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Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

May 7, 1990

ADDRESSEES

BUILDINGS RADIOLOGICAL CHARACTERIZATION REPORT

Enclosed for your information and use are copy(s) of the Buildings Radiological Characterization Report.

This report summarizes radiological characterization data on the Weldon Spring Chemical Plant (WSCP) buildings gathered as part of five previous investigations, and provides a consistent interpretation of this data. The data and data interpretation will be used to support future feasibility studies which will determine the best available technologies for ultimate disposition of the buildings and associated equipment.

Sincerely,

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BUILDINGS RADIOLOGICAL CHARACTERIZATION REPORT

For the
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared by MK-Ferguson Company and Jacobs Engineering Group

APRIL 1990 REV. 0

U.S. Department Of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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ABSTRACT

This report summarizes radiological characterization data on the Weldon Spring Chemical Plant (WSCP) buildings gathered as part of five previous investigations, and provides a consistent interpretation of this data. The data and data interpretation will be used to support future feasibility studies which will determine the best available technologies for ultimate disposition of the buildings and associated equipment.

At present, no structure or piece of equipment can be released from the WSCP for unrestricted use without further radiation measurements being performed. Some equipment and building components contain levels of surface radioactivity far below the DOE unrestricted use release guidelines and may only require spot-check measurements in order to be released for unrestricted use. Other equipment and building components contain surface radioactivity levels near the DOE guidelines and will probably require 100 percent scanning of all exterior surfaces in order to be released for unrestricted use. Equipment and building components containing surface radioactivity levels far below or near the DOE guidelines were usually found in those buildings not used for the actual processing of uranium and/or thorium.

A final group of equipment and building components contains surface radioactivity levels in excess of DOE guidelines; this group, usually found in buildings housing uranium and/or thorium processing equipment, will require decontamination and comprehensive scanning in order to be considered for unrestricted use release.

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1 INTRODUCTION

This report contains a summary of all radiological data collected from within and on the structures and equipment at the Weldon Spring Chemical Plant (WSCP) formerly known as the Weldon Spring Uranium Feed Materials Plant (WSUFMP). An interpretation of the results and conclusions regarding the status of each structure is also included.

The data were obtained from five investigations conducted between 1967 and 1989. Although each investigation presented measurement data and data interpretation, some of the data conflict, and some of the interpretations are misleading.

None of the five investigations reports data collected in all WSCP structures. In many cases two or three separate investigations were conducted at different times in the same structure. In some cases radiological data were collected in a given structure during only one investigation.

In general, data collected during one investigation agree with data collected during a different investigation in the same structure. Sometimes, however, the data conflict.

Each of the five investigations draws conclusions regarding whether a portion of a structure or equipment within a structure can be released from the site for unrestricted use. Sometimes these conclusions are misleading. Other times these conclusions have been found to be in error based on data collected during a subsequent investigation.

The purpose for preparing this summary report is to sift through the tens of thousands of radiological measurements made within and on the WSCP structures and provide a comprehensive data interpretation based on all available data. The value of

this summary report is that it provides a unified reference containing consistent data interpretation for use during feasibility studies aimed at determining the best technologies for ultimate disposition of the WSCP structures and equipment.

The main body of this report summarizes the purpose, scope, radiation monitoring techniques (when available), and the general conclusions of each of the five previous investigations. Appendix A provides building-specific summaries of all radiation measurement data, along with data interpretation and conclusions regarding the potential releasability status of building components and equipment.

Probably the most significant finding of this report is that no structure or piece of equipment can be released from the WSCP for unrestricted use without further radiation measurements being performed. The characterization information provided in Appendix A separates structural components into two categories: (1) contaminated and not releasable for unrestricted use without some form of decontamination and (2) potentially releasable for unrestricted use without decontamination. If an attempt is made to release items in category 2 for unrestricted use then at a minimum, spot-check measurements will be required of areas which were inaccessible when the characterization measurements were performed. In many cases, items determined by characterization measurements to be potentially releasable for unrestricted use will require radiation measurements performed on essentially 100 percent of the surface area of the item prior to release from the Weldon Spring Site.

2 DEPARTMENT OF THE ARMY LETTER REPORT TO WILLIAM L. HUNGATE

Results of the first survey were reported by Colonel Walter J. Davies, Acting Commander of the WSCP, to William L. Hungate, U.S. House of Representatives, on October 7, 1969 (Davies, 1969). A total of 29 buildings was included in the survey. The report concluded that sixteen of these, Buildings 302, 401, 406, 408, 409, 410, 412, 413, 414, 417, 429, 433, 435, 436, 437 and 438, were either free of radioactive contamination or could be cleaned to meet the applicable Atomic Energy Commission (AEC) guide limits; however, these guide limits are not identified. Buildings 103 and 105 were reported to require some work in order to be decontaminated to AEC guide limits. Buildings 101, 108, 201, 202, 301, 403, 404, 405A & B, 407 and 434 were considered to be so highly contaminated that economical decontamination of these buildings would not be feasible.

For most of the buildings, only the author's estimates of contamination, based on his professional judgement, are available. Specific measurement locations and results are available for Buildings 101, 103, 105, and the surrounding concrete pads, but even these results can no longer be considered an accurate representation of currently existing radioactive contamination levels, since there have been unquantifiable changes in site conditions since these measurements were made. Thus, this survey is useful only as a very general indicator of which buildings are contaminated.

3 ASSESSMENT OF WELDON SPRING CHEMICAL PLANT IN ST. CHARLES COUNTY, MISSOURI (RADCON)

During the period from September 1967 to September 1972, 23 buildings were surveyed. These surveys were conducted to determine the decontamination effort necessary to release the buildings for unrestricted use. Results of these surveys are summarized in the U. S. Army Radiation Control (RADCON) report (DA, 1976).

The RADCON report summarizes fixed and removable alpha radioactivity for the 23 buildings surveyed. RADCON indicates that only three minor structures, Buildings 302, 401, and 413, could possibly be released for unrestricted use without decontamination. It is further indicated, however, that if more comprehensive surveys were performed in these three structures, contamination in excess of unrestricted use release guidelines may be detected.

4 RETA REPORT PHASE III

A survey was performed in 1977 by Ryckman, Edgerly, Tomlinson and Associates (RETA), under contract to the U. S. Department of the Army (RETA, 1978). RETA was to determine if the buildings, equipment, and realty of the WSCP could be released for public or private use where contamination was not detrimental to such a use, or decontaminated for unrestricted use. If unrestricted use was not feasible, the Army was interested in identifying alternatives to maximize both the site's utility and compatibility with surrounding land uses.

Most buildings were surveyed by RETA in order to determine the levels of contamination present. One survey method measured gross alpha emissions from loose contamination collected on wipes and analyzed in the laboratory. Loose contamination is defined as that contamination which adheres to a surface wipe. Total contamination includes loose plus fixed contamination, where fixed contamination is interpreted as that which would require at least a broom to sweep it up, as well as that which would require more vigorous decontamination methods. A portable gross alpha detecting instrument was used to measure total alpha contamination.

A portable beta-gamma detecting instrument utilizing a thin, end-window Geiger-Müller (G-M) probe was used to detect both beta- and gamma-emitting contamination. A portable 2-inch by 2-inch sodium iodide (NaI) scintillometer was used to detect gross gamma and X-radiation. Swipes and residue from the buildings and the equipment were measured with alpha and gamma spectroscopy in order to determine the particular isotope or isotopes present. These methods are discussed in detail in the RETA Report Phase III.

RETA defined the radiological contamination in the buildings by six categories as shown in Table 4-1. Category 1 is the lowest level of contamination and Category 6 is the highest. In the table, "0.1 lbs of uranium equivalent" is the amount of radiation equivalent to that produced by 0.1 pounds of natural uranium.

RETA collected two types of air samples, area and personal breathing zone, to determine airborne particulate radioactivity concentrations in some of the buildings. Area samples were collected on filters using high-volume air samplers, while personal breathing zone samples were collected on filters using low-volume sampling pumps. These filters were analyzed for alpha activity using a gas flow proportional counter.

An engineering and radiological survey of process, utility, maintenance, and laboratory equipment was also conducted. The engineering survey included inspection of equipment items for general salvageability, and the tagging of items for identification. A total of 921 items was inspected and tagged. The inspection and tagging effort was not an exhaustive inventory of plant equipment but focused on major items and items offering the greatest potential for salvage and recovery. The radiological survey of equipment throughout the plant revealed that 21 percent of the items surveyed exhibited no contamination.

The RETA survey found that, in general, horizontal surfaces such as floors, ledges and platforms were the most contaminated. Vertical surfaces were usually either uncontaminated or could be decontaminated with a general wash-down. A major exception was wall surfaces that were adjacent to equipment that processed radioactive material in such a way that dust or material was sprayed onto the wall surface. Uranium was found to be the main

TABLE 4-1 Contamination Categories (RETA, 1978)

Category Number	Category Description	Level of Loose Contamination dpm/100 cm^2	Level of Total Contamination dpm/100 cm^2
1	Releasable	R(result) <20	R<300
2	Releasable if no radium present	20< R <200	300< R <1000
3	Releasable if no radium or thorium present	200< R <1000	1000< R <5000
4	Moderate contamination	1000 $\leq$ R	5000< R <15,000
5	High contamination		15,000< R <0.1 lbs uranium equivalent
6	High contamination		0.1 lbs uranium equivalent $\leq$ R

radioactive contaminant. Natural thorium and Ra-226 were also detected in some buildings.

The RETA study indicates levels of contamination on buildings and equipment. It estimates the percent of radiation measurements that fall into each of the previously defined categories of contamination and usually indicates the general areas in a building which have much or little contamination. It also tells which radionuclides were found in each building.

The report is useful in painting a general picture of the relative degrees of contamination in and between buildings and equipment, but was less comprehensive than subsequent studies. For this reason data collected by RETA are summarized in Appendix A in tabular form only for those buildings that were not surveyed more comprehensively at a later date.

Although the RETA report compares measurement results in the buildings to DOE unrestricted use release guidelines, the data are not comprehensive enough to actually release materials from the Weldon Spring Site for unrestricted use. If it is determined to be practical to release materials from buildings characterized by RETA from the site, more thorough radiation surveys will be performed.

5 BNI RADIOLOGICAL SURVEY

Beginning in March 1986, Bechtel National, Inc. (BNI) began detailed radiological characterizations of the structures at the WSCP at the request of the U.S. Department of Energy (DOE). The principal objective of BNI's efforts was to determine the radiological status of each WSCP structure and to describe the location and magnitude of contamination on the structure itself, as well as on equipment within the structure (BNI, 1986).

The BNI survey was terminated in May 1986. At that time only Buildings 201, 301, 403, 404, 405A and 405B had been surveyed. The survey reports are in various degrees of completeness depending on how far the survey had progressed before BNI's activities were halted. The data collected by BNI revealed significant contamination in all six buildings. This is not surprising since all these buildings were used for processing uranium and/or thorium.

For purposes of the characterization activities, a grid system was established covering all areas of each structure. For the grid planes on each surface, vertical or horizontal, alpha and beta-gamma radiation were measured directly on surfaces at grid points. Alpha measurements were made with a portable alpha scintillation detector coupled to a digital ratemeter-scaler. Beta-gamma radiation measurements were made with a thin-window G-M probe. Gamma-ray exposure rates were measured one meter above the floor at several grid point locations in each building. These measurements were made using a portable gamma-ray scintillation detector with the response calibrated in micro-Roentgen per hour (μR/hr) against a sealed Ra-226 source.

Loose contamination was determined by wiping surface areas of approximately 100 cm^2 in size with 47 mm-diameter cloth

swipes. These samples were sent to an off-site laboratory and analyzed for alpha and beta activity.

BNI also made quality control measurements. About 5% of the surface measurements were repeated in order to verify original measurements, and about 10% of the swipe samples were recounted. Comparison of the repeat measurements with the first set revealed acceptable agreement.

The BNI report provides a breakdown of the number of measurements of surface radioactivity that exceed the DOE unrestricted use guidelines shown in Table 5-1. Note that the guidelines differ depending on which radionuclides are present. The BNI report also provides a discussion on the rationale for determining which guideline applied to a specific building based on isotopic analyses of samples of dust, scale, or other debris.

TABLE 5-1 Surface Contamination Guidelines (Gilbert, 1989)

Radionuclides [2]	Allowable Total Residual Surface Contamination (dpm/100 cm²)[1]		
	Average[3,4]	Maximum[4,5]	Removable[4,6]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, & associated decay products	5,000[7]	15,000[7]	1,000[7]
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000

1 As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2 Where surface contamination by both alpha- and beta-gamma- emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

3 Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

4 The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5 The maximum contamination level applies to an area of not more than 100 cm².

6 The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

7 Specified for alpha emissions.

6 PMC RADIOLOGICAL SURVEY

The fifth radiological survey was performed by the Project Management Contractor (PMC) in 1988 and 1989 on the buildings where uranium and/or thorium processing had not been done. The characterization included radiation measurements on all building surfaces such as interior and exterior walls, exterior roofs, interior ceilings, floors, interior beams, and interior columns, as well as radiation measurements on pieces of equipment.

The purpose of the survey was to determine which building components or equipment could potentially be released for unrestricted use. The PMC key criteria, established in the RI/FS sampling plan (MKF, 1988), for determining whether a material could be released for unrestricted use are:

1. No single measurement on a surface is greater than the guidelines shown in Table 5-1.
2. The measurement data on a surface must be normally distributed.
3. The true mean surface radiation level must be estimated to within ±20 percent with 90% confidence.
4. The estimated probability of exceeding surface contamination guidelines for any single measurement taken from any location on a surface is less than 0.02 percent.
5. The contamination is surficial only.
6. The identity of the radionuclides is known.

Six types of samples or measurements were made during the PMC characterization in order to obtain data required under the key criteria. These were: (1) total; (2) removable; (3) core; (4) bulk; (5) scans; and (6) air monitoring.

Total beta-gamma radiation measurements were taken with a thin-window G-M probe coupled to a digital ratemeter/scaler and

held at contact with the surface for one minute. The detector response was corrected for detector background, area and efficiency to yield measurements in disintegrations per minute per 100 square centimeter area (DPA).

Removable surface radioactivity (loose contamination) was determined by wiping surface areas of approximately 100 cm^2 using moderate pressure. The swipes were then analyzed for gross alpha radiation for one minute on a bench-top alpha scintillation detector. The count rate results were corrected for detector background and efficiency to yield measurement results in DPA.

To determine whether contamination had seeped into the surface of porous materials such as concrete, core samples were taken. First, a one-minute G-M detector measurement was made on the surface of the core sample location. If loose material was present, it was brushed off and a second one-minute G-M measurement was obtained. Finally, a one-to-two-centimeter core sample was taken and a one-minute G-M measurement was made at contact with the freshly exposed surface. If the final G-M measurement was above the Minimum Detectable Activity (MDA) of the G-M detector, the surface was considered volumetrically contaminated and therefore not releasable for unrestricted use based on the PMC key criteria.

Samples of bulk materials, such as loose floor dust residue and flaky paint, were obtained in 500-gram quantities at designated locations. Bulk samples were taken to identify the radionuclide(s) present, both so the appropriate release guidelines could be applied and to identify the radionuclide constituents in any materials that might become airborne, so that appropriate precautions can be taken to protect workers during remedial actions. The samples were scooped or scraped off the surface of materials and then analyzed for total uranium

(U-234, U-235 and U-238), Th-232, Th-230, U-238, U-234, U-235, Th-228, and Ra-226. The analytical techniques used were laser fluorometry, and gamma and alpha spectrometry.

Bulk sample results are used to determine building-specific surface contamination guidelines. The appropriate building-specific surface contamination guideline is determined as follows. If the activity of the parent radionuclide (either U-238 or Th-232) is greater than or equal to the activity of each daughter product, the daughters are considered associated decay products and the guideline for either natural uranium or natural thorium is applicable. If the activity from Th-228 or Ra-228 exceeds the activity of its parent, Th-232, then the guideline for Th-228 and Ra-228 is applicable. If the activity of Ra-226 or Th-230 exceeds the activity of their parent U-238, the guideline for Ra-226 and Th-230 is applicable.

In many cases the guidelines for both natural uranium and natural thorium are applicable to a surface becasue radionuclides from both decay series are detected and the parent radionuclide concentration exceeds the activity of its daughters. In this case a mixture rule is applied. The mixture rule allows the calculation of a new surface release guideline based on the mixture of natural uranium and natural throium as follows:

$$\text{Calculated surface contamination guideline (dpm)} = \frac{(\text{alpha dpm attributed to U-natural})\ (5{,}000\ \text{dpm})}{\text{Total dpm}} +$$

$$\frac{(1{,}000\ \text{dpm})(\text{alpha dpm attributed to Th-natural})}{\text{Total dpm}}$$

The calculated guideline is specific to alpha activity because surface contamination guidelines are specific to alpha

activity for U-natural. Although the Th-natural decay chain consists of alpha and beta emitters, and footnote 2 to Table 5-1 specifies that when both alpha- and beta-emitting radionuclides are present the guidelines should be applied independently, the Th-natural decay chain has more alpha emitters than beta emitters. Therefore, if the guideline for Th-natural is satisfied for alpha emitters, it will be satified for beta emitters.

The alpha dpm attributed to natural uranium is determined by multiplying the activity in picocuries detected in bulk samples for each radionuclide in the U-238 decay chain by the number of alpha emissions in dpm/pCi assigned to that radionuclide. The contribution from each radionuclide is summed. Similarly, the alpha dpm attributed to radionuclides in the Th-232 decay chain is calculated. The total dpm is the sum of the alpha dpm attributed to U-natural and the alpha dpm attributed to Th-natural. Table 6-1 presents the alpha emissions (dpm/pCi) assigned to each bulk sample analyte.

Scan measurements were performed with G-M detectors. A scan consisted of moving the G-M detector at a rate of no more than five centimeters per second over the surface being scanned. The distance between the detector and the material averaged no more than two centimeters.

Air samples were collected for two purposes: (1) to determine the concentrations of airborne radionuclides in the buildings; and (2) to ensure the health and safety of personnel performing characterization activities. Airborne particulates and radon/thoron daughter samples were collected with low volume pumps (breathing zone) or general area/room samplers on air-filter paper. The filter papers were analyzed by bench-top alpha scintillation detectors for short-lived daughters of radon (Rn-222) and thoron (Rn-220) in working level (WL) units, or

TABLE 6-1 Alpha Emissions for Radionuclides

Measured Radionuclide	Total Alpha dpm per pCi
U-238	2.2
U-234	2.2
Ra-226*	11.0
Th-230	2.2
Th-232	2.2
Th-228*	11.0

* Assumed to be in secular equilibrium with remainder of decay series.

concentrations of long-lived airborne particulates in units of microcuries per milliliter of air (µCi/ml). Building-specific air sample analyses were compared to the DOE Derived Air Concentration (DAC) guidelines of the predominant radionuclide as determined by building-specific bulk sample results. The DAC guidelines are presented in Table 6-2.

Air sampling for radon and thoron gas was previously performed by the PMC in January 1987. The detectors used for this sampling were Terradex Track Etch Type F and Type M. Type F detectors consist of a hydrophobic microporous filter which allows infiltration of radon and thoron gas but discriminates against the nongaseous radon daughters. The Type M detectors are the same as the Type F except for a semi-permeable plastic membrane which slows the normal diffusion of the gas and discriminates against thoron gas while permitting radon gas to be detected. The results of the measurements were converted to concentrations in units of picocuries per liter of air (pCi/l).

The PMC survey found that horizontal surfaces were usually more contaminated than vertical surfaces. This is true for both interior and exterior surfaces and agrees with RETA's findings. Areas such as hallways that had more traffic through them than surrounding areas were usually more contaminated. Core samples showed that most, although not all, of the floors had surficial contamination only.

Process buildings, surveyed by previous contractors, were in general more heavily contaminated than the non-process buildings surveyed by the PMC. Uranium was found to be the principal contaminant in almost all buildings; natural thorium, Ra-226, Ra-228, Th-230 and Th-228 were usually found to a far lesser extent than uranium.

TABLE 6-2 Derived Air Concentration Guidelines for Occupational Exposure to Airborne Radioactive Material (DOE, 1988)

Radionuclide (a)	Concentration (µCi/ml)
U-238	2.0 E-11
U-234	2.0 E-11
Th-232	5.0 E-13
Th-230	3.0 E-12
Ra-228	5.0 E-10
Ra-226	3.0 E-10
Radon/Thoron	**Concentration**
Rn-222 + Daughters	30 pCi/l or 0.33 WL
Rn-220 + Daughters	8 pCi/l or 1.0 WL

(a) Exposures to mixtures of radionuclides shall be reduced so that the sum of the ratios of each radionuclide to the allowable limit will not exceed unity.

In general, airborne particulate, radon/thoron gas, and radon/thoron daughter concentrations were below DAC guidelines in the building surveyed by the PMC. However, buildings characterization work activities are not generally representative of dismantlement work activities and therefore additional air samples will be taken during dismantlement in order to ensure worker health and safety.

During the PMC characterization effort, equipment remaining in the buildings was inventoried. Building-specific inventories classified by type of equipment are on file with the PMC. Due to the volume of items found, only five percent of items in each equipment classification were scanned. This scanning strategy qualitatively identified equipment classifications in each building which contain potentially releasable items. However, since only a small portion of each equipment classification was scanned, further scanning will be required prior to and during building dismantling to identify exactly which pieces of equipment are releasable.

Many items were termed "DBC", which means Determined By Contractor (the PMC) to be not releasable for unrestricted use. These items were not scanned and included those which were obviously contaminated, had interior surfaces which were inaccessible, or were small enough to be picked up in one hand. Items with inaccessible interior surfaces could not be completely scanned to determine releasability status; small items, such as laboratory glassware, were not scanned because the minimal equipment value did not warrant the cost of scanning. Further labor-intensive actions, such as decontamination, equipment dismantling and/or automated scanning methods, will be required to determine the potential releasability status of equipment presently deemed as DBC.

It should be noted that although the RETA report, the BNI report, and the PMC report all use the term "releasable," they do not necessarily mean the same thing. RETA used different criteria for releasability than did BNI or the PMC. BNI and the PMC used the same criteria (DOE guidelines), but the BNI report is not always clear about which guidelines for which radionuclide are being applied. Both the RETA and the BNI report discuss the percentage of a surface that is releasable, but neither report provides documentation identifying the releasable and nonreleasable sections of surfaces. In many cases surface contamination is heterogeneously distributed, making it difficult if not impossible to separate releasable and nonreleasable sections efficiently even if this documentation was provided.

The PMC survey was the only one to demand that a set of measurements on a surface conform to the six criteria given at the beginning of this section in order for that surface to be considered potentially releasable for unrestricted use. This method allows for efficient separation of releasable and nonreleasable surfaces since the PMC criteria typically designated heterogeneously-contaminated surfaces as nonreleasable.

Appendix A contains building-specific measurement results and identifies item categories which are considered potentially releasable or non-releasable based on adherence to the six PMC criteria. Since meeting DOE surface contamination guidelines is only one of these criteria, some items may be classified in the tables of Appendix A as "non-releasable" even though measurement results conform to surface contamination guidelines. These non-releasable items failed one or more of the remaining PMC criteria.

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Appendix A

Summary of Measurement Results for the WSCP Buildings

FOREWORD

This appendix provides radiological characterization summaries for each of the 40 existing buildings at the Weldon Spring Chemical Plant. Each summary includes all radiation measurement data, both original investigation and PMC data interpretation, discrepancies between the PMC and other investigations' data or interpretations, and the PMCs evaluation of potential releasability of structures and equipment. A map of all WSCP buildings is provided as Plate 1.

It is important to note that some item categories found in the following tables are identified as "non-releasable" even though measurement results are below DOE surface contamination guidelines (Gilbert, 1989). This is because surface contamination guidelines constitute only one of six PMC criteria which a surface must pass in order to be considered potentially releasable. The items in question failed one or more of the remaining five PMC criteria.

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A-1 BUILDING 101

This building was designed to process approximately 75 tons per day of low assay uranium ore concentrates. It housed equipment and facilities for drying, grinding, screening, blending and sampling ore concentrates and process residues. The incoming ore concentrates and residues were stored in drums on a 250 ft x 300 ft concrete storage pad on the northern side of the building. The building is 100 ft x 120 ft with a 30 ft x 30 ft annex, and contains a gross volume of approximately 6 x 10^5 cubic feet (AEC, 1960).

This building has been gutted and no process equipment remains except a four-story rotary kiln-type calciner located in the southeast corner of the building. The calciner was used to heat the uranium feed materials in order to eliminate ammonia and/or residual organics.

Three radiological surveys have been performed in Building 101: one performed by the Department of the Army (DA), one by the U. S. Army Radiation Control (RADCON) team, and one by Ryckman, Edgerly, Thompson & Associates (RETA).

The first was performed in 1967, when the DA planned to convert the Weldon Spring Site to a herbicide production plant. As a result of this survey, the DA began decontamination and equipment removal activities. All of the equipment except the floor plate and the calciner was removed from the building, and the building was decontaminated to levels below Atomic Energy Commission (AEC) guidelines applicable at the time of the survey with the following exceptions: 1) no attempt was made to decontaminate the six roof levels; 2) some wall areas were not completely decontaminated; 3) no attempt was made to decontaminate the calciner or calciner rooms; 4) some floor plating was not completely decontaminated; and 5) portions of

the ground level floor and outside pad were not completely decontaminated (Davies, 1969).

A cursory survey conducted by the RADCON in 1976 indicated that Building 101 was still contaminated in excess of the applicable Nuclear Regulatory Commission (NRC) Guidelines for unrestricted use (DA, 1976).

A more comprehensive survey conducted by RETA in 1977 included with the results an estimate of the percentage of materials within this building that would be releasable for unrestricted use. This estimate was based on the number of measurements that fell below 5,000 DPA total radioactivity (see Table A-1-1).

The RETA survey included:

- 23 total alpha measurements
- 45 removable alpha measurements
- 128 total beta-gamma measurements
- 130 total gamma measurements

The results of these measurements are summarized in Table A-1-1. Approximately 95% of the measurements of loose surface contamination were at "releasable" levels. RETA found most of the loose contamination in the area of the calciner. However, when fixed as well as removable contamination was considered, only about 50% of the measurements were at "releasable" levels; about 20% were at the "moderately contaminated" level, and 30% at the "highly contaminated" level. Most of the latter were in the calciner area. The first floor of the main building contained much of the remaining contamination. Other contaminated areas were dispersed throughout the building.

