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**Final Report on the Decontamination and
Decommissioning of Crowell Hall
At The College of New Jersey
(Formerly Trenton State College)**

USNRC License# 29-15765-02
New Jersey State License # 80153/00/007

Prepared for The College of New Jersey
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1.0 Introduction

The College of New Jersey (formerly Trenton State College) plans to demolish Crowell Hall in July 2002. Crowell Hall (map shown below, Fig. 1) housed rooms where licensed materials had been used in the past. This report describes the surveys and assessments performed to demonstrate the absence of radioactive materials or contamination with the objectives of approval for the demolition by the United States Nuclear Regulatory Commission (USNRC) and the New Jersey Department of Environmental Protection (NJDEP). The surveys have followed the requirements of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) [NUREG-1575] using a graded approach or simplified version for this facility, essentially Appendix B of MARSSIM. The goal was to show either only background levels of radioactive materials or to reduce any contamination found to background levels. This revision incorporates requirements of the New Jersey Department of Environmental Protection.

The building was divided into non-impacted and impacted areas. Impacted areas were considered to be any room presently or formerly listed as an area where radioactive materials might be used. Most impacted areas would be considered as Class 3 as they have been used for a number of years for other activities such as computer labs. While only two rooms (Room 13 and the radioactive waste storage area, Room 5) would have the possibility of being called either a Class 1 or Class 2 area, the Class 3 areas were, in general, surveyed at a more conservative level than required to ensure nothing had been overlooked in the past history of the building. Other than occasional use of C-14, most of the radioisotopic use was of short half-life materials. During this period, there were no reported contamination incidents, loss of control of radioactive material or abnormal personnel exposures under the USNRC or NJDEP licenses as determined by looking at past records and by interviewing users. One contamination spot was found on the floor of the radwaste area after removal of stored waste in this area (Room 5).

2.0 Radionuclides, Processes, Possession History and Use

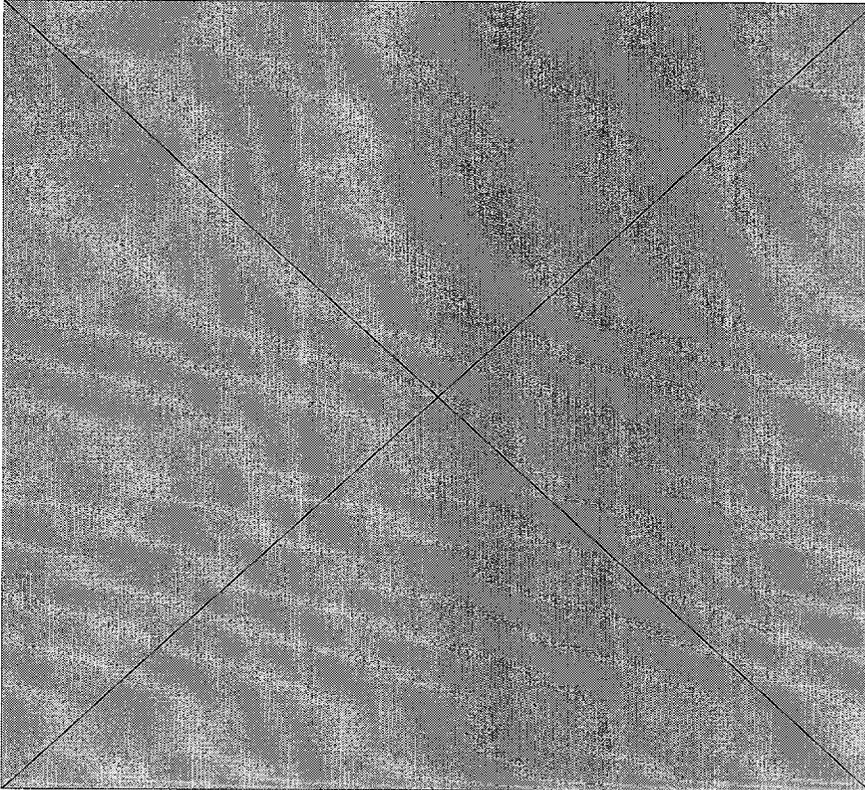
2.1 Issuance of USNRC License-1983

The College of New Jersey (TCNJ) was granted USNRC Materials License #29-15765-02 on June 15, 1983. At that time, the authorized uses of the licensed material were for teaching and training of students, instrument calibration and use of Ni-63 in a gas

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Chromatograph. The authorized licensed material is listed in Table 2.1.1 and the processes and locations are listed in Table 2.1.2.

