- Is it likely that any of the chemicals have historically been **released** from the buildings to the treatment plant, holding ponds or creeks?

  - Do you know of any **means of estimating** the potential quantities of chemicals released to the liquid effluent treatment system, holding ponds or creeks?

  - What effect would the waste treatment systems have had on concentrations of the chemicals released to the ponds?

- Are you aware of any routine or special, air or liquid effluent **sampling** that was done in or outside the building (e.g., industrial hygiene sampling or special studies of chemical emissions)?

  - What type of sampling was done?
  - Where can the sampling data be accessed?

4. Major **exhaust points** have been sampled for radionuclides and beryllium since the early years of plant operations. Are you aware of any potential radioactivity emission points from the plant that historically have **not been routinely sampled**?

5. In addition to routine emissions, ChemRisk is also interested in the **accidental** release of radionuclides or chemicals. What **accidental releases** of chemicals or radionuclides to the outside of a building are you aware of?

6. Three significant accidents have been the subject of much investigation at the plant. These three accidents are the **1957 fire** in B-771, the **1969 fire** in B-776/777 and the release of plutonium contaminated soil from the **903 Pad.**

- Do you have any information or knowledge of **key reports** on these three accidents, especially any containing estimates of **release quantities**?

- Do you know of any "**historians**" with unique or special knowledge of these events (including an address or phone number, if known)?

- Do you have any knowledge of the 1968 tritium release of 600 Curies from B-777 mentioned in the 1980 Environmental Impact Statement and press release? (This is not the 1973 or 1974 tritium releases.)