A radionuclide analysis of a specimen of surface material showed that over 99% of the activity was due to uranium, and 0.1% was due to thorium. Alpha spectroscopy of a few surface smears confirmed that the primary isotope present in this building is uranium.

The PMC measured only radon and thoron concentrations in this building in 1987. Four samples were collected, two Type F and two Type M. In addition, two air samples were collected to measure radon/thoron daughter concentrations. Results of these measurements are presented in Table A-1-2. These results indicate background concentrations of radon and thoron gas as well as background radon and thoron daughter concentrations. All results are below the Derived Air Concentration (DAC) guidelines.

There has been no documented survey on the concrete pad outside the building. However, PMC personnel have made brief scans which indicate that the pad is contaminated above guidelines for unrestricted use. Further, it is not known whether contamination has seeped beneath the surface of the pad. When the building is demolished and the pad is broken up and removed, samples of the pad can be taken to determine the presence of volumetric contamination. At that time it will be determined whether the total contamination is above the guidelines for unrestricted use.

The RETA survey data were determined to be sufficient for the PMC to conclude that Building 101 is contaminated in excess of current DOE guidelines for unrestricted use. No other measurements are necessary to determine the status of this building.

TABLE A-1-1 Building 101 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	2	2
1500< R <0.1 lbs uranium	8	53	29
5000< R <15000	5	30	22
1000< R <5000	4	39	41
300< R <1000	2	3	22
R <300	4	1	14
TOTAL MEASUREMENTS TAKEN	23	128	130

	REMOVABLE ALPHA
1000< R	3
200< R <1000	6
20< R <200	14
R <20	22
TOTAL MEASUREMENTS TAKEN	45

(a) Source: RETA, 1978
(b) Disintegrations per minute per 100 cm^2

TABLE A-1-2 Building 101 Air Sample Results

Radon Concentration (pCi/L)	Monitor Type
0.2	F
0.3	M
0.3	F
0.3	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
101-1A	0.001	0.002
101-1B	<0.0007	0.002

A-2 AREAS 102A AND B

The Refinery Tank Farm, Area 102, provided facilities for unloading, storing, and transferring liquid process materials required in the refinery operation that were supplied or handled in tank car or tank truck quantities. The tank farm is divided into Area 102A and Area 102B. Other facilities that were installed in this area were unloading docks, transfer pumps, and drum-filling equipment.

Area 102A, located near the north end of the site on the east side of the main site railroad tracks, contained four nitric acid tanks, two 50% caustic soda tanks, one sulfuric acid tank, one hexane tank, and one ether tank. Area 102B was located on the west side of the main site railroad tracks directly across from Area 102A and contained three nitric acid tanks.

The gross ground area covered by Areas 102A and 102B is 9,990 square feet and 2,200 square feet, respectively. There are no buildings in either area. All equipment was located in the open, on concrete saddle pedestals, surrounded by concrete dikes with earth bottoms for the acid tanks and concrete floors for the ether and hexane tanks.

The concrete pedestals and dikes remain. No piping remains; however, much of the scaffolding used to support transfer lines, catwalks, and other equipment is still present. The electric control boxes of the transfer equipment are still in place. Also remaining is a seriously rusted 4,500-gallon tank lying on a concrete pad and a 25,000-gallon steel silo tank on a concrete base (with no dike) (MKF, 1988).

This area was surveyed by groups subcontracted to the DA; results are summarized in the RADCON report. The results

indicated that structures associated with Area 102 had an average fixed alpha activity of 20,000 DPA, well above even the least restrictive uranium release guidelines (DA, 1976).

Neither RETA nor the PMC performed a radiological characterization of the equipment associated with Areas 102A and B. Based on the results reported by RADCON, the PMC has concluded that all remaining equipment contains surface radioactivity levels in excess of the current DOE guidelines and is therefore not releasable for unrestricted use.

A-3 BUILDING 103

This is a structural steel frame building with corrugated aluminum siding and roof, and concrete slab floor. The building is three stories high with outside dimensions of 255 ft x 121 ft and is composed of three major sections, namely the northern digestion section, the middle denitration section and the office section. In the first section, sampled uranium ore concentrates were digested and transferred as a slurry to Building 105 where the solution was purified by solvent extraction. The second section of Building 103 then received the purified uranium nitrate solution and denitrated it to yield uranium trioxide (orange oxide) product. In addition to uranium processing, natural thorium was also processed in the building during the later years of plant operation.

The office area, which is located at the south end of the building, is separated from the remainder of the building by a concrete block wall. The exterior walls of the office area are also constructed of concrete blocks (AEC, 1960).

All of the equipment, electrical circuits, and piping have been removed from the center and south sections, and all of the piping and some of the equipment and floor plate has been removed from the north section. The floor in the southwest corner of the north section was covered with a layer of tar to seal removable material when attempts by the Army to decontaminate that area were unsuccessful. Most of the floor that was successfully decontaminated to AEC guidelines has been removed. The curbings around the floor were not decontaminated (MKF, 1988).

Three radiological surveys have been performed on Building 103: one reported by RADCON, one performed by RETA, and one performed by the PMC.

RADCON summarizes average and maximum fixed, and maximum removable alpha radioactivity results from surveys performed in Building 103 from 1967 to 1972. An average fixed alpha contamination level of 30,000 DPA is reported, which is well above even the least restrictive uranium guidelines (DA, 1976).

A more comprehensive survey was performed by RETA in 1977. The RETA survey included:

- 93 total alpha measurements
- 37 removable alpha measurements
- 130 total beta-gamma measurements
- 84 total gamma measurements

The results of the alpha and beta-gamma measurements are summarized in Table A-3-1.

NaI gamma spectrometry indicated the presence of a substantial amount of thorium in the sumps, but the RETA report did not quantify the amount. RETA had no data to indicate otherwise, so it was assumed that substantial thorium is present in the building, and that it is uniformly dispersed throughout the building, except for the offices, which were assumed to be more lightly contaminated (RETA, 1978).

Assuming natural thorium is the predominant contaminant in this building, 95% of the removable alpha measurements are in the releasable range. However, when all radiation measurements, fixed as well as removable, were considered, about 40% were releasable. About 40% of the measurements fell into the "moderately contaminated" category, and about 20% into the "high contamination" category.

The PMC measured radon, thoron, and radon/thoron daughter concentrations in Building 103 in 1987. Results of these

measurements are given in Table A-3-2. The 6.7 pCi/l concentration found by one Type F sample along with the background concentration found by the corresponding Type M sample indicates above-background thoron concentrations in Building 103. However, these concentrations may be localized since the other Type F/Type M sample pair indicated near-background concentrations of both radon and thoron.

Three of the four thoron daughter measurements and one of the four radon daughter measurements are above background levels. The above-background thoron and thoron daughter concentrations measured by the PMC lend credibility to the RETA findings of Th-232 in Building 103. All radon, thoron, and radon/thoron daughter concentrations measured are below DAC guidelines.

The survey data collected by RETA is sufficient for the PMC to conclude that Building 103 is not releasable for unrestricted use. No more measurements of total surface contamination are needed. However, neither RETA nor the PMC collected bulk samples of debris in Building 103. Bulk samples of debris should be collected before dismantlement is begun in order to identify and quantify the radionuclides present, so that correct release guidelines can be determined in the event that components of Building 103 are decontaminated for unrestricted use.

TABLE A-3-1 Building 103 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA) [b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	2	8
15000 < R <0.1 lbs uranium	7	34	21
5000 < R <15000	7	21	29
1000 < R <5000	19	32	15
300 < R <1000	30	24	1
R <300	30	17	10
TOTAL NUMBER OF MEASUREMENTS	93	130	84

	REMOVABLE ALPHA
1000 < R	0
200 < R <1000	2
20 < R <200	8
R < 20	27
TOTAL NUMBER OF MEASUREMENTS	37

(a) Source: RETA, 1978
(b) Disintegrations per minute per 100 cm^2

TABLE A-3-2 Building 103 Air Sample Results

Radon/Thoron Gas Concentrations	
Radon Concentration (pCi/L)	Monitor Type
0.7	F
0.4	M
6.7	F
0.1	M

Radon/Thoron Daughter Concentrations		
Location	TDC Working Level	RDC Working Level
103-1A	0.05	0.0007
103-1B	0.0005	0.08
103-1C	0.09	0.002
103-1D	0.03	0.001

A-4 BUILDING 104

Building 104 was not mentioned in the Project History and Completion report (AEC, 1960). It is assumed that this building was built after 1956. The following description of Building 104 has been obtained from onsite investigation, old maps and blueprints.

This structure stored and distributed lime for acidity neutralization of raffinate solution. Lime slurry was delivered to raffinate concentrator tanks where the lime was mixed with the raffinate solution. The resultant slurry was transferred to the raffinate storage pits.

This structure consists of three sections stacked on each other. The entire structure rises about 80 feet above grade. The bottom section is a prefabricated steel housing with dimensions of 29 ft x 18 ft x 13 ft high and has a poured concrete floor. The middle section of this structure is a large steel hopper about 30 feet high and about 10 feet in diameter. The hopper has a cone-shaped bottom. A prefabricated steel shed sits above the hopper. The upper shed has dimensions of 15 ft x 15 ft x 20 ft high (MKF, 1988).

Building 104 has been surveyed twice. A few measurements were taken in and around this building by RETA in 1977. The results indicated no substantial levels of radiation (RETA, 1978).

The PMC performed a characterization of this building in 1988. The PMC collected six types of radiation measurements during the characterization:

- 5 bulk samples
- 315 total beta-gamma measurements

- 315 removable alpha measurements
- 1 core sample
- 4 airborne particulate samples
- numerous total beta-gamma scans on structural and equipment items

Five composite bulk samples were collected from the lower shed. Residues from the floor and equipment surfaces were collected and analyzed for isotopic uranium, isotopic thorium, and radium-226. The average concentrations for each radionuclide from the five samples are as follows:

Radionuclide	Concentration (pCi/g-dry)
U-238	80.2 ± 40
U-235	4.12 ± 5.3
U-234	76.2 ± 30
Th-230	5.92 ± 2.8
Ra-226	0.952 ± 1.45
Th-232	2.386 ± 1.34
Th-228	2.9 ± 1.6

The analytical results indicate that natural uranium and natural thorium to be the primary contaminants. Therefore the mixture rule will apply to release of material from this building.

The number of total beta-gamma and removable alpha activity measurements made on the different items is presented in Table A-4-1. The range and average radiation levels are also presented, as well as determination of releasability of the different items based on the PMC key criteria and mixture rule release criteria. Average removable alpha results are not presented in this or any other PMC radiological survey results table. These averages were not calculated because almost all measurements were well below the removable alpha guidelines, and

so did not influence the potential releasability status of the various items.

The PMC was not able to collect measurements on the upper steel shed or inside the hopper. There is no reason to suspect that the trends observed for the lower shed (e.g., horizontal versus vertical surficial contamination levels) would be different in the upper shed.

An inventory of equipment remaining in Building 104 along with associated scanning results is on file with the PMC. Examples of this equipment include electric boxes, pipe and/or conduit, electric motors and incandescent light fixtures. Approximately 40% of the 43 items inventoried are potentially releasable.

Prior to taking a core sample on the floor of the lower shed, the radiation level measured at the sampling location was 45,535 DPA. After a 2 cm core of the floor was removed, the radiation level dropped to less than 540 DPA, the minimum detectable activity (MDA) of the detector. This indicates that the contamination is surficial on the floor, and therefore surface release criteria are applicable.

Results of air samples taken during characterization activities are presented in Table A-4-2. All air samples were analyzed for long-lived alpha activity and all concentrations were found to be below DAC guidelines for U-238.

The large discrepancy between the PMC and RETA survey results is probably due to the fact that the RETA survey was cursory compared to the detailed PMC survey. The PMC results are considered more reliable due to the comprehensive survey performed.

TABLE A-4-1 Building 104 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
South Wall	Total Beta-Gamma	Yes	25	<553	2,007	<852
	Removable Alpha		25	<6	<6	
East Wall	Total Beta-Gamma	Yes	28	<553	658	<560
	Removable Alpha		28	<6	11	
North Wall	Total Beta-Gamma	Yes	28	<553	1,842	<824
	Removable Alpha		28	<6	<6	
West Wall	Total Beta-Gamma	Yes	28	<553	3,191	<1,362
	Removable Alpha		28	<6	7	
Roof, lower section	Total Beta-Gamma	No	15	1,086	10,001	3,972
	Removable Alpha		15	<6	<6	
Interior						
Floor	Total Beta-Gamma	No	30	1,349	43,461	13,847
	Removable Alpha		30	<6	38	
Walls & Ceiling	Total Beta-Gamma	No	30	<568	5,494	<948
	Removable Alpha		30	<6	<6	
Beams	Total Beta-Gamma	No	38	<568	22,602	<4,664
	Removable Alpha		38	<6	<6	

* DPA = Disintegrations per minute per 100 cm^2

TABLE A-4-1 Building 104 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Large tank and large pump	Total Beta-Gamma	No	26	<568	8,620	<1,489
	Removable Alpha		26	<6	<6	
Mixing tank and int. lime slurry	Total Beta-Gamma	Yes	30	<568	2,138	<746
	Removable Alpha		30	<6	<6	
Ext. lime slurry tank	Total Beta-Gamma	No	34	<568	5,790	<1,325
	Removable Alpha		34	<6	<6	

* DPA = Disintegrations per minute per 100 cm^2

TABLE A-4-2 Building 104 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	7.4×10^{-14}
Breathing Zone	$<6.6 \times 10^{-14}$
Breathing Zone	2.5×10^{-13}
Breathing Zone	1.2×10^{-13}

A-5 BUILDING 105

Building 105 was constructed with structural steel and corrugated aluminum siding and is divided into three distinct sections (east, northwest, and southwest) separated by two solid, explosion-proof, cinder-block walls about 90 feet high. It is three stories high with outside dimensions of 182 ft x 102 ft. The building contained equipment for producing a highly purified uranyl nitrate hexahydrate solution including extraction columns, process vessels, evaporators, and tributyl phosphate and hexane reaction tanks (AEC, 1960).

All original equipment, floor plating, and piping have been removed. A coating of tar and sections of plywood cover the floor in parts of the southwest and east sections, to seal removable material when attempts by the Army to decontaminate these areas were unsuccessful. Some sections of the wall, as well as some outside footings, were not successfully decontaminated. The concrete beneath some walkways, and the interior curbing, were not decontaminated. Upon completion of DA decontamination activities, this building still did not meet the unrestricted use release criteria for alpha contamination (Davies, 1969).

Three radiological surveys have been performed in Building 105: one performed by RADCON, one by RETA and one by the PMC.

The RADCON report summary table of alpha radioactivity results obtained from 1967 through 1972 indicates that Building 105 had an average fixed alpha radioactivity of 66,800 DPA and was contaminated to the extent that it is not releasable for unrestricted use (DA, 1976). The RADCON report did not state the total number of measurements collected.

In 1977, RETA surveyed this building. The RETA survey included:

- 8 total alpha measurements
- 8 removable alpha measurements
- 50 total beta-gamma measurements
- 50 total gamma measurements

The results of the alpha and beta-gamma measurements are summarized in Table A-5-1.

NaI gamma spectroscopy of samples from the sumps indicated the presence of much thorium and some radium. However, no estimate on the amount of thorium or radium in the building was given. With this information, RETA concluded that 20 to 40% of the measurements of total radioactivity were at the releasable level, 20 to 60% at the "moderately contaminated" level, and about 20% at the "heavily contaminated" level. All removable alpha measurements in this building were at the "releasable" level.

RETA reports that contamination is uniformly dispersed throughout the east and southeast sections of the building. The northwest section, which was never used during WSUFMP operation, was reported to have relatively lower radiation levels than the rest of the building (RETA, 1978). However, recent inspection by the PMC indicates that this section is contaminated above unrestricted use guidelines. The results of the RETA survey were sufficient for the PMC to conclude that Building 105 is contaminated in excess of DOE guidelines and is not releasable for unrestricted use. No further measurements of surface contamination will be collected before the building is dismantled.

During the PMC survey in 1987 four air samples -- two Type F and two Type M -- were collected to determine the concentrations of radon and thoron gas. Five additional air samples were collected to determine the concentrations of radon and thoron daughters. The results are presented in Table A-5-2.

The Type M samples were at approximately background levels, while the Type F samples were both above background levels, though below DAC guidelines. This indicates the presence of above-background concentrations of thoron gas in Building 105. In addition, all samples for thoron daughter concentrations were above background levels. The thoron and thoron daughter concentrations found by the PMC agree with the RETA findings concerning thorium in the building sumps. The concentrations of radon daughters were all at approximately background level.

Based on the RETA data and observation made by the PMC, the building materials are contaminated above the current DOE guidelines. No bulk samples were collected by RETA or the PMC in order to identify and quantify radionuclides present.

TABLE A-5-1 Building 105 Radiological Survey Results[a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	1	3
15000< R <0.1 lbs uranium	0	13	6
5000< R <15000	1	12	9
1000< R <5000	3	10	18
300< R <1000	2	9	7
R <300	2	5	7
TOTAL NUMBER OF MEASUREMENTS	8	50	50

	REMOVABLE ALPHA
1000< R	0
200< R <1000	0
20< R <200	0
R <20	8

(a) Source: RETA, 1978
(b) Disintegration per minute per 100 cm^2

TABLE A-5-2 Building 105 Air Sample Results

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/L)	Monitor Type
5.1	F
0.2	M
2.5	F
0.4	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
105-1A	0.06	0.001
105-1B	0.07	0.002
105-1C	0.07	0.002
105-1D	0.07	0.002
105-1E	0.05	0.0003

A-6 BUILDING 106

Building 106 is associated with the process sewer system and served as a sampling station for the process stream waste. The process stream wastes contained large quantities of manufacturing wastes including chemicals and radioactive material highly diluted with water.

The sampling station consists of a concrete structure below ground that is covered by a prefabricated steel housing above ground. The steel building is 12 ft x 12 ft x 14 ft high. The below grade structure is 12 ft x 12 ft x 10 ft deep. Both structures contain operations-related equipment (MKF, 1988).

Neither RADCON nor RETA report of surveying Building 106. The PMC performed a radiological survey in 1988 which was to include the typical measurement regime. However, beta-gamma levels of at least 2 to 3 times above background were encountered in all areas of the building which would have interfered with total beta-gamma, core sampling and equipment scanning results. Therefore, these three measurement techniques were not performed on components of this building. One bulk sample was collected, and results of radionuclide analysis performed by the PMC are listed below:

Radionuclide	Activity (pCi/g)
Ra-226	16.6 ± 5.7
U-238	600 ± 88
Ra-228	2,682 ± 11

On the basis of these results, Ra-228 is the predominant radionuclide in Building 106. However, the PMC analysis did not include Th-232, the parent radionuclide of Ra-228. Thorium-228

may be present. If Th-232 concentrations are equal to or greater than Ra-228 concentrations, the less restrictive thorium release guidelines will apply to components of Building 106. Reanalysis of the bulk sample for Th-232 should occur prior to building dismantlement to determine the proper release criteria in the event components of Building 106 are to be considered for unrestricted use.

An inventory of the equipment remaining in Building 106 is on file with the PMC. Thirty items were identified, most of which were associated with the sampling of process waste. All items have been determined to be not releasable for unrestricted use at present.

The PMC collected one air sample during inspection of the below grade structure which was analyzed for radon and thoron daughter concentrations. The concentration of radon daughters was <0.002 WL, and the concentration of thoron daughters was 0.55 WL. Radon daughter concentrations are at background levels, however thoron daughter concentrations are approximately one-half the DAC guidelines. Thorium-232 contamination deposited during thorium ore processing could be the source of high thoron daughter concentrations in the building.

These data are sufficient to conclude that Building 106 is entirely unreleasable for unrestricted use. No further measurements will be taken of surface contamination before the building is dismantled.

A-7 BUILDING 108

This building measures 65 ft x 43 ft and occupies approximately 3,000 square feet. It is a one-story structural steel building with corrugated aluminum siding and has a 20-foot and a 60-foot tower associated with it. It contains equipment for recovery and reconcentration of nitric acid and oxides of nitrogen and also a facility for housing motor controls and compressors (AEC, 1960).

This building has been surveyed three times: one as reported by RADCON, one performed by RETA, and one performed by the PMC.

RADCON reported that Building 108 had an average fixed alpha activity of 200,000 DPA and was contaminated to the extent that it did not meet unrestricted use criteria (DA, 1976). The RADCON report did not specify the number of measurements taken.

In 1977, RETA performed a survey on fixed and removable contamination in this building. The RETA survey included:

- 19 total alpha measurements
- 19 removable alpha measurements
- 33 total beta-gamma measurements
- 38 total gamma measurements

Results of these measurements are summarized in Table A-7-1.

NaI gamma spectroscopy of piping within the building showed that almost all the activity is due to natural thorium, and that it is concentrated within the compressor area. Surface smears showed that about 95% of the contamination is thorium and 5% is radium; no uranium was evident.

Based upon loose surface contamination measurements, approximately 60% of these measurements were at the "releasable" level. However, when all contamination is considered, only about 25% of all the measurements are at the releasable level. About 40% are at the "moderately contaminated" level, and about 30% at the "heavily contaminated" level (RETA, 1978).

From October 1986 through June 1987, the PMC collected three air samples for determination of thoron daughters in this building. All three samples are above background concentrations and one of the samples is almost 1.5 times the DAC guideline for thoron daughters. The high thoron daughter concentrations are most likely due to the abundant natural thorium contamination in the building as evidenced in the RETA survey results. The results of these samples are presented in Table A-7-2.

The data from the RETA survey are sufficient for the PMC to conclude that Building 108 is not releasable for unrestricted use. No further measurements of surface contamination will be taken prior to building dismantlement. However, bulk samples of loose debris should be collected prior to dismantlement in order to identify and quantify radionuclides present so that proper release criteria can be determined in the event that components of Building 108 are decontaminated for unrestricted use.

TABLE A-7-1 Building 108 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA) [b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	2	8
15000< R <0.1 lbs uranium	0	11	14
5000< R <15000	0	9	8
1000< R <5000	2	11	8
300< R <1000	0	0	0
R <300	17	0	0
TOTAL NUMBER OF MEASUREMENTS	19	33	38

	REMOVABLE ALPHA
1000< R	5
200< R <1000	3
20< R <200	6
R <20	5
TOTAL NUMBER OF MEASUREMENTS	19

(a) Source: RETA, 1978
(b) Disintegrations per minute per 100 cm^2

TABLE A-7-2 Building 108 Air Sample Results

Thoron Daughter Concentrations	
Location	TDC Working Level
108-1A	1.46
108-1B	0.37
108-1C	0.08

A-8 BUILDINGS 109 AND 110

Buildings 109 and 110 are roof-only storage sheds. The two sheds are open-sided steel-beam structures with sheet-metal roofs and are positioned on a large poured concrete pad. Each shed has dimensions of approximately 40 ft x 80 ft for a total covered area of approximately 6,400 square feet (MKF, 1988). These sheds were used to shelter drums that contained wet and dry ore concentrates and process residues from the weather.

These sheds have been surveyed twice: once as reported in RADCON and once by the PMC.

RADCON reported that the maximum fixed alpha radioactivity found on Buildings 109 and 110 were 1,400 and 35,000 DPA respectively. The locations and number of measurements were not given. The report stated that the average fixed alpha radioactivity was not given due to insufficient data.

The PMC performed a characterization of these buildings in 1988, collecting three types of radiation measurements:

- 268 total beta-gamma measurements
- 268 removable alpha measurements
- 1 core sample

Alpha and beta-gamma measurement results as well as determination of potential releasability based on the assumption of natural uranium contamination and on application of the PMC key criteria are summarized in Table A-8-1. Natural uranium was assumed to be the predominant contaminant here since this area was used during WSUFMP operations for storage of drums containing uranium ore concentrates. However, no bulk samples were taken to identify types and quantities of radionuclides present. A bulk sample should be taken and if results show

either radium or thorium to be the predominant contaminant, the more restrictive unrestricted use release criteria will be applied to these buildings in the determination of potential releasability.

A core sample was taken on the concrete floor. The radiation level measured at the undusted sample location was 7,910 DPA. After core removal the radiation level on the freshly exposed surface was 735 DPA, which is above the MDA of the detector and indicates that contamination has seeped into the pad. Therefore, the pad is volumetrically contaminated and unrestricted use surface release criteria do not apply.

TABLE A-8-1 Buildings 109 & 110 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
Roof	Total Beta-Gamma	Yes	30	<540	1,453	<919
Interior						
Ceiling	Total Beta-Gamma	Yes	30	<540	727	<553
Floor (pad)	Total Beta-Gamma	No	28	934	7,543	2,774
Columns	Total Beta-Gamma	Yes	30	<540	2,526	<623
Beams	Total Beta-Gamma	No	30	<540	8,892	3,440
Gutters	Total Beta-Gamma	No	30	554	39,755	4,409
Fire Boxes	Total Beta-Gamma	Yes	30	<540	4,913	1,328
Fire Boxes	Total Beta-Gamma	Yes	30	<540	3,322	<651
Fire Boxes	Total Beta-Gamma	Yes	30	<540	2,803	<724

* Disintegrations per minute per 100 cm^2

A-9 BUILDING 201

Building 201 is a multi-story structural steel and cinder-block building with corrugated asbestos and cinder-block walls. The building is divided into a warehouse area, a repair area, and office area, and a production area with a high ceiling. The building is 193 ft x 175 ft containing approximately 69,600 square feet of gross floor area. It contains equipment for the conversion of uranium trioxide to uranium tetrafluoride including reduction and hydrofluorination reactors, blending and packaging equipment, ammonia cracking and inert gas generating facilities; pilot, rerun, and reverter reactors; vaporization, dust collection, and waste recovery systems (AEC, 1960). Most of the equipment used during WSUFMP operation remains in the building.

Building 201 has been surveyed four times: once as reported in RADCON, once by RETA, once by BNI, and once by the PMC.