Much of the licensed material was used in the form of an aqueous solution as chlorides, e.g., Co-60, or organic compounds, e.g., tritiated toluene, labeled amino acids. This form supported the labeling and radiobiological studies and research.



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Fig. 1. Map of the TCNJ. Crowell Hall, area of interest.

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**Table 2.1.1:
Licensed Materials for 1983 USNRC License**

Licensed Material	Chemical/Physical Form	Possession Limit (milliCi)
A. Hydrogen 3	Any	35
B. Carbon 14	Any	30
C. Sodium 22	Any	2
D. Phosphorus 32	Any	6
E. Sulfur 35	Any	10
F. Calcium 45	Any	5
G. Chromium 51	Any	5
H. Manganese 54	Any	2
I. Cobalt 60	Any	6
J. Nickel 63	Any	0.05
K. Zinc 65	Any	2
L. Selenium 75	Any	5
M. Strontium 85	Any	5
N. Rubidium 86	Any	5
O. Yttrium 88	Any	2
P. Strontium 90	Any	5
Q. Technetium 99	Any	6
R. Cadmium 109	Any	2
S. Tin 113	Any	2
T. Iodine 125	Any	5
U. Iodine 131	Any	5
V. Cesium 137	Any	5
W. Cerium 139	Any	2
X. Cerium 141	Any	5
Y. Cerium 144	Any	5
Z. Mercury 203	Any	2
AA. Thallium 204	Any	3
BB. Polonium 210	Any	0.2
CC. Cesium 137	Sealed: Amersham #608336	20
DD. Cesium 137	Sealed: ICN # 76150	108
EE. Nickel 63	Plated: Varian PN 02-001972-01	Not to exceed 8
FF. Cesium 137	Sealed: ORNL	75,000

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**Table 2.1.2:
Processes and Locations of Licensed Material Usage In Crowell Hall-1983**

Location	Process
Room 333	Radioecology Research. Radiological concentration processes involving algae, mollusks, and crustacea.
Room 332	Research. (No Unusual Hazard).
Room 215	Enzyme kinetics research. Use of H-3, C-14, S-35 and P-32.
Room 213	Immunology research. Use of P-32.
Room 110	Low level counting lab. Count low activity samples for alpha, beta and gamma.
Room 14	Storage and use of neutron source, culture of algae in radioactive media.
Room 13	Radiochemistry Lab. Use for teaching and research experiments using a variety of radioactive materials.
Room 12	Student Counting Lab. Used to count with thin window G-M or NaI detector.
Room 11	Radiation Producing Equipment. Irradiate samples with X-ray irradiator.
Room 10	Hot Lab. Storage, preparation and check in of licensed material.
Room 7	Radioactive Waste Storage.
Room H-5	Meter calibration with Cs-137 source.

2.2 Renewal of USNRC License-1988

The license was renewed on July 1, 1988. While the licensed material inventory remained the same as in 1983, new rooms were added where licensed material was used. The locations and processes are listed in Table 2.2.1.

**Table 2.2.1
Additional Locations of Licensed Material Use in Crowell Hall-1988**

Location	Process
Room 302	Storage for decay. Radioecology Research. Radiological concentration processes involving marine mollusks. Sample preparation done in Room 333.

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Room 312	Student use of radioisotopes. Autoradiography to research mollusk physiology.
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2.3 Amendment 3 to USNRC License-June 1990

The College of New Jersey removed some of the licensed material listed in Table 2.1.1 from its license with amendment 3. Ramping down the instrument calibration program, the sealed Cs-137 sources were shipped off site. The remaining inventory is listed in Table 2.3.1

Table 2.3.1
TCNJ Licensed Material Inventory-1990

Licensed Material	Chemical/Physical Form	Possession Limit (milliCi)
A. Hydrogen 3	Any	35
B. Carbon 14	Any	30
C. Sodium 22	Any	2
D. Phosphorus 32	Any	6
E. Sulfur 35	Any	10
F. Calcium 45	Any	5
G. Chromium 51	Any	5
H. Manganese 54	Any	2
I. Cobalt 60	Any	6
J. Nickel 63	Any	0.05
K. Zinc 65	Any	2
L. Selenium 75	Any	5
M. Strontium 85	Any	5
N. Rubidium 86	Any	5
O. Yttrium 88	Any	2
P. Strontium 90	Any	5
Q. Technetium 99	Any	6
R. Cadmium 109	Any	2
S. Tin 113	Any	2
T. Iodine 125	Any	2
U. Iodine 131	Any	5
V. Cesium 137	Any	5
W. Cerium 139	Any	2
X. Cerium 141	Any	5
Y. Cerium 144	Any	5
Z. Mercury 203	Any	2
AA. Thallium 204	Any	3
BB. Polonium 210	Any	0.2
CC. Nickel 63	Plated: Varian PN 02-001972-01	Not to exceed 8

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2.4 Amendment 4 to USNRC License-October 1991

The College continued its strategy to remove from the license the radioisotopes it did not use and/or reduce the quantities. The inventory authorized by Amendment 4 is listed in Table 2.4.1.