RADCON reported average and maximum fixed alpha activities of 3,000 and 7,000 DPA respectively, and uranium removable alpha activity of 2,800 DPA. RADCON concluded that Building 201 is contaminated to the extent that it is not releasable for unrestricted use (DA, 1976). The locations and number of measurements obtained were not stated in the report.

The RETA survey, performed in 1977, included:

- 38 total alpha measurements
- 51 removable alpha measurements
- 95 total beta-gamma measurements
- 104 total gamma measurements

The results of these measurements are summarized in Table A-9-1.

TABLE A-9-1 Building 201 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	7	2
15000< R <0.1 lbs uranium	9	42	25
5000< R <15000	8	3	22
1000< R <5000	13	17	25
300< R <1000	8	14	24
R <300	0	12	6
TOTAL NUMBER OF MEASUREMENTS	38	95	104

	REMOVABLE ALPHA
1000 < R	4
200< R <1000	17
20< R <200	28
R <20	2
TOTAL NUMBER OF MEASUREMENTS	51

(a) Source: RETA, 1978
(b) Disintegrations per minute 100 cm^2

All but two removable activity measurements analyzed by alpha spectroscopy indicated the presence of uranium only. The other two measurements, both taken in the warehouse area, indicated the presence of about 25% thorium and 10% radium. RETA reported that about 90% of the measurements on loose surface contamination were at the releasable level assuming only uranium contamination. However, when all measurements are considered and the presence of radium is taken into account, only about 30% were at the releasable level, 40% were at the "moderately contaminated" level, and 30% were at the "heavily contaminated" level.

BNI performed a survey of Building 201 in 1986. Gamma-ray spectrometry analyses of four scale and residue samples identified U-238 as the principal radionculide present so measurement results were compared to uranium release guidelines (BNI, 1986).

Results of the radiological survey by BNI are summarized as follows: 1) Airborne concentrations of long-lived alpha activity ranged from 1E-13 to 1E-12 µCi/ml in the general work area, and from 6E-12 to 2E-11 µCi/ml in the breathing zone; 2) gamma-ray exposure rates 1 meter above the floor ranged from 6 to 175 µR/h; 3) transferable alpha and beta activity on structure surfaces ranged from <5 to 12,000 and <5 to 28,000 dpm/100 cm^2 respectively; 4) directly measured alpha radiation on building surfaces ranged from 34 to 131,107 DPA; and 5) directly measured beta-gamma dose rates on building surfaces ranged from 0.02 to 50 mrad/h. Concentrations of radon daughters and thoron daughters were each less than 0.02 WL.

Fifty-four swipe samples were taken on the warehouse floor and analyzed for transferable alpha activity; analyses indicated all samples to be below removable alpha guidelines. Seventy percent of the 212 total alpha measurements taken on the

warehouse floor were below uranium release guidelines. Walls and ceilings of the warehouse area were not surveyed.

In the production area, 98% of the 243 transferable alpha activity measurements taken on the floor were below removable uranium release guidelines. However, only 12% of the total alpha activity measurements taken on the floor were below the applicable guidelines. Walls and ceilings in the production area were not surveyed.

Within the maintenance and service areas, all 166 transferable alpha activity measurements and only 18% of the 560 direct alpha measurements taken on the floor were below the applicable uranium release guidelines. Only a small fraction of the total wall and ceiling surface for these areas was surveyed; therefore, no definite statements can be made about the surface radioactivity with respect to guideline values.

A total of 525 transferable and 759 total alpha activity measurements were taken on the floors, walls, and ceilings of the office area. All measurement results were below the applicable uranium release guidelines.

Results of samples taken in the four areas of Building 201 indicate that the floors of the production, service and maintenance areas are not releasable, while the floor of the warehouse and the floors, walls, and ceilings of the office area may be releasable for unrestricted use. However, the warehouse and office areas are structurally linked to the contaminated areas, and it would be impractical to separate these sections from the rest of the building.

In 1987, the PMC collected air samples in order to determine radon, thoron, and radon/thoron daughter concentrations in Building 201. Two Type F, two Type M and four

radon/thoron daughter measurements were made, results of which are presented in Table A-9-2. Both Type M samples were at approximately background levels, as was one Type F sample. The other Type F sample was above background but below the DAC guidelines, indicating the presence of above-background thoron concentrations. All radon/thoron working level measurements were approximately at background levels. The detection of above-background thoron concentrations without corresponding above-background thoron daughter concentrations indicates the possibility of localized areas of above-background thoron concentrations existing in Building 201. The source of these concentrations is currently unknown. The small amount of thorium activity found on the two swipes taken by RETA would not seem to indicate an abundance of thorium in this building. Also, available historical information does not indicate that thorium ore processing occurred here. Additional bulk samples should be obtained to resolve the discrepancy and to determine the proper unrestricted use release criteria in the event that components of Building 201 are decontaminated for unrestricted use.

The PMC believes that the results of the three previous surveys provided adequate information to conclude that Building 201 is presently not releasable for unrestricted use.

TABLE A-9-2 Building 201 Air Sample Results

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/L)	Monitor Type
3.8	F
0.2	M
0.3	F
0.3	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
201-1A	0.0009	0.003
201-1B	0.0	0.002
201-1C	0.004	*
201-1D	0.005	0.001

* Not analyzed for radon

A-10 BUILDING 202

Building 202 provided for tank car unloading and storage of hydrofluoric acid and ammonia and is divided into three sections: the anhydrous hydrofluoric acid section, the 70 percent hydrofluoric acid section, and the anhydrous ammonia section. This is a 3,000-square-foot building constructed of a structural steel frame with asbestos-cement wall panels and a poured gypsum roof. Equipment remaining in this building includes eight large carbon steel tanks, beam scales, pumps and piping (MKF, 1988).

Two radiological surveys have been performed on this building: one performed by RETA and the other by the PMC.

RETA surveyed this building in 1977. The RETA survey included:

- 23 total alpha measurements
- 6 removable alpha measurements
- 23 total beta-gamma measurements
- 4 total gamma measurements

Approximately 95% of all measurements fell into the "releasable" range, assuming uranium is the predominant contaminant. However, no data is provided to support the assumption of uranium contamination only (RETA, 1978).

The PMC surveyed Building 202 in 1988, and obtained three types of radiation measurements during the characterization:

- 792 total beta-gamma measurements
- 1 airborne particulate sample
- 793 removable alpha measurements

The radiological measurements are summarized in Table A-10-1. The maximum, minimum, and average radiation measurements are given. Also, the releasable items are indicated as determined by the PMC. Since bulk sample results are not available, determination of releasability was based on natural uranium release criteria. Bulk samples will be taken prior to building dismantlement to identify and quantify radionculides present.

As has been the case in most site buildings the horizontal surfaces tend to have higher total beta-gamma levels than vertical surfaces. This is true for both the interior and the exterior.

An inventory of the equipment remaining in Building 202 is on file with the PMC. None of this equipment has been surveyed, and therefore it is presently considered not releasable for unrestricted use.

No core samples were taken due to the presence of a steel plate covering the floor surface. Because of this, it is not yet known if the floor is volumetrically contaminated and so it is not presently considered releasable.

One breathing zone sample was obtained during the PMC characterization. The sample was analyzed for long-lived alpha activity, results of which were 2.5×10^{-12} µCi/ml. This is below the DAC guidelines for natural uranium.

The RETA report states that this building is probably releasable, while the PMC survey results indicate that many building components are presently not releasable for unrestricted use, assuming natural uranium is the predominant contaminant. This discrepancy is probably due to the comprehensiveness of the PMC survey as compared to RETA.

TABLE A-10-1 Building 202 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total beta-gamma	Yes	30	<553	1,908	<702
	Removable alpha		30	<2.5	3	
West Wall	Total beta-gamma	No	30	<553	9,771	1,398
	Removable alpha		30	<2.5	3	
East Wall	Total beta-gamma	No	30	<553	6,054	2,320
	Removable alpha		30	<2.5	10	
South Wall	Total beta-gamma	No	30	<553	7,863	2,133
	Removable alpha		30	<2.5	17	
Exterior Roof	Total beta-gamma	No	30	<553	8,324	2,673
	Removable alpha		30	<2.5	7	
Interior						
Walls/Ceiling	Total beta-gamma	Yes	30	<513	592	<516
	Removable alpha		30	<2.5	7	
Tanks	Total beta-gamma	Yes	30	<513	1,086	<569
	Removable alpha		30	<6	17	
Piping	Total beta-gamma	Yes	30	<513	2,336	<672
	Removable alpha		30	<2.5	17	
Beams	Total beta-gamma	No	34	<513	29,807	3,264
	Removable alpha		34	<2.5	27	
Columns	Total beta-gamma	Yes	26	<481	1,256	<530
	Removable alpha		26	<2.5	7	
Steel Liner	Total beta-gamma	Yes	30	<481	3,439	1,232
Lowest Beam	Removable alpha		30	<2.5	7	
Penthouse	Total beta-gamma	No	30	<513	6,218	<929
Walls/Ceiling	Removable alpha		30	<2.5	50	
Penthouse	Total beta-gamma	Yes	30	14,838	48,429	26,678
Floor	Removable alpha		30	<2.5	20	
Compressor House	Total beta-gamma	No	30	<513	592	<517
Walls/Ceiling	Removable alpha		30	<2.5	6	
Compressor House	Total beta-gamma	Yes	30	1,415	7,041	3,460
Floor	Removable alpha		30	<2.5	10	

TABLE A-10-1 Building 202 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
Curbs & Dikes	Total beta-gamma	No	30	559	12,996	2,771
	Removable alpha		30	<2.5	<2.5	
70% Tanks	Total beta-gamma	No	30	<513	33,354	3,679
	Removable alpha		30	<2.5	25	
Stairways	Total beta-gamma	No	30	790	220,000	36,667
	Removable alpha		30	<2.5	7	
Walkway/Piping+	Total beta-gamma	Yes	30	<540	4,740	1,704
	Removable alpha		30	<2.5	10	
201/202 Walkway	Total beta-gamma	No	30	<540	62,349	<5,518
	Removable alpha		30	<2.5	7	
Handrails	Total beta-gamma	Yes	31	<513	1,513	<763
	Removable alpha		32	<2.5	13	
Piping Sides	Total beta-gamma	Yes	50	<540	2,837	<625
	Removable alpha		50	<2.5	33	
Piping Tops	Total beta-gamma	Yes	111	<540	4,290	823
	Removable alpha		111	<2.5	7	

+ Walkway, piping and associated equipment have been dismantled as of March 1989.

* Disintegrations per minute per 100 cm^2

A-11 BUILDING 301

Building 301 has a gross floor area of 68,000 square feet and a gross volume of 2,760,000 cubic feet. It is a one-story steel frame building of mill construction with corrugated transite siding and a flat roof deck of gypsum concrete with built-up roofing. The office areas are enclosed by concrete block construction. The building housed equipment used to convert uranium tetrafluoride (UF_4) to metal. The conversion is accomplished by a batch process involving a thermite-type reduction of the uranium tetrafluoride with magnesium to uranium metal (AEC, 1960). Much of the original equipment remains in place along with equipment gathered from other buildings and stored here during previous decontamination efforts.

Four radiological surveys were performed in Building 301: one reported by RADCON, one by RETA, one by BNI and one by the PMC.

Radiological surveys performed between 1967 and 1972 and summarized by RADCON indicate that Building 301 had an average fixed alpha radioactivity of 40,000 DPA and does not meet criteria for release to the public. The report does not specify the number and locations of the survey measurements.

The RETA survey, performed in 1977, included:

42 removable alpha measurements
21 total alpha measurements
95 total beta-gamma measurements
121 total gamma measurements

The results of these measurements are summarized in Table A-11-1.

NaI gamma spectroscopy revealed the presence of thorium activity in several areas. However, no data is presented to quantify the amount of thorium present. Seven of eight loose surface contamination samples analyzed by alpha spectroscopy indicated uranium contamination only, while in the other samples 5% of the total activity was due to thorium.

Assuming uranium to be the predominant contaminant in this building, approximately 95% of the loose surface contamination measurements were at the "releasable" level. Approximately 60% of all the measurements (total and loose) were at this level. Approximately 20% of all measurements fell into the "moderately contaminated" range, and approximately 20% into the "highly contaminated" range.

RETA reports that breathing zone air samples were collected that indicated elevated levels of airborne radioactivity; the concentrations were reported to be a substantial fraction of the Maximum Permissible Concentration (MPC) for the mixture of radionuclides, principally thoron daughters. However, the report provides no data on the results of these samples.

BNI surveyed Building 301 in 1986. Relevant results of the BNI survey are summarized as follows: 1) general work area airborne concentrations of long-lived gross alpha activity ranged from 8E-14 to 6E-13 µCi/ml; 2) breathing zone airborne activity ranged from 2E-12 to 9E-12 µCi/ml; 3) gamma ray exposure rates 1 meter above the floor ranged from 6 to 355 µR/h; 4) transferable alpha and beta radioactivity on structure surfaces ranged from <5 to 770 dpm/100 cm^2 and <5 to 1000 dpm/100 cm^2 respectively; 5) directly measured alpha radiation on surfaces ranged from <144 to 43,000 dpm/100 cm^2; and 6) directly measured beta-gamma dose rates ranged from 0.02 to 12 mrad/h. Radon daughter and thoron daughter concentrations ranged from <0.01 to 0.02 WL and 0.04 to 0.1 WL respectively.

Samples of residue and scale were collected from four areas that exhibited elevated surface radiation readings. Results of the analysis of these samples revealed that U-238 was the predominant radionuclide with concentrations ranging up to 120,000 pCi/g. The concentration of Th-232 ranged from 20 to 560 pCi/g. Because the Th-232 concentrations were much lower than those of uranium, BNI compared surface radioactivity levels to the DOE guidelines for uranium.

The main plant walls, the ceiling, and the upper floors were not surveyed. Results of the 52 transferable radioactivity measurements made on the lower floor and inside partition walls were all below alpha and beta guidelines. Regarding the 133 direct alpha radiation measurements, 108 were greater than DOE unrestricted use guidelines. In regard to beta/gamma dose rate, only three of 133 measurements were below guidelines. Approximately one-half of the 172 gamma-ray exposure rate measurements were greater than guidelines.

In the office area, all measurements of direct and transferable radioactivity on the floor, walls, and ceiling of the first level were below guidelines. All gamma-ray exposure rate measurements were below guidelines. No measurements were made on the second level of the office area.

The results of the RETA and the BNI surveys were considered adequate to characterize the total surface contamination in Building 301, so the PMC did not make any more measurements of surface radioactivity. However, the PMC did collect air samples: two Terradex Type F samples, two Terradex Type M samples, and four samples each to determine radon and thoron daughter concentrations. The results are given in Table A-11-2.

One Type M sample was below detector limits. The other Type M sample and one of the Type F samples were slightly above

background, and the other Type F sample was significantly above background, though below DAC guidelines.

The radon daughter samples were at background, as were two of the thoron daughter samples. However, of the other two thoron daughter samples, one was slightly above background, and one was significantly above background, though below the DAC guidelines.

The source of above-background thoron and thoron daughter concentrations may be the thorium activity identified by the RETA NaI gamma spectroscopy survey. The presence of natural thorium is probably a result of densification (high firing) of thorium oxides in crucibles from Building 103 and the packaging of thorium oxide for shipment.

Core samples were not collected by RETA, BNI, or PMC. Core samples should be taken on the lower floor in order to determine if it is volumetrically contaminated.

The results of all previous radiological measurements in Building 301 indicate that the structure and materials within this building are radiologically contaminated in excess of the DOE residual contamination guidelines and cannot be released for unrestricted use. Additional data on total surface contamination are not needed.

TABLE A-11-1 Building 301 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	11	2
15000< R <0.1 lbs uranium	0	24	20
5000< R <15000	8	18	32
1000< R <5000	9	34	45
300< R <1000	2	8	16
R <300	2	0	6
TOTAL NUMBER OF MEASUREMENTS	21	95	121

	REMOVABLE ALPHA
1000 ≤ R	1
200< R <1000	18
20< R <200	23
R <20	0
TOTAL NUMBER OF MEASUREMENTS	42

(a) Source: RETA, 1978

(b) Disintegrations per minute per 100 cm^2

TABLE A-11-2 Building 301 Air Sample Results

Radon/Thoron Gas Concentrations

Concentration (pCi/l)	Monitor Type
0.8	M
0.9	F
<detection limit	M
2.7	F

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
301-1A	0.07	<detection limits
301-1C	0.32	not measured
301-1D	0.01	0.001
301-1E	0.005	0.001

A-12 BUILDING 302

Building 302, the Magnesium Building, served as an auxiliary facility to Building 301. The building encloses 6,000 square feet of floor space and is constructed of a steel frame with concrete block walls and poured concrete floors. The building provided facilities for storing magnesium which was used in the conversion of UF_4 to uranium metal.

Three radiological surveys have been performed in Building 302. The first survey, conducted between 1967 and 1972 and reported by RADCON in 1976, indicated that Building 302 was within unrestricted use release limits. No indication was given as to number of measurements taken or measurement results.

RETA surveyed Building 302 in 1977. The RETA survey included:

7 total alpha measurements
24 removable alpha measurements
25 total beta-gamma measurements
26 total gamma measurements

The RETA survey indicated that approximately 90% of the measurements are at the "releasable" level assuming uranium and Th-232 to be the only sources of radioactivity. However, no analyses were performed to determine the identity of radionuclides present. The process area appears to be moderately contaminated, with measurements on the rest of the building at the "releasable" level (RETA, 1978).

The PMC surveyed Building 302 in 1988. The PMC obtained eight types of measurements during the 1988 characterization:

- 5 bulk samples
- 800 total beta-gamma measurements
- 792 removable alpha measurements
- 1 core sample
- 6 airborne particulate samples
- 4 radon/thoron gas samples
- 2 radon/thoron daughter samples
- numerous total beta-gamma scans on structural elements and equipment

Five composite bulk samples were collected from interior floors and horizontal surfaces and analyzed for isotopic uranium, isotopic thorium and Ra-226. The average concentration for each radionuclide from the five samples is as follows:

Radionuclides	Concentration (pCi/g-dry)
U-238	225.4 ± 64.3
U-235	12.9 ± 3.9
U-234	284.0 ± 71
Th-232	1.2 ± 1.3
Th-230	16.2 ± 4.6
Th-228	1.2 ± 0.6
Ra-226	2.2 ± 0.9

Based on these results the PMC concluded that natural uranium was the predominant contaminant in this building. Alpha and beta-gamma measurement results as well as determination of potential releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-12-1.

An inventory of the equipment remaining in Building 302 is on file with the PMC. Most of the equipment that was scanned was found to be below natural uranium release guidelines. However, much of the remaining equipment was not scanned and

this equipment will not be considered releasable for unrestricted use until a 100% scanning survey is performed.

A core sample was taken on the floor in an area where contamination exceeded release criteria. Prior to taking the core, local dust was removed and the total beta-gamma activity measurement yielded 7,490 DPA. The radiation level on the concrete was approximately background at 2 cm below the surface, indicating that the floor is surficially contaminated and therefore surface release criteria are applicable.

The PMC collected samples for radon, thoron, and radon/thoron daughter concentrations during characterization efforts in 1986, 1987, and 1988. Two Type F and two Type M samples were taken to determine radon and thoron gas concentrations. Four samples were taken to determine radon/thoron daughter concentrations. Five breathing zone and one area sample were taken to determine long-lived alpha activity from airborne particulates. Results of all air samples collected in Building 302 are presented in Table A-12-2.

All six long-lived alpha air particulate samples were below DAC guidelines for U-238. The radon daughter concentrations were all at approximately background concentrations, while thoron daughter concentrations were below the minimum detectable activity of the detector. Both Type M samples and one Type F sample were at background levels; the other Type F sample was above background, indicating the presence of above-background thoron concentrations in some areas of this building. However, the elevated concentrations of thoron are not supported by the results of bulk samples collected by the PMC which revealed background concentrations of Th-232. Neither the RETA nor the BNI survey reported significant amounts of thorium in this building. Additional air samples which should resolve this

discrepancy will be collected prior to dismantlement of the building.

The surveys conducted in this building have produced enough data to characterize the surface contamination in Building 302. No further measurements on surface contamination will be collected prior to dismantlement to determine the status of this building.

TABLE A-12-1 Building 302 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Exterior						
East Wall	Total Beta-Gamma	Yes	30	<568	2,318	1,098
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<568	2,402	<953
	Removable Alpha		30	<6	<6	
North Wall	Total Beta-Gamma	Yes	40	<540	2,234	<854
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<574	2,353	<1,410
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	30	<574	934	<577
	Removable Alpha		30	<6	<6	
Stairs	Total Beta-Gamma	Yes	37	<574	3,979	1,055
	Removable Alpha		37	<6	12	
Handrails	Total Beta-Gamma	Yes	30	<574	727	<577
	Removable Alpha		30	<6	<6	
Asphalt Drive	Total Beta-Gamma	No	30	761	15,778	2,986
	Removable Alpha		30	<6	<6	
East/West Docks	Total Beta-Gamma	No	30	<574	23,597	<3,407
	Removable Alpha		30	<6	9	
Warehouse/Process Rooms: Floor	Total Beta-Gamma	No	30	<553	8,554	2,426
	Removable Alpha		30	<6	11	
Process Room: Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	623	<553
	Removable Alpha		30	<6	7	

* Disintegrations per minute per 100 cm^2

TABLE A-12-1 Building 302 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Warehouse: Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,211	<546
	Removable Alpha		30	<6	7	
Structural Columns	Total Beta-Gamma	Yes	30	<513	<553	<542
	Removable Alpha		30	<6	<6	
Structural Beams	Total Beta-Gamma	Yes	30	<513	2,699	1,228
	Removable Alpha		30	<6	9	
Interior Conduit/ Piping	Total Beta-Gamma	Yes	30	<540	2,906	<989
	Removable Alpha		30	<5	17	
Interior Hoist Beams	Total Beta-Gamma	No	30	<513	8,587	<2,425
	Removable Alpha		30	<6	49	
Columns, Magnetic Separator	Total Beta-Gamma	Yes	53	<540	1,020	<556
	Removable Alpha		53	<6	9	
Magnetic Separator Beams	Total Beta-Gamma	No	32	<553	6,284	<2,906
	Removable Alpha		32	<6	13	
Process Room Canisters	Total Beta-Gamma	No	30	<540	67,193	<10,200
	Removable Alpha		30	<5	14	
Hopper/Scrubber	Total Beta-Gamma	No	30	<553	8,357	<1,748
	Removable Alpha		30	<6	14	
Exterior Roof Vents	Total Beta-Gamma	Yes	30	<540	1,522	<625
	Removable Alpha		30	<6	7	

* Disintegrations per minute per 100 cm^2

TABLE A-12-1 Building 302 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Exterior HVAC +	Total Beta-Gamma	Yes	10	<540	623	<611
	Removable Alpha		10	<6	14	
Interior Floor Battery & Restroom	Total Beta-Gamma	No	30	987	32,143	13,128
	Removable Alpha		30	<6	14	
Interior Walls and Ceiling	Total Beta-Gamma	Yes	30	<553	<553	<553
	Removable Alpha		30	<6	7	
Interior Large Cartridges	Total Beta-Gamma	No	30	<540	52,142	<13,418
	Removable Alpha		30	<5	32	
Interior Piping	Total Beta-Gamma	Yes	30	<553	9,212	<2,136
	Removable Alpha		30	<5	11	

\+ Interior is inaccessible and is considered unreleasable until interior measurements can be performed.
* Disintegrations per minute per 100 cm^2

TABLE A-12-2 Building 302 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Area	1.7×10^{-13}
Breathing Zone	$<1.0 \times 10^{-13}$
Breathing Zone	1.3×10^{-13}
Breathing Zone	$<9.7 \times 10^{-14}$
Breathing Zone	9.6×10^{-13}
Breathing Zone	1.7×10^{-13}

Radon/Thoron Gas Concentrations

Concentration (pCi/l)	Monitor Type
0.5	F
0.3	M
1.0	F
0.4	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
302-1A	<0.0003	0.003
302-1B	<0.0005	0.001

A-13 BUILDING 403

Building 403 is a rigid frame, welded design, mill-type structure, having a gross building area of 17,800 square feet. It was designed to house pilot plant equipment for testing modifications to processes carried out in the digestion, extraction, and denitration areas of the operating plant. A fire wall separates this building into distinct north and south sections (AEC, 1960). At some time during the operation of the plant the building was renamed the Scrap Plant. The facility may then have been used to process scrap materials for the recovery of uranium and return of a uranium-bearing solution to Building 103.

In the last few years of the operation of this plant, there was an increased interest in the production of natural thorium (Th-232). Many of the facilities in Building 403 formerly used for uranium production were converted for thorium production. A several-hundred-gallon stainless steel tank known as the salt bath is located in the north section and contains an unknown quantity of thorium nitrate most likely associated with thorium processing. The building was partially cleaned and decontaminated by removing visible contamination; then the plant was shut down. The only section of the building that has not been partially decontaminated is the stack and the attached blower (MKF, 1988).

Building 403 has been surveyed by RETA, BNI and the PMC. The first survey was performed by RETA in 1977 and included:

- 48 removable alpha measurements
- 27 total alpha measurements
- 137 total beta-gamma measurements
- 138 total gamma measurements

The results of these radiation measurements are summarized in Table A-13-1.

Eight samples of loose contamination were collected and analyzed by alpha spectroscopy in order to determine the isotope(s) present. Six of the samples were collected in the north section and the average relative activities of uranium, thorium, and radium were 95%, 1%, and 4% respectively. The two other samples were collected in the south section and analysis showed all activity was due to uranium.

RETA reported that approximately 80% of the removable alpha activity measurements were in the "releasable" range, and approximately 75% of all measurements were in the "moderately" or "heavily contaminated" range with the heavy contamination located mostly in the north section of the building. These percentages were reported to take into account the uranium, thorium, and radium activity ratio found, but it is not clear how RETA used this ratio to determine the percentage. If uranium (the predominant contaminant) release guidelines are applied to the measurement results reported by RETA, approximately 94% of removable alpha and 23% of total measurements are in the releasable range.