**Table 2.4.1
TCNJ Licensed Material Inventory-1991**

Licensed Material	Chemical/Physical Form	Possession Limit (milliCi)
A. Hydrogen 3	Any	35
B. Carbon 14	Any	30
C. Phosphorus 32	Any	6
D. Sulfur 35	Any	10
E. Calcium 45	Any	0.5
F. Chromium 51	Any	5
G. Nickel 63	Any	0.05
H. Zinc 65	Any	0.5
I. Selenium 75	Any	5
J. Rubidium 86	Any	5
K. Cadmium 109	Any	0.5
L. Tin 113	Any	2
M. Mercury 203	Any	2
N. Nickel 63	Plated: Varian PN 02-001972-01	Not to exceed 8

2.5 Renewal of USNRC License-1994

The license was renewed on August 1, 1994. The processes for which licensed material would be used were confined to laboratory experiments, teaching and training of students. The College continued to streamline the use of licensed material and maintained the inventory from Amendment 4.

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**Table 2.5.1:
Processes and Locations of Licensed Material Usage In Crowell Hall-1994**

Location	Process
Room 216	Tissue culture lab and teaching lab.
Room 213	Student teaching and research lab.
Room 203	Physiology Lab. Student teaching lab.
Room 110	Low level counting lab. Count low activity samples for alpha, beta and gamma.
Room 14	Storage.
Room 13	Radiochemistry Lab. Use for teaching and research experiments using a variety of radioactive materials.
Room 12	Counting Lab
Room 11	Wash Area.
Room 10	Hot Lab. Storage, preparation and check in of licensed material.
Room 5	Radioactive Waste Storage.

2.6 Amendment 5 to USNRC License-May 1995

Amendment 4 removed more radioisotopes from the license inventory and confined licensed activities to facilities located at Crowell Hall Annex (rooms 5-7, 10-14). The inventory for 1995 is listed in Table 2.6.1.

**Table 2.6.1
TCNJ Licensed Material Inventory-1995**

Licensed Material	Chemical/Physical Form	Possession Limit (milliCi)
A. Hydrogen 3	Any	35
B. Carbon 14	Any	30
C. Phosphorus 32	Any	6
D. Sulfur 35	Any	10
E. Calcium 45	Any	0.5
F. Chromium 51	Any	5
G. Nickel 63	Any	0.05
H. Zinc 65	Any	0.5
I. Selenium 75	Any	5
J. Rubidium 86	Any	5
K. Cadmium 109	Any	0.5
L. Tin 113	Any	2
M. Mercury 203	Any	2

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N. Nickel 63	Plated: Varian PN 02-001972-01	8
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2.7 Amendment 6 to USNRC License-December 1998

Amendment 6 added Phosphorus 33 to the licensed material inventory. Being a short-lived (25 day half-life) low energy beta emitter (249 keV), it is used in radiobiology to replace high energy, long-lived radioisotopes used in the past. The P-33 has a possession limit of 2 milliCuries and can be used in any form. The authorized location for use continued to be Crowell Hall Annex.

2.8 Amendment 8 to USNRC License-March 2002

Amendment 8 removed the Ni-63 source used for the gas chromatograph from the licensed inventory. The source was returned to the vendor, Varian, Inc. The licensed material inventory for TCNJ in 2002 is listed in table 2.8.1.

**Table 2.8.1
TCNJ Licensed Material Inventory-2002**

Licensed Material	Chemical/Physical Form	Possession Limit (milliCi)
A. Hydrogen 3	Any	35
B. Carbon 14	Any	30
C. Phosphorus 32	Any	6
D. Phosphorus 33	Any	2
D. Sulfur 35	Any	10
E. Calcium 45	Any	0.5
F. Chromium 51	Any	5
G. Nickel 63	Any	0.05
H. Zinc 65	Any	0.5
I. Selenium 75	Any	5
J. Rubidium 86	Any	5
K. Cadmium 109	Any	0.5
L. Tin 113	Any	2
M. Mercury 203	Any	2

2.9 Radioactive Waste Shipment- March 2002

On March 7, 2002 a radioactive waste shipment was made that disposed of all legacy waste since TCNJ received its license. After this shipment, there was no licensed material in Crowell Hall except for fixed contamination in the floor of Room 5, the Radioactive Waste Storage Area.

2.10 Decontamination of Room 5 Floor-May 2002

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A section of the concrete floor in Room 5 was determined to have fixed contamination. A cross section of the floor was removed down to a depth of ~two inches and the subsequent survey indicated background readings. Analysis of the contaminated concrete determined that the contaminant was Co-57. The concrete debris from this decontamination has been removed from Crowell Hall and is awaiting shipment offsite.

2.11 New Jersey License

The College of New Jersey maintains New Jersey Radioactive Materials License No. 80153, Amendment 9 for use of state licensed radioactive materials in research and development. The location authorized for use of these radioactive materials was Crowell Hall. These radioactive materials were only used in Crowell Hall Annex and Room 203, a student teaching laboratory. The inventory is listed in Table 2.11.1.

Table 2.11.1
TCNJ New Jersey Radioactive Materials Inventory-2002

Radioactive Materials	Chemical/Physical Form	Possession Limit (milliCi)
A. Cobalt-57	Any	6.0000
B. Sodium-22	Any	5.0000

All New Jersey licensed material has been removed from Crowell Hall as of result of the March 2002 radioactive waste shipment (Ref: Section 2.9) and the decontamination of Room 5 in May 2002 (Ref: Section 2.10). The goal of TCNJ is to terminate the NJ license.

3.0 Surveys

3.1 Basis for selection of survey instrumentation

Radionuclides used at TCNJ were either beta, beta/gamma emitters, or NJDEP licensed gamma emitters. Geiger-Muller (GM) detectors and NaI were selected using a 2-inch pancake probe and 2-inch crystal, respectively as instruments with enough sensitivity to see any of the radionuclides with the exception of tritium. Wipes were completed in the areas and would detect any removable activity including tritium. In addition, a uR-meter was used to scan the areas and to look for any areas, which would have gamma emitters above background levels. The 2-inch NaI detector was utilized for assessing the survey units that used NJDEP licensed materials. Only Rooms 13 and the Rad Waste Storage Area (Room 5) were expected to have any radioactivity detectable above background, based on historical process knowledge.

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3.2 Nature of radionuclides surveyed

The types of emissions for the licensed materials used at TCNJ are listed in Table 3.2.1.

Table 3.2.1 TCNJ Radionuclide Emissions*

Radionuclide	Half-Life	Beta Energy (keV)	Gamma Energy (keV)
H-3	12.33 y	18.6	
C-14	5730 y	156.5	
Na-22	2.61 y	216 (positron)	1274
P-32	14.3 d	1711	
P-33	25.3 d	249	
S-35	87.5 d	167	
Ca-45	162.6 d	257	
Cr-51	27 d	4.38 (Auger electron)	320
Mn-54	312 d	4.78 (Auger electron)	835
Co-57	272 d	5.62 (Auger electron)	122, 136
Co-60	5.27 y	318	1173, 1332
Ni-63	100.1 y	66.95	
Zn-65	244.3 d	7.03 (Auger electron)	1115.6
Se-75	119.8 d	9.11 (Auger electron)	136, 265
Sr-85	65 d	11.4 (Auger electron)	231, 514
Rb-86	18.5	697,1774	556, 1077
Y-88	107 d	12.1 (Auger electron)	898, 1836
Sr-90	28.8 y	546, (2280 for Y-90)	
Tc-99	211,100 y	293.5	
Cd-109	461 d	18.5 (Auger electron)	88
Sn-113	115 d	20.1 (Auger electron)	392
I-125	59.4 d	22.7 (Auger electron)	27.5
I-131	8.02 d	606.3	364.5
Cs-137	30 y	513, 1175	662 from Ba-137m
Ce-139	138 d	27.4 (Auger electron)	166
Ce-141	32.5 d	435, 581	145
Ce-144	284.9 d	318	133.5
Hg-203	46.6 d	492	279
Tl-204	3.78 y	764	414, 690
Po-210	139 d	Note 1	
Ra-226	1600 y	Note 2	186

*Source: "National Nuclear Data Center," Brookhaven National Laboratory, <http://www.nndc.bnl.gov/nndc/nudat/radform.html>

Note 1: Polonium-210 emits 5.3 Mev alpha particles. This radionuclide was removed

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from the USNRC license in 1991 and would not be present due to decay.

Note 2: Ra-226 emits 4.78 (95%) and 4.6(6%) MeV alphas. Progeny emit beta up to 3.26 MeV. Removed from NJDEP license in 1990.