The RETA survey reported that Building 403 had the highest average level of airborne radioactivity of any building on site, and that this average was a substantial fraction of the MPC for a mixture of uranium, thorium, and radium. However, the RETA report did not provide data to support this claim.

The second survey was performed by BNI in March 1986 (BNI, 1986). These are the general results of the BNI survey:

1. General work area monitoring of long-lived gross alpha activity:

1×10^{-13} to 1×10^{-11} µCi/ml

2. Breathing zone air monitoring of long-lived gross alpha activity:
   5×10^{-12} to 6×10^{-11} µCi/ml
3. Gamma-ray exposure rates 1 meter above the building floor ranged from 15 to 694 µR/hr
4. Transferable alpha and beta activity on structure surfaces ranged from <11 to 8,900 dpm/100 cm^2
5. Directly measured beta-gamma dose rates on building surfaces ranged from 0.02 to 30 mrad/hr
6. Radiation measurements on 113 identified pieces of equipment revealed that most of these were contaminated in excess of DOE guidelines.

BNI analyzed bulk samples of surface residue and debris by spectrometry and found that the principal radionuclide was U-238, but that significant quantities of Th-232 were also present. For this reason, and because the thoron concentration in one section of the building exceeded DOE limits, guidelines for natural thorium were applied to this building by BNI.

BNI personnel wrapped the salt bath in polyethylene in an attempt to decrease the thoron concentration in the north section of Building 403. After this action, the thoron concentration did decrease but still exceeded DOE limits. Table A-13-2 summarizes the results of BNI's radiation measurements in Building 403 as compared to the DOE unrestricted use guidelines for natural thorium.

The third survey was performed by the PMC in 1987. Two Type F and two Type M samples were taken to determine the concentrations of radon and thoron gas, and twelve more samples were taken to determine the concentrations of thoron daughters. One sample was also analyzed for radon daughters. The data are presented in Table A-13-3.

All of the thoron daughter measurements exceeded background levels, and two measurements exceeded the DAC guidelines. One of the high readings was taken by the salt bath; the location of the other was not identified. Only one sample was analyzed for radon daughter concentrations because radon daughters were not expected. As expected, a background concentration of radon daughters was detected.

The two Type M samples are at approximately background concentrations while the two Type F samples are well above background with one sample exceeding DAC guidelines. This indicates the presence of relatively high concentrations of thoron gas in Building 403. The source of high thoron gas and thoron daughter concentrations in this building is probably the high Th-232 concentrations detected by BNI in both the thorium salt bath and throughout the building.

The results of the previous surveys are sufficient for the PMC to conclude that Building 403 is radiologically contaminated in excess of the DOE residual contamination criteria, and the entire building, as well as most if not all of the equipment in it is not releasable for unrestricted use. No further measurements of surface radioactivity are required prior to dismantlement.

Both BNI and RETA found that uranium was the predominant radionuclide in Building 403. RETA reported finding radium in this building, while BNI did not. BNI found significant quantities of thorium; RETA found some thorium but did not say whether it was a significant amount or not. For these reasons additional bulk samples of surface residues should be collected and analyzed prior to building dismantlement in order to clear up these discrepancies.

TABLE A-13-1 Building 403 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	28	36
15000< R 0.1 lbs uranium	0	78	75
5000< R <15000	2	20	26
1000< R <5000	12	9	1
300< R <1000	4	2	0
R <300	6	0	0
TOTAL NUMBER OF MEASUREMENTS	27	137	138

	REMOVABLE ALPHA
1000< R	3
200< R <1000	6
20< R <200	33
R <20	6
TOTAL NUMBER OF MEASUREMENTS	48

(a) Source: RETA, 1978
(b) Disintegrations per minute per 100 cm^2

TABLE A-13-2 BUILDING 403 Radiological Survey Results[a]

NORTH SECTION RADIATION MEASUREMENTS

Number of Measurements	Type	Number Exceeding Guidelines For Alpha	Number Exceeding Guidelines For Beta-Gamma
98	Floor Swipe	31	31
206	Wall and Ceiling Swipe	4	4
356	Direct Floor	311	326
230	Direct Wall and Ceiling	41	60

Radon daughter concentration in non-office area 0.1 WL
Thoron daughter concentration in non-office area 2 WL

SOUTH SECTION RADIATION MEASUREMENTS

Number of Measurements	Type	Number Exceeding Guidelines For Alpha	Number Exceeding Guidelines For Beta-Gamma
55	Floor Swipe	1	1
78	Wall & Ceiling Swipe	1	1
143	Direct Floor Measurements	83	124
89	Direct Wall & Ceiling Measurements	14	24

Radon daughter concentration <0.01 WL
Thoron daughter concentration <0.06 WL

(a) Source: BNI, 1986

Table A-13-3 Building 403 Air Sample Results

Radon/Thoron Gas Concentrations

Radon Exposure (pCi/L)	Monitor Type
5.5	F
0.1	M
23.6	F
0.1	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
403/103-1A	2.1	*
403/103-1B	0.6	*
403/101102-1C	0.09	*
403/103-1d	0.06	*
403/103-1E	2.5	*
403/103-1F	0.32	*
403/103-1G	0.24	*
403/103-1I	0.7	*
403/103 - UNC	0.09	*
403/103 - 1J	0.11	*
WS-160	0.24	*
403/103-1L	0.27	0.001

* Not measured

A-14 BUILDING 404

The Metals Pilot Plant (Building 404) houses the metallurgical pilot plant and includes other equipment such as blenders, jolters, breakout equipment, reduction furnaces, vacuum casting equipment, a small ceramics laboratory, and a large-scale dingot furnace. This building is a high bay, single-story building containing approximately 12,400 square feet of gross floor area. The building provided facilities for metal processing studies, ceramic work, metal testing, and miscellaneous short- and long-range development projects.

Three radiological surveys have been performed on this building: one performed by RETA, one by BNI, and one by the PMC.

RETA performed a radiological survey of this building in 1977. The RETA survey included:

- 35 total alpha measurements
- 23 removable alpha measurements
- 85 total beta-gamma measurements
- 97 total gamma measurements

The results of these measurements are summarized in Table A-14-1.

Two loose surface contamination samples were analyzed for alpha activity, and only uranium activity was found. However, NaI gamma spectroscopy indicated the presence of Th-232 in the ductwork.

RETA compared all results to uranium release guidelines and reported that about 90% of the loose surface contamination measurements were in the "releasable" range. However, only about 50% of total radioactivity measurements were in this range. About 15% of the measurements were in the "moderately

contaminated" range, and the remaining 35% were in the "highly contaminated" range. The report also states that contamination was more or less uniformly dispersed throughout the building.

In March of 1986, BNI performed the second survey. The results were:

1. Concentrations of airborne radioactivity in the breathing zone samples ranged from 7×10^{-13} to 6×10^{-12} µCi/ml.

2. Gamma-ray exposure rates 1 meter above the floor in Building 404 ranged from 6 to 94 µR/hr.

3. Transferable alpha and beta activity on the structure surface ranged from 11 to 1,200 DPA and from 4 to 3,550 DPA respectively.

4. Direct measurements of alpha activity on building surfaces ranged from 88 to 89,000 dpm/100 cm^2.

5. Directly measured beta/gamma dose rates on building surfaces ranged from 0.02 to 309 mrad/hr.

6. Radiation measurements on 115 pieces of equipment in the building revealed that most of the items were contaminated in excess of DOE guidelines.

7. The concentration of airborne radon daughter concentrations were <0.01 WL, and thoron daughter concentrations ranged from <0.01 to 0.02 WL.

BNI concluded that, using the guidelines for uranium, swipe sample analyses in the main plant show that 44 percent (158 total alpha and beta measurements) of the floor and all of the

wall and ceiling surfaces were below guidelines. Based on guidelines for direct alpha measurements, 183 of 287 total floor measurements and 151 of 155 total wall and ceiling measurements were below guidelines. Based on beta/gamma radiation levels, 236 of the 287 floor measurements and 150 of the 155 wall and ceiling measurements were below guidelines.

BNI surveyed eleven smaller rooms in Building 404 and reported that, based on guidelines for transferable alpha and beta radioactivity, 85% of the floor (92 total measurements), 84% of the wall (612 total measurements), and all of the ceiling measurements (60) were below guidelines. With regard to direct alpha, 63% of the 113 measurements taken on the floor, 84% of the 307 measurements taken on the wall, and all 30 measurmeents taken on the ceiling were below guidelines. Beta-gamma radiation measurements (same totals as direct alpha measurements) indicated that 70% of the floor, 91% of the walls, and 91% of the ceiling surfaces were below guidelines. Of course, it must be borne in mind that if part of a surface is above guidelines, that entire surface is non-releasable unless some attempt is made to segregate above-guideline from below-guideline areas.

The third survey was performed by the PMC in 1987. The PMC collected two Type F and two Type M samples to determine the concentrations of radon and thoron gas; five air samples were collected in order to measure the concentrations of radon/thoron daughters. The results are given in Table A-14-2.

All of the Type F and Type M samples showed levels of radon and thoron gas at approximately background concentrations. Likewise radon and thoron daughter concentrations are at approximately background levels. This agrees with the results of the BNI survey, which also found the concentrations of radon and thoron daughters to be in this range.

The results of the three surveys are sufficient for the PMC to determine that Building 404 is contaminated in excess of DOE guidelines and is not releasable for unrestricted use. For this reason, no further measurements will be taken on surface contamination prior to dismantlement of the building.

Air samples will be collected before dismantlement is begun, in order to ensure the health and safety of the workers. In addition bulk samples of residues should be collected to determine more accurately the radionuclides present in Building 404.

TABLE A-14-1 Building 404 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	16	7
15,000< R <0.1 lbs uranium	0	30	34
5,000< R <15,000	5	7	19
1,000< R <5,000	1	14	26
300< R <1,000	2	8	6
R <300	27	10	5
TOTAL NUMBER OF MEASUREMENTS	35	85	97

	REMOVABLE ALPHA
1,000 ≤ R	2
200< R <1,000	0
20< R <200	18
R <20	3
TOTAL NUMBER OF MEASUREMENTS	23

(a) Source: RETA 1978
(b) Disintegrations per minute per 100 cm^2

TABLE A-14-2 Building 404 Air Sample Results

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/l)	Monitor Type
0.2	F
0.1	M
0.6	F
0.3	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
404-1A	0.03	0.001
404-1B	0.01	0.002
404-1C	0.01	not measured
404-1D	0.01	not measured
404-1E	0.01	<detectable

A-15 BUILDINGS 405A AND B

Building 405A is a small shop and storage building. The building was used to store spare pilot plant equipment. It is a simple rigid-frame building with corrugated aluminum roof and siding.

Area 405B is a concrete pad (gross area 4,000 square feet) where the dust collectors and a vacuum cleaning system for Building 403 and 404 are located. Although this system served both pilot plants, most of the ducts leading into the collectors originated from the three dust collection systems in Building 404. At the present time there are no connections between the dust collectors and Building 403, but there are numerous ducts coming out of Building 403 that could have been connected to the dust collectors at some point in time.

Three radiological surveys have been performed on these buildings: one performed by RETA, one by BNI, and one by the PMC.

The first survey was performed by RETA in 1977. The RETA survey included:

- 5 total alpha measurements
- 9 removable alpha measurements
- 29 total beta-gamma measurements
- 29 total gamma measurements

The results of the measurements are summarized in Table A-15-1.

RETA compared all results to uranium release guidelines and reported that approximately 65% of the measurements on loose surface contamination were in the "releasable" range. Only

about 35% of total radiation measurements fell into this range. About 20% of all the measurements were in the "moderately contaminated" range, and 45% in the "highly contaminated" range.

Two loose surface contamination samples were analyzed by alpha spectroscopy, and only uranium activity was found. However, NaI gamma spectroscopy indicated the presence of Th-232 in the dust collectors.

BNI characterized Building 405A and the concrete pad during March and April of 1986. The BNI survey indicated that the principal radionuclide present in Building 405A is U-238, based on gamma-ray spectrometry analyses of a single sample of bulk material. The concentration of U-238 was approximately 1,000 times that of other radionuclides, so BNI applied guidelines for residual uranium contamination to the storage shed.

The results of the BNI survey of Building 405A are summarized as follows:

1. The level of long-lived gross alpha activity in the air in the general work area is 2×10^{-13} to 2×10^{-12} µCi/ml.

2. Breathing zone air monitoring of long-lived gross alpha activity showed a range of 1×10^{-12} to 2×10^{-11} µCi/ml.

3. Gamma-ray exposure rates 1 meter above the floor ranged from <10 to 27 µR/hr.

4. Transferable alpha and beta activity on structural surfaces ranged from <11 to 400 DPA, and <4 to 500 DPA respectively.

5. Directly measured alpha radiation on building surfaces ranged from 80 to 50,000 DPA.

6. Directly measured beta-gamma dose rates on building surfaces ranged from 0.02 to 13 mrad/hr.

7. Radiation measurements on 19 identified pieces of equipment revealed that 12 of these items were contaminated in excess of DOE guidelines for release for unrestricted use.

8. The radon daughter and thoron daughter concentrations averaged 0.001 and 0.002 WL, respectively.

Transferable activity analyses indicate that all surfaces in each room meet guidelines (18 measurements were taken on the floor, 53 on the walls, and 16 on the ceiling). Based on guidelines for directly measured alpha radiation levels, 48 out of a total of 62 floor measurements, 57 out of the 58 interior wall measurements, and all 19 of the ceiling measurements were below guidelines. In regard to surface beta-gamma dose rate limits, only seven out of 62 of the floor measurements meet guidelines, but 52 out of 58 of the wall and 17 out of 19 of the ceiling measurements are less than the beta-gamma dose rate limits.

BNI also surveyed the concrete pad, and the results are summarized as follows:

1. The concentration of airborne radioactivity in the breathing zone ranged from 2×10^{-12} to 4×10^{-12} μCi/ml.

2. Gamma-ray exposure rates one meter above the Area 405B pad ranged from 14 to 74 μR/hr.

3. Transferable alpha and beta activity on the pad ranged from <11 to 377 DPA and <4 to 688 DPA respectively.

4. Directly measured alpha radiation on the pad surface ranged from 170 to 14,281 DPA.

5. Directly measured beta-gamma dose rates on the pad surface ranged from 0.06 to 2.4 mrad/hr.

6. Radiation measurements on three identified pieces of equipment revealed that all of these items were contaminated in excess of applicable DOE guidelines.

Analysis of bulk material from the dust collectors showed that the concentration of U-238 was 300 to 700 times that of Th-232, so BNI applied uranium guidelines to the concrete pad.

Twenty-three measurements were made of transferable radioactivity on the concrete pad, and they were all below guidelines. For directly measured alpha radiation, 13 of 93 measurements were below guidelines, and for directly measured beta-gamma dose rates, 41 of 93 measurements were below guidelines. Directly measured alpha and beta-gamma levels inside the dust collectors exceeded guidelines with results ranging from 1,954 to 84,107 DPA and 0.1 to 296 mrad/hr respectively.

The PMC collected two Type F and two Type M samples in Building 405A in order to determine radon and thoron gas concentrations. The results are presented in Table A-15-2. Both the Type F and the Type M samples were at approximately background levels, indicating that neither radon nor thoron concentrations in the building are above background levels. The presence of thoron at background concentrations agrees with the

RETA and BNI findings of only a small amount of Th-232 in this building.

The results of the previous surveys show that the concrete pad, Area 405B, and the floor of Building 405A are contaminated and cannot be released for unrestricted use. The walls and ceiling of Building 405A may be releasable for unrestricted use, however, because only one alpha measurement made by BNI on these surfaces exceeded DOE guidelines. Nevertheless, a more comprehensive survey will be required if it is considered desirable to release the walls and ceiling for unrestricted use.

To protect the safety and health of remedial action workers more air sampling is required during building dismantlement. Also, additional bulk samples of surface residues should be collected, especially in ducts, to identify the radionuclides present.

TABLE A-15-1 Building 405 Radiological Survey Results [a]

RADIATION LEVEL RANGE (DPA) [b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	0	7	13
15,000< R <0.1 lbs uranium	1	6	4
5,000< R <15,000	2	6	5
1,000< R <5,000	0	5	6
300< R <1,000	0	3	1
R <300	2	2	0
TOTAL NUMBER OF MEASUREMENTS	5	29	29

	REMOVABLE ALPHA
1,000 ≤ R	3
200< R <1,000	0
20< R <200	5
R <20	1
TOTAL NUMBER OF MEASUREMENTS	9

(a) Source: RETA, 1978
(b) Disintegrations per minute per 100 cm^2

TABLE A-15-2 Building 405 Air Sample Results

Radon/Thoron Gas Concentrations	
Radon Concentration (pCi/l)	Monitor Type
0.4	F
0.2	M
0.3	F
0.2	M

A-16 BUILDING 406

This warehouse is a 194 ft x 78 ft cinder-block building divided into four interconnecting areas which contain 15,132 square feet of floor area. The four areas were originally known as Rooms 107, 108, and 109 and the office area consisting of Rooms 101, 102, 103, 104, 105, and 106. The entire building is currently designated as a WSSRAP RCRA storage area and contains numerous drums of both hazardous and non-hazardous materials. A description of these drums and associated contents is on file with the PMC.

Two radiological surveys have been performed on Building 406: one performed by RETA and one by the PMC. RETA performed a survey in 1977. The RETA survey included:

- 63 total alpha measurements
- 24 removable alpha measurements
- 66 total beta-gamma measurements
- 9 total gamma measurements

All of the measurements on loose surface contamination fell into the "releasable" range, but only 90% of total radiation measurements did; the other 10% were in the "moderately contaminated" range. RETA found that this contamination was generally confined to Room 109, and to the concrete pad and loading dock on the west side of the building.

The PMC surveyed Building 406 in 1988. The PMC survey included:

- 5 bulk samples
- 677 total beta-gamma measurements
- 677 removable alpha measurements
- 2 core samples

- 2 airborne particulate samples
- 4 radon/thoron air samples (2 Type F, 2 Type M)
- 2 radon/thoron daughter air samples

Five bulk samples were collected. The average activity of each radionuclide is given below:

Radionuclide	Activity (pCi/g - dry)
Ra-226	1.2 ± 0.2
U-234	77.5 ± 7.8
U-235	7.0 ± 0.9
U-238	81.2 ± 9.8
Th-232	2.4 ± 0.3
Th-228	2.2 ± 0.3
Th-230	249.8 ± 18.8

The analytical results indicate Th-230 to be the primary contaminant. Table A-16-1 summarizes alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria. Because of the restrictive Th-230 release criteria, none of the items comprising Building 406 are releasable for unrestricted use.

An inventory of equipment remaining in Building 406 other than that associated with RCRA storage is on file with the PMC. The PMC determined that all equipment is presently not releasable for unrestricted use.

Two core samples were taken in Building 406. Before core removal, debris was brushed off and beta-gamma measurements were taken at each location. Both of these measurements were found to be above Th-228 release criteria. After core removal beta-gamma measurements at both locations were still above

release criteria, indicating contamination had seeped beyond the concrete surface and that the floor was volumetrically contaminated. For this reason the floor of Building 406 is not releasable for unrestricted use.

The results of air samples taken in Building 406 are presented in Table A-16-2. Both long-lived alpha air particulate samples were below the DAC guidelines for Th-230. One Type F track-etch sample shows an above-background concentration of 1.7 pCi/l while both Type M samples were near background, indicating the possibility of above-background, but below DAC guideline thoron concentrations in this building.

Two samples were taken to determine radon and thoron daughter concentrations. Both samples showed near background radon and thoron working level concentrations. The near-background thoron daughter concentrations along with the above-background thoron gas concentrations suggest the presence of localized areas within the building containing above-background thoron concentrations.

TABLE A-16-1 Building 406 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Exterior						
Loading dock, Floor	Total Beta-Gamma	No	30	1,384	15,051	5,221
	Removable Alpha		30	<5	9	
Loading dock, Walls/Ceiling	Total Beta-Gamma	No	30	<540	6,055	<1,529
	Removable Alpha		30	<5	5	
North Wall	Total Beta-Gamma	No	30	<540	3,010	<1,637
	Removable Alpha		30	<5	5	
South Wall	Total Beta-Gamma	No	30	<540	4,533	<1,448
	Removable Alpha		30	<5	12	
East Wall	Total Beta-Gamma	No	30	<540	4,913	<2,094
	Removable Alpha		30	<5	5	
West Wall	Total Beta-Gamma	No	30	<540	4,498	<934
	Removable Alpha		30	<5	5	
Roof	Total Beta-Gamma	No	32	5,301	146,254	45,147
	Removable Alpha		32	<5	51	
Interior						
Room 109, Beams	Total Beta-Gamma	No	25	796	10,207	<3,106
	Removable Alpha		25	<5	42	
Room 109, Columns	Total Beta-Gamma	No	30	<540	1,765	<602
	Removable Alpha		30	<5	12	
Room 109, Walls/Ceiling	Total Beta-Gamma	No	30	<540	2,976	<826
	Removable Alpha		30	<5	<5	
Room 109, Floor	Total Beta-Gamma	No	30	2,422	12,075	6,391
	Removable Alpha		30	<5	18	
Room 107, Beams	Total Beta-Gamma	No	16	<540	12,491	<3,639
	Removable Alpha		16	<6	65	

TABLE A-16-1 Building 406 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Room 107, Columns	Total Beta-Gamma	No	30	<540	2,560	<785
	Removable Alpha		30	<5	22	
Room 107, Walls/Ceiling	Total Beta-Gamma	No	28	<481	2,870	<952
	Removable Alpha		28	<6	9	
Room 107, Floor	Total Beta-Gamma	No	30	1,868	37,506	10,418
	Removable Alpha		30	<5	12	
Room 108, Beams	Total Beta-Gamma	No	30	900	24,912	5,942
	Removable Alpha		30	<5	58	
Room 108, Columns	Total Beta-Gamma	No	30	<540	1,626	<705
	Removable Alpha		30	<5	12	
Room 108, Walls/Ceiling	Total Beta-Gamma	No	30	<540	1,557	<672
	Removable Alpha		30	<5	5	
Room 108, Floor	Total Beta-Gamma	No	30	7,093	35,707	15,831
	Removable Alpha		30	<5	94	
Rooms 105 & 106 Walls/Ceiling	Total Beta-Gamma	No	30	<540	1,246	<624
	Removable Alpha		30	<5	9	
Rooms 105 & 106 Floor	Total Beta-Gamma	No	30	1,003	11,972	3,800
	Removable Alpha		30	<5	12	
Rooms 101-104, Walls/Ceiling	Total Beta-Gamma	No	36	<540	4,671	<869
	Removable Alpha		36	<5	5	
Rooms 101-104, Floor	Total Beta-Gamma	No	30	<540	6,228	<2,671
	Removable Alpha		30	<5	5	

* Disintegrations per minute per 100 cm^2

TABLE A-16-2 Building 406 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (uCi/ml)
Breathing Zone	3.2×10^{-13}
Breathing Zone	4.4×10^{-13}

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/l)	Monitor Type
0.6	F
0.4	M
1.7	F
0.1	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
406-1A	0.01	0.001
406-1B	0.01	0.005

A-17 BUILDING 407

Building 407, the laboratory, is a one-story structure consisting of a structural steel frame with concrete block exterior walls, and containing a gross area of 53,850 square feet. There are 113 rooms of various sizes and functions in the building. A penthouse on the roof contains an electrical substation and heating and cooling equipment. The building had two dust collection systems, one on the roof and one located on the south side of the building. A small metal storage building and a small concrete block building are adjacent to Building 407.

There have been two surveys performed on Building 407. The first was performed by RETA in 1977; the second was performed by the PMC in 1988. The RETA survey included:

- 408 total alpha measurements
- 449 removable alpha measurements
- 728 total beta-gamma measurements
- 726 total gamma measurements

RETA found that 90 to 95% of the measurements on loose surface contamination were in the "releasable" range. On the basis of total surface contamination there are two estimates; about 75% of the measurements are in the "releasable" range if there is uranium contamination only, but only 55% are in the "releasable" range if thorium is present. About 10 to 30% of all other measurements were in the "moderately contaminated" range, and 15% in the "highly contaminated" range.

Of 10 loose surface contamination samples examined with alpha spectrometry, the average assay was 60% uranium, 4% radium, and 30% Th-232 on an activity basis. NaI spectroscopy

revealed thorium in the dust collectors. However, no attempt was made to determine the amount of thorium present.

RETA found that measurements of total surface contamination in the following rooms are in the "highly contaminated" range:

1. Powder Sample Room: visible contamination, room not entered, probably uranium.
2. Metal Sample Room: visible contamination, room not entered, probably uranium.
3. Sample Preparation Room (Room 17): 27% radium, 29% thorium, and 44% uranium.
4. Acceptability Testing Laboratory: 8% radium, 27% thorium, 65% uranium (one sample proved to be 100% thorium).
5. Wet Chemistry Laboratory (Rooms 68, 70-72): 5% radium, 20% thorium, and 75% uranium.
6. Special Analysis Laboratory (Room 65): 100% thorium
7. Metal Punch Room, Methods Development, Sample Machine Area, Instrument Room: 100% uranium.

Finally, RETA found that the office areas of the building are essentially releasable (RETA, 1978).

The PMC survey included measurements in 107 of the 113 rooms in Building 407. Six rooms were not surveyed because they contained unknown and possibly hazardous materials, or because they were inaccessible. Results of the measurements are specified according to room number designations currently existing in Building 407. The penthouse, the storage building, and the concrete block building were also surveyed. The PMC survey included:

- 26 bulk samples
- 3,090 total beta-gamma measurements

- o 3,090 removable alpha measurements
- o 9 core samples
- o 3 airborne particulate samples
- o 4 radon/thoron gas samples
- o 7 radon/thoron daughter samples

Twenty-six bulk samples were collected. The average activity of each radionuclide is given below:

Radionuclide	Activity (pCi/g - dry)
Ra-226	0.9 ± 0.2
U-234	199.0 ± 20.3
U-235	10.8 ± 2.2
U-238	211.6 ± 19.1
Th-230	5.9 ± 0.6
Th-232	2.9 ± 0.3
Th-228	5.1 ± 0.7

The analytical results indicate natural uranium and natural thorium to be the primary contaminants. Therefore the mixture rule will apply to release of material from this building.