3.3 Measurement techniques and instruments

Scanning surveys were done of all surfaces within impacted areas, at close proximity to the surface with the Geiger-Mueller (GM) counter using a pancake probe and in contact with the surface with Na I scans. Background levels were checked in rooms known not to be a part of the impacted area to establish a data for a reference area (room 111). Gamma uR-survey meter scanning surveys were done at a waist high level within each of the areas. As the surveyor approached concrete walls (poured or block), the levels increased, as expected, due to natural radioactivity within the concrete, but never exceeded 20 uR/hr. A gamma NaI survey was completed for 4 survey unit areas where gamma emitters were used during the history of this facility, plus a reference room where no radionuclides were used. This included room 111 as the reference room, room 5 where concrete was removed for decon, rooms 6, 7, 10, 11, 12, 13, and 14(Crowell Hall Annex), and room 203. The gamma scan consisted of a one minute integrated count at the surface of the floor or wall using a 2-inch Ludlum Measurement, Inc., NaI detector and 2218 Dual Analyzer scalar. These data are found in survey forms 19 through 27.

After the gross monitoring and the removal of any detectable activity, a dry wipe test using Q-tips as the medium was employed. This was completed in all areas and included bench equipment, lab equipment, floors, walls, hoods, drawers, and ductwork. The radioisotopes in use at TCNJ were either strong beta emitters (other than tritium), or beta-gamma emitters. A new Packard liquid-scintillation counter (Model No. 2100TR, Serial No. 426726, manufactured in 2001) was purchased and used for analysis. Intrinsic efficiencies were determined using NIST traceable Tritium and Carbon-14 standards using gravimetric methodology. The instrument efficiencies were determined to be 50.9% for ^3H and 96.8% for ^{14}C . Background levels were 15 counts per minute (cpm) for the tritium channel, 23 cpm for the C-14 channel and 32 cpm for Gross Beta (0-2048 keV). Over 2,000 wipe samples were taken and each sample was counted for 100 minutes to ensure adequate statistics. The biodegradable scintillation cocktail used was Ultima Gold and counting procedures were 10 ml of cocktail, one q-tip in a glass sample vial for a 100 minute count.

3.4 Minimum Detectable Concentrations

NaI Detectors:

As previously stated, a gamma scan on the surface of the floor or wall was performed using a Ludlum Model 2218 dual analyzer, Serial # 25739 with a 2 inch NaI detector, Serial # PR020276. For a one minute integrated count time, the background was 657 cpm and the efficiencies for New England Nuclear Ba-133 and Na-22 sources were determined to be 12.2% and 20.3% respectively. This calibration was performed in Room 251 of the New Biology Building at TCNJ. The MDC calculation for this detector is:

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From MARSSIM (p. 6-37): $MDC = C \times (3 + 4.65\sqrt{B})$

where:

$B = \sim 657$ counts/min;

For Ba-133:

$C = (8.17 \text{ dpm/count})(\text{Bq}/60 \text{ dpm})(1/20.3 \text{ cm}^2 \text{ probe area})(10,000 \text{ cm}^2/\text{m}^2) = 67.2$
Bq/m²counts

$MDC = 67.2 \times (3 + 4.65\sqrt{657}) = 8198 \text{ Bq/m}^2 (\sim 4919 \text{ dpm}/100 \text{ cm}^2)$

For Na-22:

$C = (4.93 \text{ dpm/count})(\text{Bq}/60 \text{ dpm})(1/20.3 \text{ cm}^2 \text{ probe area})(10,000 \text{ cm}^2/\text{m}^2) = 40.5$
Bq/m²counts

$MDC = 40.5 \times (3 + 4.65\sqrt{657}) = 4939 \text{ Bq/m}^2 (\sim 2963 \text{ dpm}/100 \text{ cm}^2)$

Since Co-57 efficiencies are generally higher than either Ba-133 or Na-22, Co-57 MDC may be extrapolated to meet the 5,000 dpm/100 cm² requirement.

GM Detectors

Detection sensitivities for the GM survey meters, based on MARSSIM calculation would be less than 5,000 dpm/100 cm² for select beta emitters. The efficiency was on the order of ~20% as determined by the calibration with a Tc-99 source of the appropriate geometry. This is also a typical efficiency for this instrument according to MARSSIM for beta emitters.

From MARSSIM (p. 6-43): Scan MDC =
$$\frac{MDCR}{\sqrt{P} \varepsilon_i \varepsilon_s} \frac{\text{probe area}}{100 \text{ cm}^2}$$

where:

MDCR = 50 from Table 6.6 of MARSSIM;

P, or surveyor efficiency is 0.5; surface efficiency is 0.54, and instrument efficiency is 0.2, and the probe area is 15 cm². Thus the Scan MDC is 4365 dpm/100 cm².