These results show little Th-232 contamination, in contrast to RETA survey results. It is not known why the survey results between RETA and the PMC differ on this point; however the PMC results will be used in this report due to the much more extensive sampling effort performed by the PMC.

Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria are summarized in Table A-17-1. As can be calculated from the data provided in this table, approximately 75% of both the floor and the wall/ceiling populations identified in Building 407 are potentially releasable for unrestricted use.

Results of the previous surveys show that walls and the undersides of the drop ceilings are generally releasable, whereas floors, counter tops, fume hoods and equipment are contaminated. This pattern fits the trend evidenced in most buildings regarding horizontal versus vertical surfaces.

No measurements have been made on structural steel or structural materials between the roof and the drop ceiling. Structural materials are probably uncontaminated because they are above the drop ceiling and would not have been exposed to radioactive materials.

Ductwork from fume hoods that were used for handling radioactive materials was also not surveyed due to inaccessibility above drop ceilings, but these ducts are probably contaminated.

Some rooms could not be surveyed in accordance with the PMC sampling plan. These included Room 34, which is stacked from floor to ceiling with equipment, making many measurement locations inaccessible; Rooms 17 and 20, which contained hazardous chemicals; and Rooms 18 and 19, which can only be entered through Room 17. No data are available for Room 36. In addition, the small concrete block building attached to the laboratory was not surveyed since it contained potentially hazardous material.

Nine core samples were taken on the floor at locations that had surface readings above natural uranium release limits. The measurements are presented in Table A-17-2. For each location, a reading was taken on the undisturbed surface. Then the dust was brushed off, and a second measurement was taken. A third measurement was taken when the tile was removed. At three of the four locations where readings exceeded the instrument MDA following tile removal, a concrete core was removed. These

results indicate that contamination has not seeped into the concrete; therefore surface release criteria are applicable to the floor.

A detailed inventory of all substantial equipment remaining in Building 407 is on file with the PMC; small items such as laboratory glassware were not inventoried. A small fraction of the inventoried equipment was scanned, and all scanned equipment was found to be not releasable for unrestricted use. Because of this and the enormous amount of equipment remaining in the building, all equipment is considered to be not releasable at present.

Air samples collected in Building 407 were analyzed for long-lived alpha radioactivity on airborne particulates, radon and thoron gas, and radon/thoron daughters. Air sample results are presented in Table A-17-3.

Three radioactive air particulate samples were analyzed for long-lived alpha activity, and all sample concentrations were below DAC guidelines for U-238. All of the radon daughter samples were at approximately background levels. Five of the thoron daughter samples were at approximately background levels. Two thoron daughter samples collected in the primary laboratory were above background, though below the DAC guidelines.

Both Type M samples were at approximately background level. One Type F sample was at approximately background level while the other was slightly above background, indicating the possible presence of above-background thoron concentrations in localized areas of the building. Thoron concentrations slightly above background levels may be due to the slightly above-background concentrations of Th-228 found in the bulk samples taken by the PMC.

TABLE A-17-1 Building 407 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<553	1,974	<773
	Removable Alpha		30	<6	9	
South Wall	Total Beta-Gamma	No	30	<553	12,008	<1,400
	Removable Alpha		30	<6	9	
East Wall	Total Beta-Gamma	Yes	30	<553	592	<554
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<553	1,744	<680
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	No	30	<553	21,253	<2,925
	Removable Alpha		30	<6	9	
Storage Building	Total Beta-Gamma	No	30	<553	19,279	<2,916
	Removable Alpha		30	<6	<6	
Rooms 1-5 and 14	Total Beta-Gamma	Yes	30	<553	1,875	<632
Floor	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	No	30	<553	4,803	<755
	Removable Alpha		30	<6	18	
Rooms 7, 8, 9, 12, 13						
Floor	Total Beta-Gamma	Yes	30	<504	4,935	<790
	Removable Alpha		30	<6	<6	
Rooms 7-13						
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	6,383	<1,136
	Removable Alpha		30	<6	9	
Rooms 15 and 16						
Floor	Total Beta-Gamma	No	30	<553	3,553	<696
	Removable Alpha		30	<6	12	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<553	559	<553
	Removable Alpha		30	<6	12	
Rooms 21, 22, 23						
Floor	Total Beta-Gamma	Yes	30	<553	1,908	<756
	Removable Alpha		30	<6	12	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<553	1,612	<589
	Removable Alpha		30	<6	<6	
Rooms 16 and 26						
Floor	Total Beta-Gamma	Yes	30	<513	2,369	<1,034
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<513	822	<566
	Removable Alpha		30	<2.5	7	
Rooms 24 and 25						
Floor	Total Beta-Gamma	No	30	<504	25,416	<3,351
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	865	<517
	Removable Alpha		30	<6	9	
Rooms 27-29						
Floor	Total Beta-Gamma	No	30	<504	16,401	<1,306
	Removable Alpha		30	<6	12	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,127	<571
	Removable Alpha		30	<6	9	
Room 34						
Floor	Total Beta-Gamma	No	8	<504	1,471	<695
	Removable Alpha		8	<6	<6	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	27	<504	595	<508
	Removable Alpha		27	<6	<6	
Rooms 30 and 31						
Floor	Total Beta-Gamma	No	30	<504	10,924	<1,763
	Removable Alpha		30	<6	12	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	782	<532
	Removable Alpha		30	<6	<6	
Room 35						
Floor	Total Beta-Gamma	No	30	<504	1,596	<645
	Removable Alpha		30	<6	<6	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	751	<526
	Removable Alpha		30	<6	<6	
Room 39/Hallway						
Floor	Total Beta-Gamma	No	30	814	78,156	7,170
	Removable Alpha		30	<6	48	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	<504	<504
	Removable Alpha		30	<6	61	
Room 37						
Floor	Total Beta-Gamma	No	30	<504	18,029	<2,188
	Removable Alpha		30	<6	18	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	814	<516
	Removable Alpha		30	<6	<6	
Room 42						
Floor	Total Beta-Gamma	No	30	<504	36,965	<4,246
	Removable Alpha		30	<2.5	29	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,127	<572
	Removable Alpha		30	<2.5	13	
Rooms 44-46						
Floor	Total Beta-Gamma	No	30	<481	23,741	<2,653
	Removable Alpha		30	<2.5	23	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	4,485	<1,045
	Removable Alpha		30	<2.5	<2.5	
Rooms 65-67						
Floor	Total Beta-Gamma	No	30	<504	7,950	<1,982
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	No	30	<504	3,255	<656
	Removable Alpha		30	<6	9	
Rooms 69 and 70						
Floor	Total Beta-Gamma	No	30	<504	5,697	<900
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	751	<529
	Removable Alpha		30	<6	9	
Rooms 73 and 74						
Floor	Total Beta-Gamma	Yes	30	<504	1,346	<561
	Removable Alpha		30	<6	<6	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,704	<746
	Removable Alpha		30	<6	<6	
Rooms 47-49						
Floor	Total Beta-Gamma	No	30	<481	59,651	<4,498
	Removable Alpha		30	<6	18	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	2,990	<846
	Removable Alpha		30	<6	<6	
Rooms 50 and 51						
Floor	Total Beta-Gamma	No	30	<504	16,746	<1,498
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	2,974	<642
	Removable Alpha		30	<6	9	
Room 53						
Floor	Total Beta-Gamma	Yes	30	<481	3,110	<1,112
	Removable Alpha		30	<2.5	10	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	4,724	<1,482
	Removable Alpha		30	<2.5	10	
Rooms 54, 55, & 59						
Floor	Total Beta-Gamma	Yes	30	<481	1,136	<666
	Removable Alpha		30	<2.5	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	957	<520
	Removable Alpha		30	<2.5	10	
Rooms 56-58						
Floor	Total Beta-Gamma	Yes	30	<481	2,900	<1,011
	Removable Alpha		30	<2.5	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	867	<516
	Removable Alpha		30	<2.5	7	
Rooms 60 and 61						
Floor	Total Beta-Gamma	No	30	<504	28,546	<1,765
	Removable Alpha		30	<2.5	16	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	532	<505
	Removable Alpha		30	<2.5	10	
Rooms 62 and 63						
Floor	Total Beta-Gamma	Yes	30	<504	3,787	<955
	Removable Alpha		30	<3	20	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,158	<538
	Removable Alpha		30	<3	10	
Room 64						
Floor	Total Beta-Gamma	No	30	<504	9,860	1,559
	Removable Alpha		30	<2.5	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,346	<660
	Removable Alpha		30	<6	22	
Rooms 71 and 72						
Floor	Total Beta-Gamma	No	30	<481	17,685	<2,218
	Removable Alpha		30	<2.5	16	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,283	<660
	Removable Alpha		30	<6	9	
Rooms 76 and 77						
Floor	Total Beta-Gamma	No	30	<481	14,262	<1,755
Walls/Ceiling	Total Beta-Gamma	No	30	<481	5,591	
Room 78						
Floor	Total Beta-Gamma	No	30	<481	5,801	1,875
	Removable Alpha		30	<2.5	9	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	4,126	2,026
	Removable Alpha		30	<6	<6	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Rooms 81-85						
Floor	Total Beta-Gamma	No	30	<504	8,326	<1,699
	Removable Alpha		30	<2.5	23	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	689	<517
	Removable Alpha		30	<2.5	10	
Interior of Storage Building						
Floors, Walls, and Ceiling	Total Beta-Gamma	No	30	<481	29,033	<7,295
	Removable Alpha		30	<2.5	20	
Rooms 86-88						
Floor	Total Beta-Gamma	No	30	<504	17,465	<3,816
	Removable Alpha		30	<6	18	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	5,322	
Room 75						
Floor	Total Beta-Gamma	No	30	747	120,527	32,627
Walls/Ceiling	Total Beta-Gamma	No	30	<504	6,604	<885
	Removable Alpha		30	<6	127	
Interior of Concrete Block Building						
Walls/Ceiling	Total Beta-Gamma	No	30	<481	7,684	<3,116
	Removable Alpha		30	<6	15	
Rooms 102 and 103						
Floor	Total Beta-Gamma	No	30	1,017	27,000	6,836
	Removable Alpha		30	<6	25	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	4,425	<798
	Removable Alpha		30	<6	174	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Rooms 98 and 99						
Floor	Total Beta-Gamma	No	30	<481	10,106	<1,637
	Removable Alpha		30	<2.5	20	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	927	<537
	Removable Alpha		30	<2.5	7	
Rooms 100, 101, and 104						
Floor	Total Beta-Gamma	No	30	<481	7,027	<1,656
	Removable Alpha		30	<2.5	20	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	2,900	<631
	Removable Alpha		30	<2.5	10	
Rooms 92, 93, and 95						
Floor	Total Beta-Gamma	Yes	30	<504	1,690	<598
	Removable Alpha		30	<6	12	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,283	<593
	Removable Alpha		30	<6	9	
Rooms 32 and 33						
Floor	Total Beta-Gamma	No	30	<504	5,039	<1,383
	Removable Alpha		30	<6	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,784	<664
	Removable Alpha		30	<6	7	
Rooms 80 and 94						
Floor	Total Beta-Gamma	No	30	1,525	4,963	2,930
	Removable Alpha		30	<6	16	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,405	<705
	Removable Alpha		30	<6	7	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE		NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Rooms 105 and 113						
Floor	Total Beta-Gamma	No	30	<481	5,532	<828
	Removable Alpha		30	<2.5	13	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	957	<681
	Removable Alpha		30	<2.5	7	
Penthouse						
Floor, (Heating Side)	Total Beta-Gamma	No	30	807	7,774	2,702
	Removable Alpha		30	<6	15	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	718	<511
	Removable Alpha		30	<6	12	
Floor, (Electrical Side)	Total Beta-Gamma	Yes	30	<504	1,854	<975
	Removable Alpha		30	<6	12	
Walls/Ceiling	Total Beta-Gamma	No	30	<504	1,824	<582
	Removable Alpha		30	<6	38	
Rooms 38, 40, and 41						
Floor	Total Beta-Gamma	No	30	1,346	39,782	<838
	Removable Alpha		30	<6	51	
Walls/Ceiling	Total Beta-Gamma	No	30	<504	4,194	783
	Removable Alpha		30	<6	9	
Room 52						
Floor	Total Beta-Gamma	No	30	508	102,557	9,824
	Removable Alpha		30	<2.5	59	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	6,937	<2,262
	Removable Alpha		30	<2.5	16	

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Room 68						
Floor	Total Beta-Gamma	No	30	1,002	17,778	3,912
	Removable Alpha		30	3	26	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,502	<704
	Removable Alpha		30	<2.5	10	
Room 90						
Floor	Total Beta-Gamma	No	30	<481	37,576	<8,676
	Removable Alpha		30	<2.5	20	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	4,993	<932
	Removable Alpha		30	<2.5	20	
Room 89						
Floor	Total Beta-Gamma	No	30	<481	12,349	<3,582
	Removable Alpha		30	<2.5	36	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	7,834	<992
	Removable Alpha		30	<2.5	208	
Room 97						
Floor	Total Beta-Gamma	No	30	845	229,648	17,501
	Removable Alpha		30	<2.5	53	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	2,692	<797
	Removable Alpha		30	<2.5	43	
Room 79						
Floor	Total Beta-Gamma	Yes	30	<481	2,930	<941
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,017	<481

TABLE A-17-1 Building 407 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA) * MINIMUM	MAXIMUM	AVERAGE
Room 96						
Floor	Total Beta-Gamma	No	30	2,191	12,270	6,214
	Removable Alpha		30	<2.5	26	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,878	<673
	Removable Alpha		30	<2.5	10	
Room 115						
Floor	Total Beta-Gamma	No	30	2,422	45,568	7,987
	Removable Alpha		30	<2.5	20	
Walls/Ceiling	Total Beta-Gamma	No	30	<481	6,399	<1,406
	Removable Alpha		30	<2.5	30	
Penthouse Exterior						
North Wall	Total Beta-Gamma	Yes	30	<553	625	<555
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<553	1,119	<591
	Removable Alpha		30	<6	9	
East Wall	Total Beta-Gamma	Yes	30	<553	592	<554
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<553	3,915	<1,395
	Removable Alpha		30	<6	9	
Roof	Total Beta-Gamma	No	30	<553	7,830	<1,518

TABLE A-17-2 Building 407 Core Sample Results

Location	Total Activity (DPA)	Remarks
B407 ST 0241	14,043	Initial reading
B407 ST 0241	29,078	After dusting
B407 ST 0241	775	Tile removed
B407 ST 0327	3,534	Initial reading
B407 ST 0327	9,145	After dusting
B407 ST 0327	<504	Tile removed
B407 ST 0385	5,053	Initial reading
B407 ST 0385	4,371	After dusting
B407 ST 0385	<504	Tile removed
B407 ST 0484	2,418	Initial reading
B407 ST 0484	2,170	After dusting
B407 St 0484	<504	Tile removed
B407 ST 0601	1,395	Initial reading
B407 ST 0601	589	After dusting
B407 ST 0601	<504	Tile removed
B407 ST 0548	961	Initial reading
B407 ST 0548	<504	After dusting
B407 ST 0736	6,944	Initial reading
B407 ST 0736	5,704	After dusting
B407 ST 0736	6,386	Tile removed
B407 ST 0736	<504	1/8" deep
B407 ST 0797	59,334	Initial reading
B407 ST 0797	53,382	After dusting
B407 ST 0797	527	Tile removed
B407 ST 0797	<504	2 cm deep
B407 ST 1811	127,255	Initial reading
B407 ST 1811	114,979	After dusting
B407 St 1811	<504	1/4" deep

TABLE A-17-3 Building 407 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
High Volume	6.2×10^{-13}
Breathing Zone	2.0×10^{-13}
Breathing Zone	6.7×10^{-13}

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/l)	Monitor Type
0.4	F
0.5	M
0.9	F
0.3	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
407-1A (primary lab on floor)	0.14	<MDA
407-1B (primary lab)	0.14	0.002
407-1C (primary lab)	0.02	0.002
407-1D (central hall)	0.03	0.001
407-1E (bomb shelter)	0.07	0.006
407-1F (near drill rig)	0.001	0.001
Bldg 407 by UNC (borehole WS-157)	<MDA	0.0008

A-18 BUILDING 408

This major support building is a 361 ft x 193 ft structural steel frame one-story structure with cinder-block exterior walls containing 70,700 square feet of gross floor area. It formerly contained numerous maintenance shops, an office area, garage, a receiving and shipping area, a decontamination room, and a large storage area. A masonry wall in the north-south direction divides the building in half. Much equipment and furniture remains in the building including many loose nuts and bolts, chairs, workbenches, and large drill presses (MKF, 1988).

Building 408 has been surveyed three times: once by RETA, and twice by the PMC. RETA surveyed this building in 1977. The RETA survey included:

- 216 total alpha measurements
- 109 removable alpha measurements
- 234 total beta-gamma measurements
- 38 total gamma measurements

RETA compared all results to uranium release guidelines and reported that essentially 100% of the measurements on loose surface contamination were in the "releasable" range. However, when total surface contamination was considered, only about 95% of the measurements were in this range. RETA found that the contamination is generally confined to the Decontamination Room.

In July of 1987, the PMC performed a preliminary survey of Building 408 in order to determine the levels of fixed versus removable alpha activity on the floors, walls, and equipment, and to determine the beta and gamma dose rates. This was done in order to see if the building could be used for storage and warehousing for the WSSRAP. The building was determined to be

radiologically suitable for storage, but since PCBs were present, it could not be used.

In order to determine the extent of radioactive contamination, alpha and beta measurements were made at 56 locations on the floor and at 36 locations on the walls. Alpha swipes were made at these locations, and alpha measurements were made on the wall three feet from the floor. Beta measurements were made with the probe three feet from the surface being measured. Direct gamma exposure measurements were also made. The results are summarized in Table A-18-1.

Contamination on the structure was found to be random. The greatest amount of activity was found to be 7,000 DPA direct and 400 DPA removable. All other readings were less than 4,000 DPA.

Most equipment scanned was found to be above uranium release guidelines. A detailed inventory of equipment in Building 408 is on file with the PMC.

The PMC performed a more comprehensive survey on Building 408 in 1988 which included measurements in all 39 rooms. Results of the measurements are specified according to room number designations currently existing in Building 408. The survey included:

- 10 bulk samples
- 1,762 total beta-gamma measurements
- 1,761 removable alpha measurements
- 6 core samples
- 1 airborne particulate sample
- 4 radon/thoron gas samples
- 2 radon/thoron daughter samples

Ten bulk samples were collected. The average activity of each radionuclide is given below:

Radionuclide	Activity (pCi/g - dry)
Ra-226	4.5 ± 2.4
U-234	275.5 ± 115.4
U-235	15.0 ± 6.6
U-238	277.7 ± 117.8
Th-230	7.8 ± 6.7
Th-232	1.0 ± 3.4
Th-228	0.7 ± 1.4

Based on these results, natural uranium is the predominant radionuclide in Building 408. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-18-2. Approximately 73% of the interior wall/ceiling populations shown in the table are potentially releasable, while 92% of the floor populations are not releasable for unrestricted use. As for the exterior, the south, east and west walls are potentially releasable, but the north wall and roof are not.

Six core samples were taken at the locations of the highest total beta-gamma measurements on the floors. These were in Rooms 101, 104/107, 109, 114, 116, and 136.

Table A-18-3 presents the results of these measurements. In Rooms 101, 104/107, 116, and 136, the radiation levels 2 cm below the surface were less than the MDA of the detector indicating no volumetric contamination. The measurements at 2 cm below the surface in Rooms 109 and 114 were above the MDA of the detector. This suggests that the floors in these rooms are volumetrically contaminated, so surface contamination

release criteria do not apply; therefore these floors are not releasable.

One long-lived alpha air particulate sample, two radon and thoron gas samples, and two radon/thoron daughter concentrations samples were collected. These results are presented in Table A-18-4.

The long-lived alpha air particulate sample was below the DAC for U-238. Radon and thoron daughter concentrations were at approximately background levels.

The two Type F track-etch samples showed concentrations slightly above background, while the two Type M samples were near background concentrations. This suggests the presence of above-background thoron concentrations, but these are probably localized since thoron daughter measurements and Th-228 concentrations in bulk samples were near background levels.

TABLE A-18-1: Results of PMC Preliminary Survey of Building 408

Type of Survey	Average Activity
Direct alpha, on floor	792 dpm/100 cm^2
Removable alpha, floor (swipe)	50 dpm/100 cm^2
Direct alpha, walls	558 dpm/100 cm^2
Swipe for alpha, walls	37 dpm/100 cm^2
Direct beta, floor	42 cpm
Direct beta, walls	37 cpm
Direct gamma exposure	7 μR/hr

(Maximum exposure reading was 12 μR/hr.)

TABLE A-18-2 Building 408 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	No	30	<553	3,093	<758
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<553	4,244	<1,180
	Removable Alpha		30	<6	9	
East Wall	Total Beta-Gamma	Yes	30	<553	1,908	<728
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<553	4,639	<1,318
	Removable Alpha		30	<6	9	
Roof	Total Beta-Gamma	No	29	6,609	100,305	23,410
	Removable Alpha		29	<6	60	
Rooms 109, 129						
Floor	Total Beta-Gamma	No	30	1,250	16,878	6,203
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	24	<553	3,487	<571
	Removable Alpha		25	<6	103	
Room 108						
Floor	Total Beta-Gamma	No	30	796	19,826	5,137
	Removable Alpha		30	<6	35	
Walls/Ceiling	Total Beta-Gamma	No	30	<540	6,643	<860
	Removable Alpha		30	<6	13	
Rooms 110, 130						
Floor	Total Beta-Gamma	No	31	790	40,039	5,539
	Removable Alpha		30	<6	<6	

TABLE A-18-2 Building 408 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	29	<553	1,678	<565
	Removable Alpha		30	<6	9	
Rooms 132 and 133 Floor	Total Beta-Gamma	No	30	<553	6,679	<871
	Removable Alpha		30	<6	17	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<553	1,184	<604
	Removable Alpha		30	<6	9	
Rooms 111 and 131 Floor	Total Beta-Gamma	No	32	724	23,885	7,388
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	No	29	<553	8,159	<608
	Removable Alpha		30	<6	60	
Rooms 122 and 123 Floor	Total Beta-Gamma	Yes	30	<540	2,837	<1,054
	Removable Alpha		30	<6	17	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,315	<720
	Removable Alpha		30	<6	<6	
Rooms 135 and 137 Floor	Total Beta-Gamma	No	30	<504	40,052	6,580
	Removable Alpha		30	<6	17	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	2,604	<918
	Removable Alpha		30	<6	<6	
Rooms 104-107 Floor	Total Beta-Gamma	No	30	796	41,139	10,430
	Removable Alpha		30	<6	42	

TABLE A-18-2 Building 408 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	2,733	<1,065
	Removable Alpha		30	<5	17	
Area "X"						
Floor	Total Beta-Gamma	No	35	1,415	38,065	8,493
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	No	25	<504	4,712	<1,309
	Removable Alpha		30	<6	53	
Rooms 103 and 128						
Floor	Total Beta-Gamma	No	31	<504	5,988	<1,571
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	29	<504	1,349	<799
	Removable Alpha		30	<6	17	
Room 116C						
Floor	Total Beta-Gamma	No	30	<553	2,369	<1,019
	Removable Alpha		30	<6	9	
Room 116C						
Walls/Ceiling	Total Beta-Gamma	Yes	30	<553	1,283	<682
	Removable Alpha		30	<6	17	
Room 115						
Floor	Total Beta-Gamma	No	30	<540	5,813	1,659
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,453	<712
	Removable Alpha		30	<6	<6	
Room 134						
Floor	Total Beta-Gamma	No	30	<540	7,266	<2,125
	Removable Alpha		30	<6	17	

TABLE A-18-2 Building 408 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Building 134						
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,488	<854
	Removable Alpha		30	<6	9	
Room 116B						
Floor	Total Beta-Gamma	No	30	<553	6,679	<1,092
	Removable Alpha		30	<6	<6	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<553	1,316	<640
	Removable Alpha		30	<6	9	
Room 116A						
Floor	Total Beta-Gamma	No	30	<553	3,685	<1,063
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<553	1,250	<693
	Removable Alpha		30	<6	9	
Room 117						
Floor	Total Beta-Gamma	No	30	554	21,556	3,056
	Removable Alpha		30	<6	24	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	2,526	<912
	Removable Alpha		30	<6	9	
Rooms 136-138						
Floor	Total Beta-Gamma	No	12	<504	60,202	12,470
	Removable Alpha		10	<6	125	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,736	<757
	Removable Alpha		30	<6	<6	
Room 120						
Floor	Total Beta-Gamma	No	30	<526	7,468	3,066
	Removable Alpha		30	<6	13	

TABLE A-18-2 Building 408 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	No	30	<504	14,043	<2,033
	Removable Alpha		30	<6	17	
Room 124						
Floor	Total Beta-Gamma	Yes	30	588	3,224	1,354
	Removable Alpha		30	<6	27	
Walls/Ceiling	Total Beta-Gamma	Yes	28	<540	1,868	<882
	Removable Alpha		30	<6	<6	
Rooms 125 and 126						
Floor	Total Beta-Gamma	No	30	<553	3,948	<923
	Removable Alpha		30	<6	9	
Rooms 125 and 126						
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	2,284	<881
	Removable Alpha		30	<6	9	
Room 101						
Floor	Total Beta-Gamma	No	30	1,142	27,438	5,542
	Removable Alpha		30	<6	35	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,522	<797
	Removable Alpha		30	<6	13	
Room 119						
Floor	Total Beta-Gamma	No	30	868	5,611	2,578
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	No	30	<504	2,895	<822
	Removable Alpha		30	<6	9	
Rooms 118, 127 and 102						
Floor	Total Beta-Gamma	No	30	<553	13,950	<2,912
	Removable Alpha		30	<6	27	

TABLE A-18-2 Building 408 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,579	<768
	Removable Alpha		30	<6	<6	
Room 121						
Floor	Total Beta-Gamma	No	30	<553	8,620	<3,316
	Removable Alpha		30	<6	<6	
Walls/Ceiling	Total Beta-Gamma	No	30	<553	10,758	<1,408
	Removable Alpha		30	<6	9	
Room 112						
Floor	Total Beta-Gamma	No	32	888	10,857	4,617
	Removable Alpha		30	<6	9	<6
Walls/Ceiling	Total Beta-Gamma	Yes	28	<504	1,597	<644
	Removable Alpha		30	<6	<6	<6
Room 114						
Floor	Total Beta-Gamma	No	18	1,382	66,326	<11,571
	Removable Alpha		17	<6	174	36
Walls/Ceiling	Total Beta-Gamma	No	30	<553	18,720	<1,906
	Removable Alpha		30	<6	45	8
Building 408 Interior						
Beams	Total Beta-Gamma	No	30	<540	40,274	6,926
	Removable Alpha		30	<6	13	40
Columns	Total Beta-Gamma	Yes	30	<540	558	<552
	Removable Alpha		30	<6	13	<6

* Disintegrations per minute per 100 cm^2

TABLE A-18-3 Building 408 Core Sample Results

Location	Number of Measurements	Total Activity (DPA)*	Remarks
Room 101	1	17,019	Surface
	1	<504	2 cm deep
Room 136	1	58,900	Surface
	1	<504	2 cm deep
Room 116A	1	16,368	Surface
	1	<504	2 cm deep
Room 104/107	1	23,777	Surface
	1	<504	2 cm deep
Room 109	1	470,394	Surface
	1	651	2 cm deep
Room 114	1	23,467	Tile not removed
	1	1,240	Tile removed

* Disintegration sper minute per 100 cm^2

TABLE A-18-4 Building 408 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration
Breathing Zone	3.1×10^{-13} µCi/ml

Radon/Thoron Gas Concentrations

Sample Type	Concentration (pCi/l)
F	0.8
M	0.2
F	0.8
M	0.3

Radon/Thoron Daughter Concentrations

Sample	TDC Working Level	RDC Working Level
408-1A	0.001	0.002
408-1B	0.003	0.004

A-19 BUILDING 410

Building 410 is a one-story structural steel frame cinder-block building with a poured concrete floor and 52,300 square feet of gross floor area. The building contained the plant security office, health and safety office, kitchen, dining room, contaminated-laundry facility, and clean and contaminated locker rooms with shower facilities (MKF, 1988).