Micro-R Meter

Background gamma readings were in the 10-18 uR/hr range depending on the closeness to a concrete wall using a uR/hr meter.

Liquid Scintillation Counter

Liquid scintillation counter efficiency is ~50% for tritium and ~97% for C-14. Minimum detectable limits for a 100 cm² wipe test sample were: Tritium-3.54 dpm, C-14-2.3 dpm and Gross Beta-2.72 dpm (using a C-14 efficiency for gross beta efficiencies). These values were determined using the LLD formula from HASL-300:

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$$LLD = \frac{4.65 \sqrt{\frac{R_b}{t}}}{E}$$

3.5 Calibration, maintenance and field testing of instrumentation

Survey instruments were always within a one-year calibration cycle. Calibration certifications are on file. A calibration source was used prior to any survey to check the functionality of the survey meter, and again at the end of the survey to ensure that the meter was working for the entire process. The NaI detector was calibrated on the day of use on 6/26/2002 and field checks were performed during scans of survey units with a Na-22 source.

The LSC QA/QC program consisted of a vendor Self-Normalization count every 23 hours as well as a TCNJ background and intrinsic calibration standards with each set of wipe test samples. In addition, during this period, the vendor performed periodic preventative maintenance and calibration checks on the instrument.

3.6 Personnel qualifications

Scanning surveys were completed by Health Physicist, Dr. Joseph R. Stencel and Mr. Jerry D. Gilbert. Each has over 25 years of experience in radiation related work and resumes are attached at the end of the report (Appendix B).

Wipe test surveys were completed with student help trained by the Health Physicist and under their direction.

3.7 Survey interpretation methods

The goal of the survey was to ensure that all areas were either at detectable levels not different from surrounding background, or if found above background levels, to decon these areas to background levels. Any instrumentation or lab hardware found with any levels exceeding background were disposed as radioactive waste. The one location where there was facility contamination, Room 5 (radioactive waste storage) was deconned to ~background levels.

3.8 Measurement results and locations

All areas were initially monitored (scanned) using Geiger counter pancake probe instrument along with a uR-meter. Instruments used were within a one-year calibration. A check source was used to check the instrument prior to use and upon completion of the survey. If any detectable levels were measured above background, the offending item, if not a part of the facility, was moved to rad-waste storage. The only items or areas found to be above background where: a) known sources within the hoods or refrigerators, b) one

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metal shelf (Room 13) in a metal lab bench had minor C-14 contamination, c) a sink trap from Room 13, and d) a spill on the concrete in the rad-waste storage area (Room 5) which was detected once the stored material was removed (this contamination was determined to be Co-57 via Ge(Li) spectroscopy). Some lead bricks in the rad-waste spill area of room 5 were also slightly contaminated and deconned to background.

Gamma scans using a NaI detector and integrated for one minute were used in NJDEP survey units (rooms 5, 203, Crowell Hall Annex and 111, which utilized NJDEP licensed gamma-emitting isotopes. A default scan location value of 30 (Appendix B of MARSSIM) was used for each survey unit. A reference room was utilized that had not used radioactive materials and was, in general, representative of Crowell Hall construction. The average one minute count for the floor of this room (room 111) was 1141 ± 153 cpm. The wall count was 1630 ± 162 cpm. It should be noted that concrete block walls in Crowell Hall exhibit a much higher natural background count rate and influence floor measurements made in the vicinity of these walls. This noted in both the uR/hr survey meter readings and in the NaI gamma scans. Liquid scintillation counting results of over 2000 wipe test samples indicate no removable contamination above regulatory limits. (See section 4 for statistical analysis of LSC results.

All rooms show no net counts or dpm/100 cm² above the reference room average background at the 95% confidence level other than room 5. Note that rooms 10, 11, 12, 13, and 14 actually have a much lower measurement value, which is attributed to the building materials. Room number 5, is a small area enclosed by higher background level concrete block walls. Because of the default survey unit of 30 survey points, many of these values are close enough to these walls to give readings, which exceed the reference room values. However, there are no indications of hot spots, even in the former contaminated area which was decontaminated, and it is our professional judgment that this room is also at background levels.

Appendix A provides the scanning survey forms.

4.0 Measurement statistics-t Test or indistinguishable from Background

All μ R-meter survey measurements were at or below the reference area (Room 111) background levels (10-15 uR/hr) and GM pancake probe measurements were 40 cpm or less in all areas. In general, the higher levels measured are at the interface of the room and the solid concrete or block concrete walls (see survey sheets, Appendix A).