Building 410 has been surveyed twice. One survey was performed by RETA in 1977 and one survey was performed by the PMC in 1988. The RETA survey included:

- 432 total alpha measurements
- 292 removable alpha measurements
- 441 total beta-gamma measurements
- 167 total gamma measurements

One swipe sample taken in the laundry room was analyzed by alpha spectrometry and showed 85% radium and 15% uranium. Based on radium release guidelines, approximately 96% of removable alpha and 64% of total measurements reported by RETA are in the "releasable range." RETA reports obtaining positive NaI gamma spectra results in the laundry facility, the shower facilities, and in an instrument room in the building. However, RETA does not indicate which nuclides or what concentrations were associated with the positive results.

The second survey of Building 410 was performed by the PMC in 1988. Measurements were made in all 100 rooms. Results of the measurements are specified in Table A-19-1 according to room number designations currently existing in Building 410. The PMC survey included:

- o 1,672 total beta-gamma measurements
- o 1,677 removable alpha measurements
- o 10 bulk samples
- o 8 core samples
- o 2 airborne particulate samples
- o 4 radon/thoron gas samples
- o 2 radon/thoron daughter samples

Ten bulk samples were collected. The average activity of each radionuclide is given below:

Radionuclide	Activity (pCi/g - dry)
Ra-226	1.8 ± 0.4
U-234	77.3 ± 8.3
U-235	4.3 ± 1.2
U-238	81.6 ± 8.6
Th-230	11.7 ± 1.5
Th-232	1.5 ± 0.5
Th-228	1.6 ± 0.6

Based on these results, natural uranium is the predominant contaminant in Building 410. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-19-1. These results indicate that approximately 60% of the floor items and all wall/ceiling items are potentially releasable for unrestricted use.

While PMC sample results indicate uranium to be predominant in Building 410, with near background Ra-226 concentrations, the RETA report indicates Ra-226 to be the predominant radionuclide. This discrepancy is not understood, but the PMC results are assumed to be more representative of the

contamination in Building 410 based on the comprehensiveness of the PMC survey.

The building contains many large and small pieces of equipment, ranging from electric boilers to dishes in the kitchen. None of the equipment has been inventoried or scanned, so all of it is presently not releasable for unrestricted use.

Eight core samples were taken at locations on the floors which had high beta-gamma radiation levels. The results are presented in Table A-19-2. The radiation level 2 cm beneath the surface was less than the MDA of the detector at seven locations, and above the MDA of the detector at the eighth location. This suggests that part of the floor is volumetrically contaminated, and therefore surface contamination release criteria do not apply.

Results of all air samples are shown in Table A-19-3. Both long-lived alpha air particulate samples were below DAC guidelines for U-238. Both radon/thoron working level samples were at background levels. The two Type F radon and thoron gas samples and one Type M radon gas sample were at background levels. One Type M radon sample, however, exceeded background concentrations. Since the Type F sample at the same location measured a background concentration of radon and thoron gas, and radon daughter working levels were at background levels, the one above-background Type M result is probably erroneous.

TABLE A-19-1 Building 410 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<553	2,007	<696
	Removable Alpha		30	3	7	
South Wall	Total Beta-Gamma	Yes	30	<553	1,086	<608
	Removable Alpha		30	3	7	
East Wall	Total Beta-Gamma	Yes	30	<553	757	<575
	Removable Alpha		30	3	7	
West Wall	Total Beta-Gamma	No	30	<553	46,159	<2,397
	Removable Alpha		30	3	10	
Roof	Total Beta-Gamma	No	30	<540	8,581	3,245
	Removable Alpha		30	3	7	
Rooms 105A, 106A						
Floor	Total Beta-Gamma	Yes	30	<481	2,900	<1,400
	Removable Alpha		30	3	7	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,615	<686
	Removable Alpha		30	3	9	
Rooms 107A, 108A						
Floor	Total Beta-Gamma	No	30	1,972	83,790	11,932
	Removable Alpha		30	<6	15	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	3,944	<977
	Removable Alpha		30	<6	22	
Rooms 110A, 119A, 120A, 130A						
Floor	Total Beta-Gamma	No	30	1,346	4,351	<2,708
	Removable Alpha		30	<6	16	

TABLE A-19-1 Building 410 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	2,254	<1,172
	Removable Alpha		30	<6	7	
Rooms 111A, 112A, 114A-118A						
Floor	Total Beta-Gamma	No	30	1,471	8,294	4,272
	Removable Alpha		30	<6	13	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	2,976	<1,201
	Removable Alpha		30	<6	26	
Room 122B and Central Corridor						
Floor	Total Beta-Gamma	Yes	30	<540	1,003	<575
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,346	<649
	Removable Alpha		30	<6	26	
Rooms 155B, 123B-127B						
Floor	Total Beta-Gamma	Yes	30	<504	751	<520
	Removable Alpha		30	<6	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,252	<654
	Removable Alpha		30	3	10	
Rooms 128B-133B						
Floor	Total Beta-Gamma	Yes	27	<540	2,387	<738
	Removable Alpha		27	3	13	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,252	<643
	Removable Alpha		30	3	10	
Rooms 147B, 146, 152B						
Floor	Total Beta-Gamma	Yes	30	<481	2,754	<1,352
	Removable Alpha		30	3	7	

TABLE A-19-1 Building 410 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	867	<538
	Removable Alpha		30	3	10	
Room 145						
Serving Line	Total Beta-Gamma	Yes	30	<540	623	<545
	Removable Alpha		30	3	13	
Rooms 117B-121B						
Floor	Total Beta-Gamma	Yes	30	<540	626	<526
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,534	<613
	Removable Alpha		30	<6	9	
Rooms 101B-107B						
Floor	Total Beta-Gamma	Yes	26	<540	211	<703
	Removable Alpha		30	<6	16	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,375	<572
	Removable Alpha		30	<6	9	
Rooms 122A, 123A, 125A, 126A, 128A, 129A						
Floor	Total Beta-Gamma	No	30	1,408	7,481	3,859
	Removable Alpha		30	<6	13	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	2,560	<1,064
	Removable Alpha		30	<6	10	
Boiler Room						
Floor	Total Beta-Gamma	No	30	1,596	15,775	5,321
	Removable Alpha		30	<6	18	
Walls/Ceiling	Total Beta-Gamma	No	30	<504	7,794	<945
	Removable Alpha		30	<6	12	

TABLE A-19-1 Building 410 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Laundry Room						
Floor	Total Beta-Gamma	No	30	2,692	51,395	14,071
	Removable Alpha		30	<6	35	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	2,598	<793
	Removable Alpha		30	<6	18	
Rooms 134B and 153B						
Floor	Total Beta-Gamma	No	30	<481	38,750	<2,492
	Removable Alpha		30	3	13	
Walls/Ceiling	Total Beta-Gamma		30	<481	1,435	<685
	Removable Alpha	Yes	30	3	16	
Rooms 115C-120C						
Floor	Total Beta-Gamma	No	30	<481	4,096	<1,500
	Removable Alpha		30	3	7	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	727	<492
	Removable Alpha		30	3	17	
Rooms 109C-114C and 121C						
Floor	Total Beta-Gamma	Yes	30	<481	2,721	<920
	Removable Alpha		30	3	17	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	2,422	<663
	Removable Alpha		30	<6	<6	
Rooms 101C-106C, 124C						
Floor	Total Beta-Gamma	Yes	30	<504	2,535	<1,769
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,440	<758
	Removable Alpha		30	<6	<6	<6

TABLE A-19-1 Building 410 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Rooms 105C-108C, 123C, 126C, 127C						
Floor	Total Beta-Gamma	No	30	<481	7,024	<926
	Removable Alpha		30	<6	15	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,644	<780
	Removable Alpha		30	<6	9	
Room 108B and North Corridor						
Floor	Total Beta-Gamma	Yes	30	<504	970	<557
	Removable Alpha		30	<6	<6	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	761	<612
	Removable Alpha		30	<6	18	
Rooms 109B-113B						
Floor	Total Beta-Gamma	Yes	30	<540	796	<555
	Removable Alpha		30	<6	15	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	837	<512
	Removable Alpha		30	<6	<6	
Rooms 114B-116B						
Floor	Total Beta-Gamma	No	30	568	9,897	1,872
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	4,914	<1,310
	Removable Alpha		30	<6	12	
East and South Corridor						
Floor	Total Beta-Gamma	Yes	20	<540	2,457	<1,267
	Removable Alpha		30	<6	9	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,315	<754
	Removable Alpha		30	<6	<6	

TABLE A-19-1 Building 410 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Rooms 140b, 149B						
Floor	Total Beta-Gamma	Yes	30	<481	2,348	<786
	Removable Alpha		30	3	7	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	1,002	<559
	Removable Alpha		30	3	9.9	
Rooms 151B, 146B						
Floor	Total Beta-Gamma	Yes	30	927	2,302	1,475
	Removable Alpha		30	3	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<481	867	<579
	Removable Alpha		30	3	10	
Rooms 135B-139B, 141B-145B						
Floor	Total Beta-Gamma	Yes	30	<504	3,224	<1,507
	Removable Alpha		30	3	10	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<504	1,377	<612
	Removable Alpha		30	3	10	

* Disintegrations per minute per 100 cm^2

TABLE A-19-2 Building 410 Core Sample Results

Location	Total Activity (DPA)*	Remarks
B410 ST 0071	27,860	Surface brushed off
B410 ST 0071	1,260	2 cm deep
B410 ST 0071	595 (MDA+ = 540)	3 cm deep
B410 ST 0073	32,095	Surface untouched
B410 ST 0073	12,530	Surface brushed off
B410 ST 0073	<540	2 cm deep
B410 ST 0072	11,935	Surface untouched
B410 ST 0072	11,340	Surface brushed off
B410 ST 0072	<540	2 cm deep
B410 ST 0837	81,900	Surface untouched
B410 ST 0837	10,990	Surface brushed off
B410 ST 0837	<540	2 cm deep
B410 ST 0838	16,730	Surface untouched
B410 ST 0838	4,865	Surface brushed off
B410 ST 0838	<540	2 cm deep
B410 ST 1234	9,380	Surface untouched
B410 ST 1234	10,150	Surface brushed off
B410 ST 1234	<540	2 cm deep
B410 ST 1193	4,515	Surface untouched
B410 ST 1193	1,435	Surface brushed off
B410 ST 1193	<540	2 cm deep
B410 ST 1115	4,550	Surface untouched
B410 ST 1115	4,725	Surface brushed off
B410 ST 1115	<540	2 cm deep

* Disintegrations per minute per 100 cm^2
\+ Minimum Detectable Activity

TABLE A-19-3 Building 410 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	1.45×10^{-13}
Breathing Zone	3.72×10^{-13}

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/l)	Monitor Type
0.2	F
0.3	M
0.2	F
1.0	M

Radon/Thoron Daughter Concentrations

Location	TDC Working Level	RDC Working Level
410-1A	0.003	0.001
410-1B	0.002	0.001

A-20 BUILDING 412

Building 412 was the main electrical substation and contained the electrical equipment necessary for transforming incoming power from 34.5 kV to plant distribution power of 13.8 kV. The building is constructed of concrete block walls and a poured concrete roof deck supported by structural steel framework, and a floor of reinforced concrete. Overall dimensions are 50 ft x 23 ft x 13 ft high.

Adjacent to Building 412 was the transformer yard which is a fenced area with dimensions of 45 ft x 81 ft. All transformers were mounted on reinforced concrete pads. The transformers have been removed. This area is covered with six inches of crushed-rock fill (MKF, 1988d).

The PMC performed a radiological survey on Building 412 in 1988. The PMC survey included:

- 5 bulk samples
- 300 total beta-gamma measurements
- 300 removable alpha measurements
- numerous equipment scans
- 4 airborne particulate samples

Five bulk samples were collected. The average activity of each radionuclide is given below:

Radionuclide	Concentration (pCi/g-dry)
Ra-226	0.4 ± 0.3
U-234	36.4 ± 7.6
U-235	1.7 ± 1.6
U-238	33.4 ± 7.6

Radionuclide	Concentration (pCi/g-dry)
Th-230	6.5 ± 1.9
Th-232	0.4 ± 0.5
Th-228	1.0 ± 0.1

From these results, natural uranium is seen to be the predominant contaminant in Building 412; therefore uranium release criteria were applied to this building.

The total beta-gamma and removable alpha measurements are summarized in Table A-20-1. Also provided is the PMC determination of whether or not the structural components are potentially releasable for unrestricted use based on the PMC key criteria and natural uranium release criteria.

The floors are not releasable for unrestricted use because they had total radiation levels above release limits. However, when all visible dust and residue were wiped from floor sample locations, the total surface readings were reduced to background levels. For this reason, no core samples were taken.

An inventory of equipment remaining in Building 412 is on file with the PMC. Examples of items identified by the PMC include electrical equipment, light fixtures, cabinets and doors. Most of the approximately 60 items identified are potentially releasable for unrestricted use.

The results of the airborne particulate samples are presented in Table A-20-2. No readings exceeded the DAC guidelines.

No air samples were collected and analyzed for radon and thoron and their daughters. The results of the bulk samples show that there are background concentrations of Ra-226 and

Th-228 in this building, and therefore background concentrations of radon and thoron gas and radon/thoron daughters are expected.

TABLE A-20-1 Building 412 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
East Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	7	
North Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	7	
West Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	7	
South Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	7	
Roof	Total Beta-Gamma	No	30	987	5,330	<2,030
	Removable Alpha		30	<6	11	
Electrical Substation						
Equipment	Total Beta-Gamma	Yes	30	<540	1,038	<604
	Removable Alpha		30	<6	27	
Interior						
Walls/Ceiling	Total Beta-Gamma	Yes	30	<568	1,349	<594
	Removable Alpha		30	<6	14	
Beams	Total Beta-Gamma	Yes	30	<540	<540	<540
	Removable Alpha		30	<6	14	
Columns	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	14	
Floor	Total Beta-Gamma	No	30	<568	7,139	<1,145
	Removable Alpha		30	<6	11	

* Disintegrations per minute per 100 cm^2

TABLE A-20-2 Building 412 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (μCi/ml)
Breathing Zone	7.8×10^{-13}
Breathing Zone	1.1×10^{-13}
Breathing Zone	4.2×10^{-13}
Breathing Zone	1.4×10^{-13}

A-21 BUILDING 413

This building designation includes the pumphouse and the adjacent cooling tower. The cooling tower is constructed of redwood lumber and measures 30 ft x 90 ft x 22 ft high. This structure is built above a concrete collection basin which measures 90 ft x 40 ft x 5 ft deep and has an 8 ft wide x 3.5 ft deep dock on two sides.

The pumphouse is a steel frame building with corrugated asbestos and translucent plastic siding which houses the pumping facilities, and the chemical treatment and electrical equipment necessary for the operation. The building has a concrete floor that is 4 ft below grade with dimensions of 29 ft 2 in. x 49 ft 8 in. x 23 ft 9 in. high (MKF, 1988).

This building has been surveyed twice; once by RETA and once by the PMC.

RETA performed a radiological survey on Building 413 in 1977. The RETA survey included:

- 39 total alpha measurements
- 11 removable alpha measurements
- 43 total beta-gamma measurements
- 9 total gamma measurements

RETA assumed that this building contains only uranium, but no radionuclide analyses were performed to substantiate this assumption. All of the measurements on the loose surface contamination were in the "releasable" range. However, only about 90% of all the total surface radioactivity measurements were in this range. The few high readings were reported to be associated with the underground drainage pipes around the building perimeter.

The PMC surveyed Building 413 in 1988. The PMC survey included:

- o 8 bulk samples
- o 452 total beta-gamma measurements
- o 452 removable alpha measurements
- o 1 core sample
- o numerous equipment scans
- o 8 airborne particulate samples

Eight bulk samples of loose material on horizontal surfaces were collected. The average activity of each radionuclide in the sample is given below:

Radionuclide	Concentrations (pCi/g-dry)
Ra-226	0.8 ± 0.9
U-234	303.3 ±103.4
U-235	14.7 ± 9.5
U-238	326.5 ±103.4
Th-230	8.5 ± 3.4
Th-232	2.1 ± 2.6
Th-228	2.5 ± 3.4

From these results, the PMC concluded that natural uranium is the predominant contaminant in Building 413, and that it is appropriate to apply uranium release criteria to radiation measurements collected in this building.

Table A-21-1 presents a summary of the total beta-gamma and removable alpha measurements. Also presented is the PMC determination of which building components are potentially releasable for unrestricted use based on the PMC key criteria and natural uranium release criteria.

One core sample was taken on the pumphouse floor. After dust removal, the surface beta-gamma reading was 180,110 DPA indicating that the concrete surface was contaminated. After core removal the radiation level was approximately equal to the MDA of the detector, indicating that the concrete was not volumetrically contaminated, and therefore surface release guidelines could be applied.

An inventory of equipment remaining in Building 413 is on file with the PMC. Examples of equipment identified includes pumps, motors, light fixtures, and heaters. About one-half of the approximately 30 items identified are potentially releasable for unrestricted use.

Eight airborne particulate samples were collected. The results are presented in Table A-21-2. None of the sample concentrations exceeded DAC for U-238. No air samples were collected to determine the radon and thoron concentrations in Building 413, but results of the bulk samples indicate that there are background concentrations of Ra-226 and Th-228 present. Therefore, only background concentrations of radon and thoron gas and radon/thoron daughters are expected.

TABLE A-21-1 Building 413 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<540	1,349	<699
	Removable Alpha		30	<5	7	
South Wall	Total Beta-Gamma	No	30	<568	11,614	<3,566
	Removable Alpha		30	<6	29	
West Wall	Total Beta-Gamma	Yes	30	<568	2,402	<1,168
	Removable Alpha		30	<6	22	
East Wall	Total Beta-Gamma	No	30	<568	4,738	<1,431
	Removable Alpha		30	<6	22	
Roof	Total Beta-Gamma	No	30	3,224	10,660	6,219
	Removable Alpha		30	<6	11	
Cooling Tower	Total Beta-Gamma	No	30	1,086	22,898	6,420
	Removable Alpha		30	<6	35	
Concrete Dock						
Sides	Total Beta-Gamma	No	30	<568	42,441	<6,828
	Removable Alpha		30	<6	17	
Top	Total Beta-Gamma	No	30	1,513	60,141	24,110
	Removable Alpha		30	<6	<6	
Interior						
Beams	Total Beta-Gamma	No	30	<540	3,529	<1,402
	Removable Alpha		30	<6	7	
Columns	Total Beta-Gamma	Yes	30	<540	<568	<554
	Removable Alpha		30	<6	7	<6

TABLE A-21-1 Building 413 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	<568	<561
	Removable Alpha		30	<6	7	
Floor	Total Beta-Gamma	No	30	<568	81,822	<6,820
	Removable Alpha		30	<6	7	
Collection Basin	Total Beta-Gamma	No	30	7,271	166,507	47,024
	Removable Alpha		30	<6	<6	
Switch Boxes/Tanks	Total Beta-Gamma	No	32	<540	2,731	<733
	Removable Alpha		32	<6	14	
Handrails	Total Beta-Gamma	Yes	30	<540	2,457	<691
	Removable Alpha		30	<6	7	

* Disintegration sper minute per 100 cm^2

TABLE A-21-2 Building 413 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (μCi/ml)
Breathing Zone	$<1.1 \times 10^{-13}$
Breathing Zone	6.7×10^{-13}
Breathing Zone	$<9.9 \times 10^{-14}$
Breathing Zone	$<4.8 \times 10^{-14}$
Breathing Zone	2.3×10^{-13}
Breathing Zone	1.4×10^{-13}
Breathing Zone	4.1×10^{-13}
Breathing Zone	$<8.9 \times 10^{-14}$

A-22 BUILDING 414

This is a one-story structural steel building with corrugated aluminum siding measuring 20 ft x 60 ft which is situated on a 150-ft x 200-ft concrete storage pad. During WSUFMP operations it served as a salvage shop and equipment storage space. The building is being used at present by the PMC as a storage and maintenance area for groundskeeping equipment.

The storage pad was decontaminated by the Army in 1969 (MKF, 1988). Building 414 has been surveyed twice: once by RETA and once by the PMC.

RETA performed a radiological survey on this building in 1977. The RETA survey included:

- 24 total alpha measurements
- 12 removable alpha measurements
- 28 total beta-gamma measurements
- 6 total gamma measurements

RETA found that nearly 100% of the measurements on loose surface contamination are in the "releasable" range, but only 95% of total radioactivity measurements are in this range. RETA did not perform any radionuclide analyses on surface materials, but assumed that the only significant activity present was due to uranium.

The PMC surveyed Building 414 in 1988. The PMC survey included:

- 5 bulk samples
- 333 total beta-gamma measurements
- 333 removable alpha measurements

- o 1 core sample
- o equipment scans
- o 2 airborne particulate samples

Five bulk samples were collected. The average concentration of each radionuclide is listed below:

Radionuclide	Activity (pCi/g - dry)
Ra-226	1.1 ± 0.1
U-234	13.6 ± 1.0
U-235	0.8 ± 0.4
U-238	14.5 ± 1.7
Th-230	5.2 ± 0.4
Th-232	1.3 ± 0.2
Th-228	0.2 ± 0.1

Based on these results, natural uranium is the predominant contaminant in Building 414. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-22-1.

A core sample was taken on the concrete floor. Before core removal, the beta-gamma reading was 5,797 DPA. After core removal, the reading was below the MDA of the detector, indicating that the floor is not volumetrically contaminated. For this reason, it is appropriate to apply surface release criteria to the floor.

An inventory of equipment presently housed in Building 414 is on file with the PMC. Most equipment contains interior surfaces which were inaccessible to scanning meters and therefore were determined to be not releasable at present. Examples of equipment that was completely scanned include seven

storage cabinets and 23 incandescent lamps, all found to be not releasable.

Two long-lived alpha air particulate samples were collected in this building. The results are given in Table A-22-2. Neither of the samples exceeded the DAC guideline for U-238.

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TABLE A-22-1 BUILDING 414 RADIOLOGICAL SURVEY RESULTS

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<504	1,209	<550
	Removable Alpha		30	<2.5	6	
South Wall	Total Beta-Gamma	Yes	30	<504	1,891	<597
	Removable Alpha		30	<2.5	16	
East Wall	Total Beta-Gamma	No	30	<504	3,813	<1,016
	Removable Alpha		30	<2.5	7	
West	Total Beta-Gamma	Yes	30	<504	<504	<504
	Removable Alpha		30	<2.5	7	
Roof	Total Beta-Gamma	No	30	1,003	9,826	3,346
	Removable Alpha		30	<2.5	7	
Interior						
Walls/Ceiling	Total Beta-Gamma	Yes	29	<504	11,894	<956
	Removable Alpha		30	<2.5	43	
Columns	Total Beta-Gamma	Yes	30	<504	<504	<504
	Removable Alpha		30	<2.5	36	
Beams	Total Beta-Gamma	No	33	<504	13,490	<4,376
	Removable Alpha		33	<2.5	89	
Floor	Total Beta-Gamma	No	31	<504	22,692	<6,739
	Removable Alpha		30	<2.5	7	
South Concrete Pad	Total Beta-Gamma	No	30	<504	49,485	<4,945
	Removable Alpha		30	<2.5	3	<2.5
North Concrete Pad	Total Beta-Gamma	Yes	30	<504	1,534	<792
	Removable Alpha		30	<2.5	3	<2.5

*Disintegrations per minute per 100 cm^2

TABLE A-22-2 Building 414 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	8.5×10^{-13}
Breathing Zone	3.1×10^{-13}

A-23 BUILDING 415

Building 415 is an incinerator which was used to burn trash and classified documents. The incinerator is a brick structure with dimensions of 6 ft x 10 ft x 7 ft high.

Building 415 has been surveyed twice: once by RETA and once by the PMC. A few measurements were taken in and around this building by RETA in 1977. RETA reported that all measurements were in the "releasable" range assuming the primary contaminant was natural uranium (RETA, 1978).

The PMC surveyed this building in 1988. The PMC survey included:

- 5 bulk samples
- 60 total beta-gamma measurements
- 60 removable alpha measurements
- equipment scans
- 2 airborne particulate samples

Five bulk samples were collected. The average activity of each radionuclide in the sample is given below.