Because there was sufficient data to assume a normal distribution, the Student t-test was utilized in looking at liquid scintillation results. The mean and standard deviation for the reference area (Room 111) was 32.3 ± 1.0 cpm at the 95% confidence level, and 33.4 ± 2.7 cpm for background counts completed with each set of samples analyzed. The t tests performed resulted in "significant differences" between the reference area (Room 111) background cpm and the LSC background cpm (both 100 minute counts). Clearly, both

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were background samples. Thus, the validity of the t test for verifying the presence of activity at or near background in this case is questionable. Therefore, the uncertainty calculation for a 100 minute count time results in the conclusion that the activity in room 5 is at or near background and is not significant.

In room 5, after removal of contaminated concrete, left gross counts of 40.6 ± 15.8 cpm were measured from wipe tests. The room was washed down and the next set of samples indicated 38.6 ± 7.2 cpm.

If the uncertainty in the source count rate for Room 5 and LSC background is evaluated, the residual in Room 5 appears to be random. The difference in means is $38.64 - 33.44 = 5.2$ cpm. The propagation of errors indicates the residual activity to be 5.2 ± 7.7 cpm at the 95% confidence level. This results would indicate that the activity in this room is a random fluctuation and not due to increased radioactivity. Again, the validity of the t-test for verifying the presence of activity at or near background in this case is questionable. The uncertainty calculation for a 100 minute count time results in the conclusion that any activity which is removal in room 5 is at or near background and is not significant. In addition uR-survey meter and GM survey meter indicate no fixed activity above normal background as noted above. This is corroborated by the NaI survey, which indicates background levels at these locations.

It is the conclusion of this report, after D&D efforts by TCNJ, that all radioactivity within Crowell Hall is at or near background and we recommend a request for termination of the NJDEP license and the amendment of the NRC license for these areas so that the building is released for demolition activities.

5.0 Documentation

A radwaste manifest is on file indicating disposal of all accumulated radioactive materials and waste. All survey data for this evaluation is on file and available for inspection.

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Appendix A: Scanning Survey Forms

21

Radiation Survey
The College of New Jersey

Survey #: 00-01 Location: Crowell Hall, RM 13 Date/Time: 11/18/2000

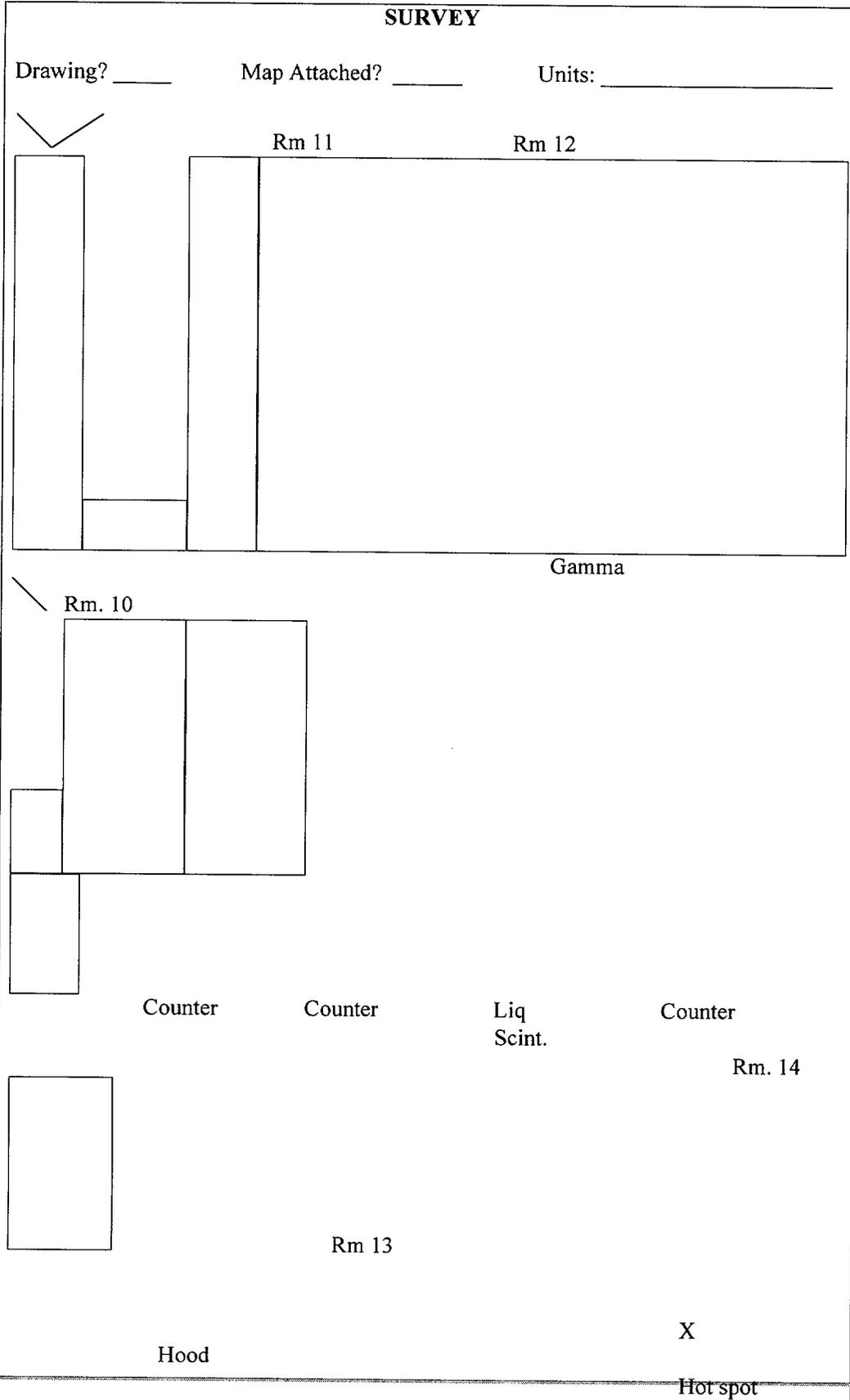
SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial#: 35216/34929/65907 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