Radionuclide	Activity (pCi/g-dry)
Ra-226	1.0 ± 0.8
U-234	84.4 ± 18.5
U-235	4.4 ± 2.5
U-238	83.8 ± 18.9
Th-230	1.6 ± 1.0
Th-232	0.4 ± 0.3
Th-228	0.5 ± 0.4

The results of these samples indicated that natural uranium is the predominant contaminant in the incinerator.

The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-23-1. Also included is the PMC determination of which building components are potentially releasable for unrestricted use based on the PMC key criteria and natural uranium release criteria.

Total beta-gamma and removable alpha measurements were not taken on the interior of the incinerator because initial scanning confirmed the presence of above guideline contamination, as expected based on historical information. Therefore, the interior is presently considered not releasable.

Equipment associated with the incinerator includes an exhaust duct, angle iron, small metal doors, frames and counterweights. All equipment was scanned and all was found to be potentially releasable except for the doors and the counter-weights.

Two gross alpha air particulate samples were collected in Building 415. The results are given in Table A-23-2. Neither of the samples exceeded the DAC for U-238.

TABLE A-23-1 BUILDING 414 RADIOLOGICAL SURVEY RESULTS

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Building Exterior	Total Beta-Gamma	No	30	1,176	4,844	2,470
	Removable Alpha		30	<6	13	
Building Base	Total Beta-Gamma	No	30	<540	6,263	3,241
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-23-2 Building 415 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (μCi/ml)
Breathing Zone	1.4×10^{-13}
Breathing Zone	$<6.6 \times 10^{-14}$

A-24 BUILDING 417

Building 417, the Paint Shop, was part of the maintenance facilities. It is a one-story structure of steel frame and concrete block construction with a concrete floor and gypsum concrete roof deck. The gross area of the building is 2,772 square feet.

The building is divided into three sections: the general work area, the spray-painting area and the flammable material storage room. The original blueprints show only two areas; a room was added later on the east side and the spray booth was moved into it.

The general work area located in the north and west part of Building 417 was used for storage of paint cans and equipment used in the paint shop. There are numerous small and large pieces of equipment in this area. Furniture such as lockers, tables, chairs and workbenches are also present.

The equipment in the spray-painting room includes the spray-painting booth and cabinets.

The flammable material storage area is a room located on the south side of the building. Equipment such as carts and barrels, stands, tables and steam heaters is present.

This building has been surveyed twice; once by RETA and once by the PMC.

RETA performed a radiological survey on Building 417 in 1977. The RETA survey included:

- 12 total alpha measurements
- 12 removable alpha measurements

- o 29 total beta-gamma measurements
- o 2 total gamma measurements

Nearly 100% of the measurements on loose surface contamination were reported in the "releasable" range, assuming the only significant activity present is natural uranium. Of the measurements on total surface contamination, about 55% were in the "releasable" range, 10% were in the "moderately contaminated" range, and about 35% in the "highly contaminated" range. The assumption of natural uranium contamination was based on the results of a composite sample made from the wipes of several buildings, of which Building 417 was the most contaminated. The results indicated about 88% uranium, 10% thorium, and 2% radium (RETA, 1978).

The PMC surveyed this building in 1988. The PMC survey included:

- o 1 bulk sample
- o 270 total beta-gamma measurements
- o 270 removable alpha measurements
- o 1 core sample
- o 1 airborne particulate sample
- o 4 radon/thoron gas samples

One bulk sample was collected, and the results are given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	1.2 ± 0.5
U-234	960 ± 100
U-235	47 ± 5
U-238	1000 ± 100
Th-230	2.6 ± 0.5

Radionuclide	Activity (pCi/g-dry)
Th-232	0.56 ± 0.23
Th-228	<0.5

The results indicate that natural uranium is the predominant contaminant in this building, and that it is appropriate to apply natural uranium release criteria to this building.

The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-24-1. Also provided is the PMC determination of which building components are potentially releasable for unrestricted use based on the PMC key criteria and natural uranium release criteria.

One core sample was taken on the floor. Before core removal, the beta-gamma reading was 28,455 DPA. After core removal, the radiation level was less than the MDA of the detector, indicating that the floor is not volumetrically contaminated and therefore surface release criteria are applicable.

An inventory of the equipment remaining in Building 417 is on file with the PMC. Examples of equipment remaining include light fixtures, tables and desks, shelves, pipe and conduit. All equipment was determined by the PMC to be not releasable for unrestricted use. No scans were made since almost all of the building had been found to be not releasable.

Air samples were analyzed for gross alpha air particulates, and radon and thoron gas. Results are presented in Table A-24-2.

The single air particulate sample had a long-lived alpha concentration less than the DAC for U-238. Both the Type F and the Type M samples were slightly above background but below the

DAC, indicating the presence of above-background thoron concentrations. However, this is not supported by the bulk sample results, which indicate Th-228 concentrations slightly below background levels. The source of the above-background thoron concentrations is therefore not known at present, but further air sampling would identify it.

TABLE A-24-1 Building 417 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
South Wall	Total Beta-Gamma	No	30	<568	5,922	<1,460
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	No	30	<568	23,425	<2,750
	Removable Alpha		30	<6	13	
West Wall	Total Beta-Gamma	No	30	1,020	6,284	2,986
	Removable Alpha		30	<6	9	
North Wall	Total Beta-Gamma	No	30	592	20,859	6,182
	Removable Alpha		30	<6	17	
Roof	Total Beta-Gamma	No	30	2,518	55,162	17,501
	Removable Alpha		30	<6	20	
Interior						
Floor	Total Beta-Gamma	No	30	588	35,603	4,986
	Removable Alpha		30	<5	17	
Walls/Ceiling	Total Beta-Gamma	Yes	30	<540	1,349	<638
	Removable Alpha		30	<6	20	
Beams	Total Beta-Gamma	No	30	692	227,800	13,397
	Removable Alpha		30	<6	531	
Columns	Total Beta-Gamma	No	15	<540	5,363	<1,043
	Removable Alpha		15	<5	9	
Pipes/Conduits	Total Beta-Gamma	No	15	<540	4,636	<154
	Removable Alpha		15	<5	107	

* Disintegrations per minute per 100 cm^2

TABLE A-24-2 Building 417 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	5.1×10^{-13}

Radon/Thoron Gas Concentrations

Monitor Type	Concentration (pCi/l)
F	1.1
M	0.7
F	0.7
M	0.5

A-25 BUILDING 426

The Building 426 designation refers to an elevated water storage tank which supplies water to St. Charles County. It is ellipsoidal in shape and has a capacity of 350,000 gallons (AEC, 1960).

This building has been surveyed twice; once by RETA, and once by the PMC.

RETA surveyed this building in 1977. The RETA survey included:

- o 4 total alpha measurements
- o 1 total gamma measurement

All measurements were at the "releasable" level, assuming that all activity is due to natural uranium. However, RETA performed no radionuclide analyses of surface material samples to verify this assumption (RETA, 1978).

In 1988, the PMC surveyed the water tower. The PMC survey included:

- o 120 total beta-gamma measurements
- o 120 removable alpha measurements

Table A-25-1 presents the maximum, minimum, and average radiation levels found and the releasability of each item based on the PMC key criteria and natural uranium release criteria.

During the survey it was not possible to make measurements above 60 feet. Therefore the radiological status of the tank itself is unknown. However, the interior of the tank is assumed

to be uncontaminated due to the positive pressure of the water which would prevent contamination from entering.

Additional exterior measurements will have to be made above the 60 foot level in order to determine radiological status.

TABLE A-25-1 Building 426 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Water Tower Vertical Columns	Total Beta-Gamma	Yes	30	<504	<504	<504
	Removable Alpha		30	<6	<6	
I-Beam ledge away from plant	Total Beta-Gamma	Yes	30	1,020	2,822	1,921
	Removable Alpha		30	<6	<6	
Top I-Beam	Total Beta-Gamma	Yes	30	<500	2,788	1,034
	Removable Alpha		30	<6	8	
I-Beam facing Plant	Total Beta-Gamma	No	30	1,700	5,542	3,045
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

A-26 BUILDING 427

Building 427 is the primary sewage treatment plant located near the south boundary line of the site. It was sized to handle sewage wastes for approximately 1,300 persons per day. Large equipment remaining in the building includes an Imhoff tank used for sludge settling and digestion, a comminutor and bar screen structure for handling the influent, and a sump installed for sludge removal.

Building 427 was surveyed by RETA in 1977. The RETA survey included:

- 10 total alpha measurements
- 25 total beta-gamma measurements
- 21 total gamma measurements

The results of these measurements are summarized in Table A-26-1.

About 68% of the total surface contamination measurements are in the "releasable" range, assuming the only significant activity in the building is due to natural uranium. About 4% of the remaining measurements are at the "moderately contaminated" level, and about 28% are at the "highly contaminated" level. RETA did not obtain loose surface contamination measurements (RETA, 1978).

Radionuclide analyses of bulk samples from Building 427 have not been performed, so identity and concentrations of radionuclides present are currently unknown. Air samples have not been collected in this structure, so radon and thoron gas and radon/thoron daughter concentrations as well as long-lived alpha activity on airborne particulates are also unknown. The equipment has not been scanned or inventoried and is all presently considered not releasable. Building 427 will have to

be surveyed by the PMC in order to determine the present radiological status.

TABLE A-26-1
BUILDING 427 RADIOLOGICAL SURVEY RESULTS [a]

RADIATION LEVEL RANGE (DPA)[b]	NUMBER OF MEASUREMENTS COLLECTED TOTAL ALPHA[c]	TOTAL BETA-GAMMA	TOTAL GAMMA
>0.1 lbs uranium	-	0	1
15,000< x <0.1 lbs. uranium	0	1	14
5,000< x <15,000	0	1	1
1,000< x <5,000	0	0	5
300< x <1,000	0	5	0
x <300	10	18	0
TOTAL NUMBER OF MEASUREMENTS	10	25	21

(a) Source: RETA, 1978
(b) Disintegrations per minute per 100 cm^2
(c) Loose surface contamination was not monitored.

A-27 BUILDING 428

Building 428 is a propane gas plant which supplied fuel gas to the various buildings for process heating. The building still contains assorted equipment used to operate the propane gas plant along with numerous transfer lines of different sizes. The building is fabricated with an asbestos material. The approximate dimensions of the structure are 24 ft x 14 ft x 16 ft (MKF, 1988).

Building 428 has been surveyed twice; once by RETA, and once by the PMC.

RETA performed a radiological survey of this building in 1977. The RETA survey included:

- 6 total alpha measurements
- 3 removable alpha measurements
- 7 total beta-gamma measurements
- 5 total gamma measurements

RETA found that 100% of the loose surface contamination measurements are in the "releasable" range. However, only about 70% of the total surface contamination measurements are in this range, assuming the only significant activity is due to natural uranium. About 15% of the remaining measurements are in the "moderately contaminated" range, and 15% are in the "highly contaminated" range. Most of these high readings are associated with the area around fuel gas pumps in the northeast corner of the building. RETA did not perform any radionuclide analyses on loose surface material to confirm the assumption of natural uranium being the predominant contaminant in this building (RETA, 1978).

The PMC surveyed Building 428 in 1988. The PMC survey included:

- o 5 bulk samples
- o 300 total beta-gamma measurements
- o 300 removable alpha measurements
- o 1 core sample
- o equipment scans
- o 5 airborne particulate samples

Five bulk samples were collected. The average activity of each radionuclide in the samples is given below.

Radionuclide	Activity (pCi/g-dry)
Ra-226	3.5 ± 1.5
U-234	139.6 ± 42.3
U-235	5.0 ± 4.6
U-238	123.6 ± 32.8
Th-230	13.4 ± 2.3
Th-232	3.7 ± 0.9
Th-228	4.6 ± 0.9

The analytical results indicate natural uranium and natural thorium to be the primary contaminants. Therefore the mixture role will apply to release of material from this building.

The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-27-1. The maximum, minimum, and average radiation measurements found are presented along with the releasability of each item as determined by the PMC.

One core sample was taken on the floor. Before core removal, the beta-gamma radiation level was 24,552 DPA. After core removal, the radiation level was less than the MDA of the detector. This indicates that the floor is surficially contaminated, and therefore surface release criteria can be applied.

An inventory of equipment remaining in Building 428 is on file with the PMC. Examples of equipment identified include electric motors, pipe, light fixtures, and fire hose. All but 4 of the approximately 50 items identified by the PMC were determined to be not releasable at present.

Five long-lived alpha airborne particulate samples were collected. The results are presented in Table A-27-2. None of the samples exceeded the DAC guideline for U-238.

TABLE A-27-1 Building 428 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<568	2,040	<755
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<568	<2,402	<1,297
	Removable Alpha		30	<6	7	
West Wall	Total Beta-Gamma	Yes	30	<568	790	<585
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<568	2,632	1,572
	Removable Alpha		30	<6	7	
Roof	Total Beta-Gamma	Yes	30	790	4,047	2,278
	Removable Alpha		30	<6	11	
Interior						
Floor	Total Beta-Gamma	No	30	<540	36,651	<6,705
	Removable Alpha		30	<5	61	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<540	757	<566
	Removable Alpha		30	<5	7	
Beams	Total Beta-Gamma	No	30	<540	12,897	2,434
	Removable Alpha		30	<6	18	
Columns	Total Beta-Gamma	Yes	30	<540	691	<545
	Removable Alpha		30	<6	11	
Propane Tanks	Total Beta-Gamma	Yes	30	<568	625	<570
	Removable Alpha		30	<6	7	

* Disintegrations per minute per 100 cm^2

TABLE A-27-2 Building 428 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	2.9×10^{-12}
Breathing Zone	7.5×10^{-14}
Breathing Zone	7.4×10^{-14}
Breathing Zone	1.4×10^{-13}
Breathing Zone	$<2.1 \times 10^{-13}$

A-28 BUILDING 429

This building designation includes a pump house and a 700,000 gallon ground storage tank, which were known collectively as the Reserve Water Facilities. The pump house is a standard prefabricated type steel building erected on a reinforced concrete slab and is 28 ft long, 24 ft wide, and 17 ft high (MKF, 1988).

Building 429 has been surveyed twice: once by RETA, and once by the PMC.

RETA performed a radiological survey of this building in 1977. The RETA survey included:

- 4 total alpha measurements
- 4 total gamma measurements

RETA did not enter the building; all measurements were taken on external surfaces. All measurements were in the "releasable" range, assuming that the only significant activity in this building is due to natural uranium. However, RETA did not perform any radionuclide analyses on surface material samples to confirm this assumption. Loose surface contamination measurements were not obtained (RETA, 1978).

The PMC surveyed this building in 1988. The PMC survey included:

- 270 total beta-gamma measurements
- 270 removable alpha measurements
- 1 core sample
- equipment scans

The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-28-1, which lists the minimum, maximum and average radiation levels found and the releasability of each item as determined by the PMC. The PMC assumed, like RETA, that the only significant activity in this building is due to natural uranium.

One core sample was taken on the floor of this building. The radiation level at the undusted location was 1,435 DPA. After the location was dusted, the radiation level was 1,470 DPA, indicating that the concrete surface was contaminated. After core removal, the radiation level was less than the MDA of the detector, indicating that contamination is surficial on the floor.

An inventory of equipment remaining in Building 429 is on file with the PMC. Examples of equipment remaining include piping, electrical boxes, and water pumps. All but 3 of the approximately 25 items identified are potentially releasable based on the assumption of natural uranium contamination.

TABLE A-28-1 Building 429 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<504	961	<524
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<504	1,054	<563
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<504	2,945	<716
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<504	2,108	<640
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	30	727	4,775	2,507
	Removable Alpha		30	<6	<6	
Tank Sides	Total Beta-Gamma	Yes	30	<540	<540	<540
	Removable Alpha		30	<6	9	
Tank Top	Total Beta-Gamma	Yes	30	<540	2,422	<686
	Removable Alpha		30	<6	9	
Interior						
Floor	Total Beta-Gamma	Yes	30	<504	2,733	<1,321
	Removable Alpha		30	<6	9	
Walls	Total Beta-Gamma	Yes	30	<540	796	<551
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

A-29 BUILDING 430

Building 430 was known as the ambulance garage. The structure consists of cinder-block walls with an aluminum corrugated ceiling and garage door. Cabinets and miscellaneous debris are present. The approximate dimensions of the garage are 20 ft x 20 ft x 15 ft (MKF, 1988).

This building has been surveyed twice: once by RETA and once by the PMC.

In 1977, RETA took a few measurements in and around this building which were all at the "releasable" level, assuming natural uranium contamination.

The PMC performed a radiological survey on this building in 1988. The PMC survey included:

- 5 bulk samples
- 270 total beta-gamma measurements
- 270 removable alpha measurements
- 1 core sample
- equipment scans

Five bulk samples were collected. The average activity of each radionuclide in the sample is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	2.22 ± 0.28
U-234	90.0 ± 8.6
U-235	5.36 ± 0.84
U-238	94.6 ± 8.8
Th-230	6.66 ± 0.72

Radionuclide	Activity (pCi/g-dry)
Th-232	3.38 ± 0.47
Th-228	<11.46

The analtyical results indicate natural uranium and natural thorium to be the primary contaminants. Thererfore the mixture rule will apply to release of material from this building.

The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-29-1, along with the determination of releasability based on the PMC key criteria.

One core sample was taken on the floor at a location that exceeded uranium release limits. Before core removal, the beta-gamma reading was 8,215 DPA. After core removal, the reading was less than the MDA of the detector, showing that contamination is only surficial on the floor.

An inventory of equipment remaining in Building 430 is on file with the PMC. Examples of equipment identified include piping, light fixtures and portable ladders.

TABLE A-29-1 Building 430 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<504	682	<536
	Removable Alpha		30	<2.5	6	
South Wall	Total Beta-Gamma	Yes	30	<504	806	<519
	Removable Alpha		30	<2.5	6	
East Wall	Total Beta-Gamma	Yes	30	<504	899	<535
	Removable Alpha		30	<2.5	<2.5	
West Wall	Total Beta-Gamma	No	30	<504	930	<577
	Removable Alpha		30	<2.5	<2.5	
Interior						
Floor	Total Beta-Gamma	No	30	1,349	7,197	3,181
	Removable Alpha		30	<2.5	6	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<540	1,107	<611
	Removable Alpha		30	<2.5	10	
Roof	Total Beta-Gamma	No	30	1,107	17,784	6,508

* Disintegrations per minute per 100 cm^2

A-30 BUILDING 431

This building served as a sampling station for the process stream wastes from Building 407. The process stream wastes consisted of large quantities of laboratory wastes containing chemicals and radioactive material highly diluted with water.

This proof sampling station consists of a concrete structure and flume below ground covered by a prefabricated steel housing. The structure houses a proof sampler enclosed in a cabinet, a storage tank, instrumentation and an electric heater. The concrete structure below grade houses the flume, flow orifices, pumps and auxiliary instrumentation. The steel building is 12 ft x 12 ft x 14 ft high. The below-grade structure has dimensions of 12 ft x 12 ft x 13 ft deep (MKF, 1988).

Building 431 has been surveyed twice: once by RETA, and once by the PMC.

RETA took a few measurements in and around this building in 1977. They were at the "moderately contaminated" level.

The PMC performed a radiological survey on this building in 1988. The PMC survey included:

- 5 bulk samples
- 250 total beta-gamma measurements
- 250 removable alpha measurements
- 1 core sample
- 1 radon/thoron daughter air sample

The average activity of each radionuclide in the bulk samples is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	3.6 ± 1.2
U-234	618 ± 136.4
U-235	53.8 ± 14.1
U-238	662 ± 136.4
Th-230	12.1 ± 3.7
Th-232	3.8 ± 2.2
Th-228	6.2 ± 2.2

The analytical results indicate natural uranium and natural thorium to be the primary contaminants. Therefore the mixutre role will apply to release of material from this building.

The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-30-1. The minimum, maximum, and average radioactivity measurements and the releasability of each item as determined by the PMC are given.

One core sample was taken on the floor. Before core removal the radiation level at the surface was 20,615 DPA. After core removal, the radiation level was still above the MDA of the detector, so the floor is volumetrically contaminated and surface release criteria do not apply.

One air sample was collected in Building 431. It showed that the thoron daughter concentration in this building was 0.007 WL, and the radon daughter concentration was 0.001 WL. These values are below the DAC guidelines. Radon and thoron gas concentrations have not been measured.

TABLE A-30-1 Building 431 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	No	30	<504	5,859	<1,091
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<504	1,922	<761
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<504	2,046	<635
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<504	4,340	<999
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	30	<504	1,922	<860
	Removable Alpha		30	<6	9	
Interior						
Floor	Total Beta-Gamma	No	30	2,077	32,829	10,787
	Removable Alpha		30	<6	20	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<504	1,333	<550
	Removable Alpha		30	<6	13	
Beams	Total Beta-Gamma	No	30	<504	13,919	<3,200
	Removable Alpha		30	<6	45	
Columns	Total Beta-Gamma	Yes	30	<504	2,666	<657
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

A-31 BUILDING 432

Building 432 was another sampling station for the process stream wastes. It is similar to Building 431 in both design and function. The building consists of a below-grade concrete structure and an above-grade prefabricated steel housing. The below-grade structure has dimensions 12 ft x 12 ft x 13 ft deep. The above grade structure is 12 ft x 12 ft x 14 ft high. (MKF, 1988).

Building 432 has been surveyed by RETA and by the PMC. In 1977, RETA took a few measurements in and around this building. They were all at the "releasable" level (RETA, 1978).

The PMC performed a radiological survey on this building in 1988. The PMC survey included:

- 5 bulk samples
- 270 total beta-gamma measurements
- 270 removable alpha measurements
- 1 core sample
- equipment scans
- 1 radon/thoron daughter air sample

A total of five bulk samples were collected in the above- and below-ground structures of Building 432. The average activity of each radionuclide found in the samples is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	3.1 ± 0.8
U-234	68.8 ± 22.3
U-235	5.3 ± 17.1
U-238	88.2 ± 23.2
Th-230	10.0 ± 3.0
Th-232	1.3 ± 1.6
Th-228	1.2 ± 0.7

Based on these results, the PMC concluded that natural uranium is the predominant contaminant and that it is appropriate to apply natural uranium release criteria to Building 432. Alpha and beta-gamma measurement results for the various items as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-31-1.

A core sample was taken on the concrete floor. The beta-gamma radiation level at this location was 8,509 DPA before loose debris was removed and 8,877 DPA after debris removal, indicating that the floor is a significant source of beta-gamma radiation. A 2 cm core was removed and the beta-gamma radiation level on the freshly exposed surface was less than the MDA of the detector, indicating surficial rather than volumetric contamination of the floor.

An inventory of the equipment remaining in Building 432 along with associated scanning results are on file with the PMC. All of the underground equipment was determined by the PMC to be not releasable for unrestricted use. Nineteen of the 20 items composing the above-ground equipment are potentially releasable.

One radon/thoron daughter concentration air sample was collected in the below-ground structure. The radon daughter concentration was 0.003 WL, and the thoron daughter concentration was 0.007 WL, which are both at approximately background levels.

No air samples have been collected to measure the radon and thoron concentrations in this building. However, the Ra-226 and Th-228 concentrations found in the bulk samples suggest that radon and thoron concentrations will probably be near background levels.

TABLE A-31-1 Building 432 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<568	625	<570
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	9	
Roof	Total Beta-Gamma	Yes	30	<568	1,283	<614
	Removable Alpha		30	<6	<6	
Interior						
Floor	Total Beta-Gamma	No	30	<553	16,516	<2,502
	Removable Alpha		30	<6	<6	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	9	
Beams	Total Beta-Gamma	Yes	30	<568	2,007	<763
	Removable Alpha		30	<6	<6	
Columns	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

A-32 BUILDING 433

Building 433 is constructed of industrial prefabricated steel; i.e., steel beam frame with sheet metal exterior. The floor is a paved concrete slab. The building is 40 ft x 182 ft x 24 ft high and was used for the storage of maintenance vehicles and small mechanical components. Much of the equipment remains in the building at present. A small concrete structure is attached to the southeast corner and measures 13 ft x 13.5 ft x 11 ft high (MKF, 1988).

Building 433 has been surveyed twice: once by RETA and once by the PMC.

In 1977, RETA took a few measurements in and around this building. All the measurements were at the "releasable" level.

The PMC performed a radiological survey on this building in 1988. The PMC survey included:

- 6 bulk samples
- 458 total beta-gamma measurements
- 458 removable alpha measurements
- 1 core sample
- 4 radon/thoron gas samples
- 1 airborne particulate sample

Six bulk samples of loose debris were collected. The average activity of each radionuclide in the samples is given below.

Radionuclide	Activity (pCi/g-dry)
Ra-226	1.4 ± 1.0
U-234	83.7 ± 24.5

Radionuclide	Activity (pCi/g-dry)
U-235	4.5 ± 2.2
U-238	83.9 ± 24.6
Th-230	11.0 ± 3.6
Th-232	2.7 ± 1.8
Th-228	2.5 ± 1.2

Based on these results, the PMC concluded that natural uranium is the predominant radionuclide and that it is appropriate to apply natural uranium release criteria to this building. Alpha and beta-gamma measurement results for the various items as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-32-1.

One core sample was taken on the floor of the concrete structure. The beta-gamma radiation level at the surface was 4,257 DPA before core removal and 1,023 DPA after core removal. This shows that contamination has seeped beneath the surface of the floor and therefore surface release criteria do not apply.

Building 433 contains a large quantity of equipment, all of which the PMC considers to be not releasable at present. A detailed inventory of this equipment is on file with the PMC.

The results of the air samples collected in this building are presented in Table A-32-2. One Type F sample was above background and both Type M samples were near background, indicating the possibility of above-background thoron concentrations in this building. However, the second Type F sample indicated near background concentrations, and the Th-228 concentrations in the bulk sample results are not high enough to indicate a source of above-background thoron concentrations.

The source of above-background thoron concentrations could be identified through further air sampling. In any event all measured radon and thoron concentrations are below DAC guidelines. The breathing zone sample analyzed for long-lived alpha activity revealed a concentration below the DAC guideline for U-238.

TABLE A-32-1 Building 433 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Concrete Structure						
Exterior						
South Wall	Total Beta-Gamma	Yes	30	<540	1,314	<882
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<568	1,052	<709
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	554	1,453	949
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	30	1,384	4,083	2,696
	Removable Alpha		30	<6	<6	
Interior Walls	Total Beta-Gamma	No	30	<553	1,546	<631
	Removable Alpha		30	<6	7	
Sheet Metal Building						
Exterior						
Aluminum North Wall	Total Beta-Gamma	No	33	735	9,590	2,079
	Removable Alpha		33	<6	9	
Aluminum South Wall	Total Beta-Gamma	Yes	30	<540	1,316	<791
	Removable Alpha		30	<6	9	
Aluminum West Wall	Total Beta-Gamma	Yes	30	<568	2,249	<949
	Removable Alpha		30	<6	28	

* Disintegrations per minute per 100 cm^2

TABLE A-32-1 Building 433 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Aluminum East Wall	Total Beta-Gamma	Yes	30	<553	2,284	<861
	Removable Alpha		30	<6	9	
Aluminum Roof	Total Beta-Gamma	Yes	30	724	3,290	1,788
	Removable Alpha		30	<6	<6	
Interior Walls and Ceiling Aluminum Bldg	Total Beta-Gamma	Yes	30	<513	4,145	<932
	Removable Alpha		30	<6	7	
Columns	Total Beta-Gamma	No	30	<553	6,843	<1,206
	Removable Alpha		30	<6	11	
Floor	Total Beta-Gamma	No	30	790	5,330	2,971
	Removable Alpha		30	<6	14	
Piping and Conduits	Total Beta-Gamma	No	30	<540	2,906	<750
	Removable Alpha		30	<5	11	

* Disintegrations per minute per 100 cm^2

TABLE 32-2 Building 433 Air Sample Results

Long-Lived Alpha Air Particulate Concentration

Sample Type	Concentration
Breathing Zone	3.84×10^{-13} µCi/ml

Radon/Thoron Gas Concentrations

Monitor Type	Concentration (pCi/l)
F	1.7
M	0.8
F	0.5
M	0.8

A-33 BUILDING 434

This is a single-story structure with 19,200 square feet of floor space constructed in an industrial prefabricated steel design; i.e. steel beam frame with sheet metal exterior. The floor is paved concrete slab. This building was used by the AEC for storage of high-value ore concentrates.

Building 434 is currently being used for temporary storage of contaminated materials and debris gathered during various clean-up efforts. The majority of this material consists of double-bagged asbestos insulation removed from overhead piping and Building 401, and drums of contaminated soil and debris. A complete listing of material stored in this building is presented in a PMC inter-office correspondence (MKF and JEG, 1989).

Building 434 has been surveyed once by the PMC in 1988. The PMC survey included:

- 4 bulk samples
- 348 total beta-gamma measurements
- 348 removable alpha measurements
- 2 core samples
- 1 airborne particulate sample
- 4 radon/thoron gas air samples

Four bulk samples were collected. The average activity of each radionuclide in the sample is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	12.6 ± 2.3
U-234	1063.3 ± 217.7

Radionuclide	Activity (pCi/g-dry)
U-235	51.0 ± 7.4
U-238	873.3 ± 141.4
Th-230	109.7 ± 14.7
Th-232	1.9 ± 1.0
Th-228	<2.0

Based on these results, it can be concluded that natural uranium is the predominant radionuclide in this building. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-33-1.

Two core samples were taken on the floor. One location had a total activity of 20,150 DPA at the surface, the other 50,964 DPA at the surface. Both locations had activities greater than the MDA of the detector after core removal, which shows that contamination has seeped beneath the surface of the floor. Therefore, surface contamination release criteria do not apply to the floor of this building.

An inventory of equipment remaining in Building 434 which is not associated with the contaminated material storage is on file with the PMC. This equipment has been determined by the PMC to be not releasable at present.

Air sample results are presented in Table A-33-2. Measured radon and thoron gas concentrations are all near background levels and are below DAC guidelines. The long-lived alpha activity concentration measured on the breathing zone sample is below the DAC guideline for U-238.

TABLE A-33-1 Building 434 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	No	30	<540	1,453	<600
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	No	30	<540	1,142	<564
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	No	30	<540	554	<541
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	No	30	<540	588	<542
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	No	60	<540	1,680	<830
	Removable Alpha		60	<6	9	
Interior						
Floor	Total Beta-Gamma	No	29	<540	280,087	<31,111
	Removable Alpha		29	7	888	
Walls and Ceiling	Total Beta-Gamma	No	53	<540	13,615	<1,161
	Removable Alpha		53	<2.5	304	
Beams	Total Beta-Gamma	No	30	2,041	28,130	10,109
	Removable Alpha		30	3	201	
Columns	Total Beta-Gamma	Yes	26	<540	1,073	<559
	Removable Alpha		26	<2.5	26	

* Disintegrations per minute per 100 cm^2

TABLE 33-2 Building 434 Air Sample Results

Long-Lived Alpha Air Particulate Concentration

Sample Type	Concentration
Breathing Zone	$<1.9 \times 10^{-14}$ µCi/ml

Radon/Thoron Gas Concentrations

Concentration (pCi/l)	Monitor type
0.7	F
0.5	M
0.2	F
0.2	M

A-34 BUILDING 435

Building 435 is of an industrial prefabricated steel design with concrete slab floor, having dimensions of 150 ft x 40 ft x 20 ft high. The building was used for storage and still contains numerous pieces of equipment such as workbenches, cabinets, tables and counters (MKF, 1988).

Building 435 has been surveyed twice: once by RETA, and once by the PMC.

RETA performed a radiological survey on this building in 1977. The RETA survey included:

- 21 total alpha measurements
- 14 removable alpha measurements
- 34 total beta-gamma measurements
- 36 total gamma measurements

All measurements on loose surface contamination were at the "releasable" level, but only about 30% of the total surface contamination measurements were at this level. Approximately 17% of the rest were at the "moderately contaminated" level. All other total surface contamination measurements were at the "highly contaminated" level. These estimates were based on the assumption that the only significant activity in this building is due to natural uranium, although RETA performed no radionuclide analyses on loose surface material to confirm this. RETA found that most of the high readings were associated with contaminated equipment stored in this building, and they suggested that the building would probably be releasable if the equipment were moved and the building cleaned (RETA, 1978).

The PMC survey included:

- o 6 bulk samples
- o 300 total beta-gamma measurements
- o 300 removable alpha measurements
- o 1 core sample
- o equipment scans
- o 8 airborne particulate samples
- o 4 radon/thoron gas samples

Six bulk samples were collected in this building. The average activity of each radionuclide found in the samples is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	8.5 ± 2.0
U-234	193.7 ± 61.5
U-235	8.8 ± 4.6
U-238	191.7 ± 59.0
Th-230	12.3 ± 3.2
Th-232	1.3 ± 0.8
Th-228	2.4 ± 1.6

Based on these results, the PMC concluded that natural uranium is the predominant radionuclide in this building. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-34-1.

One core sample was taken on the floor. The total beta-gamma activity at this location was 4,620 DPA after dust was removed. After core removal, the total activity was 595 DPA, above the MDA of the detector. This suggests that the floor is

volumetrically contaminated, so surface release criteria do not apply to it.

An inventory of equipment in Building 435 along with associated scanning results is on file with the PMC. Most equipment either did not meet PMC key criteria and/or natural uranium release criteria, or was determined by the contractor to be not releasable at present.

The results of the air samples collected in this building are presented in Table A-34-2. One Type F sample was above the background concentration which, along with the near-background concentration measured by both Type M detectors, suggests the presence of above-background thoron concentrations here. However, the other Type F sample measured a near-background concentration, and Th-228 concentrations measured in the bulk sample results are not high enough to indicate a source of above-background thoron concentrations. All measured radon and thoron concentrations are below DAC guidelines. All eight breathing zone samples were analyzed for long-lived alpha activity and all concentrations were below DAC guidelines for U-238.

TABLE A-34-1 Building 435 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<540	2,180	<654
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<540	1,073	<634
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<540	900	<576
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<540	934	<567
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	60	<540	1,349	<796
	Removable Alpha		60	<6	<6	
Interior						
Floor	Total Beta-Gamma	No	30	658	50,041	4,069
	Removable Alpha		30	<6	13	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	9	
Beams	Total Beta-Gamma	Yes	30	<568	2,533	<882
	Removable Alpha		30	<6	13	
Columns	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	<6	
Conduit/Piping	Total Beta-Gamma	Yes	30	<568	1,711	<610
	Removable Alpha		30	<6	13	

* Disintegrations per minute per 100 cm^2

TABLE A-34-2 Building 435 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	2.9×10^{-13}
Breathing Zone	5.7×10^{-14}
Breathing Zone	2.8×10^{-13}
Breathing Zone	2.1×10^{-13}
Breathing Zone	2.2×10^{-13}
Breathing Zone	8.8×10^{-13}
Breathing Zone	6.0×10^{-13}
Breathing Zone	3.9×10^{-13}

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/l)	Monitor Type
0.7	F
0.7	M
1.5	F
0.4	M

A-35 BUILDING 436

Building 436 is of an industrial prefabricated steel design with concrete slab floor having dimensions of 180 ft x 40 ft x 20 ft high. The building contains numerous equipment items such as sinks, office furniture, freezers and numerous pipe fittings.

Building 436 has been surveyed twice; once by RETA and once by the PMC. RETA performed a radiological survey on this building in 1977. The RETA survey included:

- o 12 total alpha measurements
- o 14 removable alpha measurements
- o 9 total beta-gamma measurements
- o 25 total gamma measurements

All loose surface contamination measurements were at the "releasable" level. However, only about 50% of total surface contamination measurements were at the "releasable" level. Of the rest of the measurements, about 25% were at the "moderately contaminated" level, and 25% were at the "highly contaminated" level. All of the estimates of contamination were based on RETA's assumption that the only significant activity in this building was due to natural uranium; however no radionuclide analyses are presented to confirm this (RETA, 1978).

The PMC surveyed this building in 1988. The PMC survey included:

- o 6 bulk samples
- o 430 total beta-gamma measurements
- o 430 removable alpha measurements
- o 1 core sample
- o equipment scans

- 5 airborne particulate samples
- 4 radon/thoron gas samples
- 1 radon daughter air sample

Six bulk samples were collected. The average activity of each radionuclide found in the samples is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	3.5 ± 1.3
U-234	249.5 ± 87.1
U-235	14.2 ± 5.5
U-238	260.2 ± 90.4
Th-230	33.1 ± 10.1
Th-232	1.3 ± 1.6
Th-228	1.8 ± 2.8

Based on these results, the PMC concluded that natural uranium is the predominant radionuclide in Building 436. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-35-1.

A core sample was taken on the floor. Before core removal, the total beta-gamma activity was 5,355 DPA. After core removal, the total activity was less than the MDA of the detector, indicating that the floor is surficially contaminated only and that surface release criteria are applicable.

An inventory of the equipment in Building 436 along with associated scanning results is on file with the PMC. Most equipment either did not meet PMC key criteria and/or natural uranium release criteria, or was determined by the PMC to be not releasable at present.

Table A-35-2 presents the results of air samples collected in Building 436. Measured radon and thoron gas concentrations are all near background levels and are below DAC guidelines. The long-lived alpha activity concentrations measured by the five breathing zone samples are all below the DAC guideline for U-238. The measured radon daughter concentration of 0.001 WL is near background levels.

TABLE A-35-1 Building 436 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<540	727	<577
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<574	<574	<574
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	Yes	30	<521	2,237	<680
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	Yes	30	<521	588	<532
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	40	<521	2,698	1,074
	Removable Alpha		40	<6	<6	
Interior						
Conduit/Piping	Total Beta-Gamma	No	30	<540	4,256	<821
	Removable Alpha		30	<6	9	
North Room,						
Floor	Total Beta-Gamma	No	30	<553	14,641	<2,139
	Removable Alpha		30	<6	13	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<553	691	<572
	Removable Alpha		30	<6	<6	
Beams	Total Beta-Gamma	Yes	30	<553	2,500	<861
	Removable Alpha		30	<6	13	
Columns	Total Beta-Gamma	Yes	30	<553	<553	<553
	Removable Alpha		30	<6	9	

* Disintegrations per minute per 100 cm^2

TABLE A-35-1 Building 436 Radiological Survey Results (Continued)

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
South Room,						
Floor	Total Beta-Gamma	No	30	<553	18,227	<3,151
	Removable Alpha		30	<6	13	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<553	823	<568
	Removable Alpha		30	<6	9	
Beams	Total Beta-Gamma	No	30	<553	47,080	<2,762
	Removable Alpha		30	<6	9	
Columns	Total Beta-Gamma	Yes	30	<553	<553	<553
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-35-2 Building 436 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	2.2×10^{-13}
Breathing Zone	$<9.7 \times 10^{-13}$
Breathing Zone	5.1×10^{-13}
Breathing Zone	3.3×10^{-12}
Breathing Zone	1.6×10^{-13}

Radon/Thoron Gas Concentrations

Radon Concentrations (pCi/l)	Monitor Type
0.4	F
0.5	M
0.4	F
0.2	M

Radon Daughter Concentration

RDC
0.001 WL

A-36 BUILDING 437

Building 437 is a 70 ft x 33 ft x 15 ft single-story brick building on a concrete foundation. This building was part of the previous ordnance works and was later used as storage space for reports and files. The building contains file cabinets, office furniture, a furnace and miscellaneous debris (MKF, 1988).

Building 437 has been surveyed twice: once by RETA and once by the PMC.

RETA performed a radiological survey on this building in 1977. The RETA survey included:

- 16 total alpha measurements
- 11 removable alpha measurements
- 16 total beta-gamma measurements
- 6 total gamma measurements

RETA found that all the measurements on both loose and total surface contamination were at the "releasable" level based on the assumption that the only significant activity in this building is due to natural uranium; RETA made no radionuclide analyses on loose surface materials to confirm this assumption.

The PMC surveyed this building in 1988. The PMC survey included:

- 4 bulk samples
- 250 total beta-gamma measurements
- 250 removable alpha measurements
- equipment scans
- 2 airborne particulate samples

Four bulk samples were collected. The average activity of each radionuclide found in the samples is given below:

Radionuclide	Activity (pCi/g-dry)
Ra-226	0.98 ± 0.4
U-234	3.8 ± 3.1
U-235	0.3 ± 0.28
U-238	3.7 ± 3.1
Th-230	2.9 ± 1.4
Th-232	5.8 ± 2.4
Th-228	3.8 ± 1.4

Based on these results the PMC concluded that natural thorium is the predominant radionuclide in Building 437. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural thorium release criteria are summarized in Table A-36-1.

An inventory of the equipment remaining in Building 437 as well as associated scanning results is on file with the PMC. None of the equipment in this building is releasable at present.

The results of the airborne particulate samples are presented in Table A-36-2. Neither of the long-lived alpha air particulate concentrations exceeded the DAC guidelines for Th-232.

TABLE A-36-1 Building 437 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	No	30	<568	2,145	<1,034
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	No	40	<568	1,872	<1,240
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	No	30	<568	2,040	<1,207
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	No	30	<568	1,908	<1,339
	Removable Alpha		30	<6	9	
Roof	Total Beta-Gamma	Yes	30	<568	757	<603
	Removable Alpha		30	<6	<6	
Interior						
Floor	Total Beta-Gamma	No	30	<540	1,107	<667
	Removable Alpha		30	<6	9	
Walls and Ceiling	Total Beta-Gamma	No	30	<553	1,546	<822
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-36-2 Building 437 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (μCi/ml)
Breathing Zone	1.4×10^{-13}
Breathing Zone	7.9×10^{-14}

A-37 BUILDING 438

Building 438 is a steel frame butler building with concrete floor and foundations. Dimensions are 100 ft by 40 ft by 16 ft high. This building contains contaminated process equipment; uranium oxides are visible on surfaces of this equipment (MKF, 1988).

Building 438 has been surveyed once by the PMC in 1988. The PMC survey included:

- o 6 bulk samples
- o 300 total beta-gamma measurements
- o 300 removable alpha measurements
- o 1 core sample
- o equipment scans
- o 8 airborne particulate samples
- o 4 radon/thoron gas samples

Six bulk samples were collected. The average activity of each radionuclide in the samples is given below:

Radionuclide	Concentration (pCi/g - dry)
Ra-226	5.1 ± 1.4
U-234	295.9 ± 92
U-235	13.7 ± 3.6
U-238	314.4 ± 87.2
Th-230	27.7 ± 5.5
Th-232	43.0 ± 10.1
Th-228	3.9 ± 5.1

The analytical results indicate natural uranium and natural thorium to be the primary contaminants. Therefore the mixture rule will apply to release of material from the building. Alpha

and beta-gamma measurements results as well as determination of releasability based on the PMC criteria are summarized in Table A-37-1.

One core sample was taken on the floor. Before core removal, the total activity at this location was 48,708 DPA. After core removal, the total beta-gamma activity on the freshly exposed surface was less than the MDA of the detector, indicating that the contamination is only surficial on the floor.

An inventory of equipment remaining in Building 438 as well as associated scanning results is on file with the PMC. None of the equipment in this building is releasable at present.

The results of the air samples collected in this building are presented in Table A-37-2.

Two of the eight long-lived alpha air particulate samples exceeded the DAC guideline for Th-232. All of the radon/thoron samples were at approximately background levels.

TABLE A-37-1 Building 438 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<521	<540	<531
	Removable Alpha		30	<6	<6	
South Wall	Total Beta-Gamma	Yes	30	<521	588	<532
	Removable Alpha		30	<6	<6	
East Wall	Total Beta-Gamma	No	30	<521	1,176	<575
	Removable Alpha		30	<6	<6	
West Wall	Total Beta-Gamma	No	30	<540	969	<567
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	No	30	<521	1,753	<781
	Removable Alpha		30	<6	<6	
Interior						
Floor	Total Beta-Gamma	No	30	<568	84,454	<7,888
	Removable Alpha		30	<6	22	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<568	<568	<568
	Removable Alpha		30	<6	18	
Columns	Total Beta-Gamma	Yes	30	<553	<568	<554
	Removable Alpha		30	<6	<6	
Beams	Total Beta-Gamma	No	30	<553	15,331	<1,829
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-37-2 Building 438 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	$<2.0 \times 10^{-14}$
Breathing Zone	3.0×10^{-13}
Breathing Zone	2.6×10^{-13}
Breathing Zone	2.9×10^{-12}
Breathing Zone	$<1.1 \times 10^{-13}$
Breathing Zone	1.4×10^{-13}
Breathing Zone	2.0×10^{-13}
Breathing Zone	1.3×10^{-12}

Radon/Thoron Gas Concentrations

Radon Concentration (pCi/l)	Monitor Type
0.4	F
0.0	M
0.6	F
0.4	M

A-38 BUILDING 439

Building 439 was used to administer classroom training to WSUFMP personnel as part of the site safety and fire protection program. The building is fabricated of aluminum siding with steel beam frames. The floor is concrete and has debris (wood and tires) scattered upon it. The approximate dimensions of the building are 14 ft x 14 ft x 13.5 ft high. Radioactive materials are not known to have been handled or stored in this building (MKF, 1988).

Building 439 has been surveyed twice: once by RETA and once by the PMC. In 1977, RETA took a few measurements in and around this building. All the measurements were at the "releasable" level (RETA, 1978).

The PMC surveyed this building in 1988. The PMC survey included:

- 5 bulk samples
- 270 total beta-gamma measurements
- 270 removable alpha measurements
- equipment scans
- 3 airborne particulate samples

Five bulk samples were collected. The average activity of each radionuclide found in the samples is given below:

Radionuclide	Concentration (pCi/g-dry)
Ra-226	0.83 ± 0.7
U-234	37.2 ± 9.6
U-235	2.0 ± 2.2
U-238	36.0 ± 8.8

Radionuclide	Concentration (pCi/g-dry)
Th-230	4.5 ± 1.1
Th-232	0.8 ± 0.4
Th-228	0.9 ± 0.7

Based on these results, natural uranium is the predominant contaminant in Building 439. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-38-1. As noted in this table, all items composing Building 439 except the beams are potentially releasable for unrestricted use.

An inventory of equipment remaining in Building 439 is on file with the PMC. Little equipment remains in the building, mainly light fixtures, a fire sprinkler valve, piping and a barbecue pit. All scanned equipment other than electrical conduit is potentially releasable for unrestricted use.

The results of the long-lived alpha air particulate samples are presented in Table A-38-2. All samples were below the DAC guidelines for U-238.

TABLE A-38-1 Building 439 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	Yes	30	<568	1,283	<632
	Removable Alpha		30	<6	11	
South Wall	Total Beta-Gamma	Yes	30	<568	1,579	<703
	Removable Alpha		30	<6	14	
East Wall	Total Beta-Gamma	Yes	30	<568	1,711	<773
	Removable Alpha		30	<6	7	
West Wall	Total Beta-Gamma	Yes	30	<568	855	<581
	Removable Alpha		30	<6	7	
Roof	Total Beta-Gamma	Yes	30	<553	2,500	<1,397
	Removable Alpha		30	<6	7	
Interior						
Floor	Total Beta-Gamma	Yes	28	<568	3,915	<2,134
	Removable Alpha		30	<6	7	
Walls and Ceiling	Total Beta-Gamma	Yes	30	<568	1,678	<637
	Removable Alpha		30	<6	7	
Columns	Total Beta-Gamma	Yes	24	<553	<553	<553
	Removable Alpha		30	<6	<6	
Beams	Total Beta-Gamma	No	36	<568	6,547	<1,633
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-38-2 Building 439 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	1.1×10^{-13}
Breathing Zone	2.5×10^{-13}
Breathing Zone	1.7×10^{-13}

A-39 BUILDING 441

Building 441 is an elevated loading dock located along the railroad tracks and east of Building 414. Dimensions are 20 ft x 15 ft x 20 ft high. The dock is concrete and elevated 4 feet above grade and surrounded by handrails and a wire fence. The total thickness of the concrete floor/deck is unknown. Steel and cinder-block cylinder racks are located on the concrete pad. The roof is corrugated aluminum and is supported by steel support columns (MKF, 1988).

Building 441 has been surveyed twice: once by RETA and once by the PMC.

In 1977, RETA took a few measurements in and around this building. All of the measurements were at the "releasable" level assuming natural uranium contamination.

The PMC performed a radiological survey on this building in 1988. The PMC survey included:

- 300 total beta-gamma measurements
- 290 removable alpha measurements
- 1 core sample
- 4 airborne particulate samples

There was no visible residue or dust so no bulk samples were collected. However, soil samples taken from the ground adjacent to this building indicate natural uranium contamination. Alpha and beta-gamma measurement results as well as determination of releasability based on the PMC key criteria and natural uranium release criteria are summarized in Table A-39-1.

A core sample was taken on the concrete floor. The total beta-gamma activity at this location before core removal was 4,725 DPA. The total beta-gamma activity after core removal on the freshly exposed surface was less than the MDA of the detector. This shows that the floor is surficially contaminated only and that surface release criteria are applicable.

The results of the long-lived alpha air particulate samples are presented in Table A-39-2. None of these samples exceeded the DAC guidelines for U-238.

TABLE A-39-1 Building 441 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Exterior						
North Wall	Total Beta-Gamma	No	30	<568	10,594	<2,201
	Removable Alpha		30	<6	7	
South Wall	Total Beta-Gamma	No	20	691	12,963	<2,392
	Removable Alpha		20	<6	7	
East Wall	Total Beta-Gamma	No	30	<568	35,269	<9,059
	Removable Alpha		30	<6	14	
West Wall	Total Beta-Gamma	No	30	<568	33,591	<5,511
	Removable Alpha		30	<6	7	
Roof	Total Beta-Gamma	Yes	30	796	4,083	2,157
	Removable Alpha		30	<6	7	
Interior						
Floor	Total Beta-Gamma	No	30	1,744	8,982	4,016
	Removable Alpha		30	<6	<6	
Ceiling	Total Beta-Gamma	Yes	30	<540	658	<546
	Removable Alpha		30	<6	7	
Columns	Total Beta-Gamma	No	40	<553	1,903	<773
	Removable Alpha		30	<6	<6	
Beams	Total Beta-Gamma	No	30	<540	14,246	<4,532
	Removable Alpha		30	<6	40	
Handrails	Total Beta-Gamma	Yes	30	<553	1,972	<980
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-40-1 Building 443 Radiological Survey Results

ITEM(S)	MEASUREMENT TYPE	RELEASABLE	NO. OF MEASUREMENTS	ACTIVITY (DPA)* MINIMUM	MAXIMUM	AVERAGE
Columns	Total Beta-Gamma	Yes	40	<540	727	<555
	Removable Alpha		30	<6	<6	
Roof	Total Beta-Gamma	Yes	30	<553	2,632	<1,155
	Removable Alpha		30	<6	<6	

* Disintegrations per minute per 100 cm^2

TABLE A-39-2 Building 441 Air Sample Results

Long-Lived Alpha Air Particulate Concentrations

Sample Type	Concentration (µCi/ml)
Breathing Zone	7.4×10^{-14}
Breathing Zone	1.4×10^{-14}
Breathing Zone	$<9.4 \times 10^{-14}$
Breathing Zone	1.5×10^{-14}

A-40 BUILDING 443

Building 443 is a dilapidated single-story wooden shed. Portions of the wooden floor, shingled roof and wood support structure still remain. This structure was used to store the fire protection training equipment. The approximate dimensions of this structure are 12 ft x 24 ft x 8 ft high (MKF, 1988).

Building 443 has been surveyed twice: once by RETA and once by the PMC.

In 1977, RETA took a few measurements in and around this building. All of the measurements were at the "releasable" level.

The PMC performed a radiological survey on this building in 1988. The PMC survey included:

- o 1 bulk sample
- o 60 total beta-gamma measurements
- o 60 removable alpha measurements
- o equipment scans

The results of the bulk sample are not yet available. Until they are, the PMC is assuming natural uranium to be the primary contaminant in this building. The results of the total beta-gamma and the removable alpha measurements are summarized in Table A-40-1. The floor was not surveyed since little of it remains.

An inventory of the equipment remaining in this building is on file with the PMC. All of the equipment was found to be potentially releasable for unrestricted use.