22



23

Comments: Scoping Survey. Background on GM ~ 40 cpm in Hallway near elevator. Screening survey indicated sources in room, and one hot spot on shelf in cabinet under a counter (marked X). Shelf removed to radwaste.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 11/18/2000

24

Radiation Survey
The College of New Jersey

Survey #: 00-02 Location: Crowell Hall Rm 12 Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

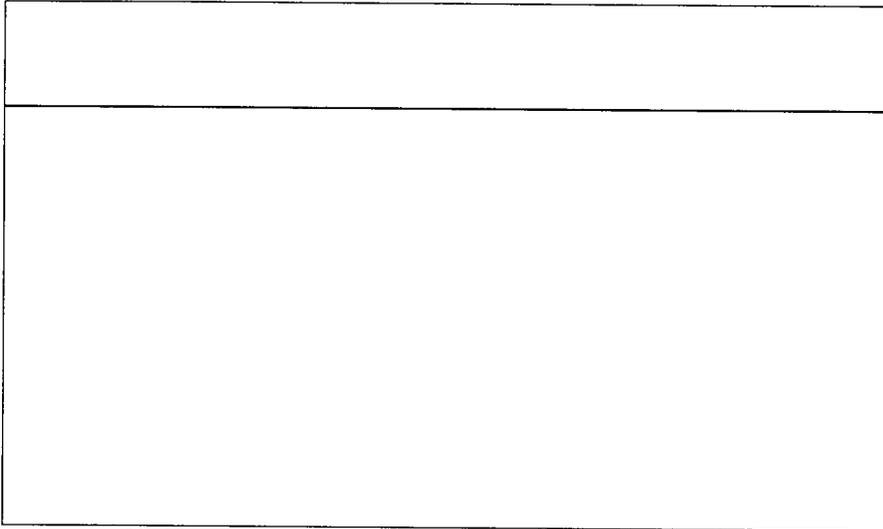
Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencel Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

25

SURVEY

Drawing? _____ Map Attached? _____ Units: _____

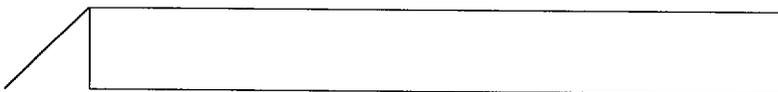


Shelf: <50 cpm

110 cpm

counter < 40 cpm on GM

floor < 50 cpm



Counter < 40 cpm on GM

Comments: Scoping Survey Check sources stored in bench drawer. Counter top above drawers with check sources indicated ~ 110 cpm on GM. The entire room was less than 40 cpm on Ludlum GM and did not show anything above background on beta scintillator or uR meter.

26

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 11/18/2000 f

27

Radiation Survey

The College of New Jersey

Survey #: 00-03 Location: Crowell Room 10 Date/Time: 11/18/2000**SURVEY INSTRUMENT**Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/BetaBattery Check: OK Source Check: OK Meter Condition: OKInstrument Checked by: J. Stencil Date/Time: 11/18/00: 1110Calibration Date: 6-2000

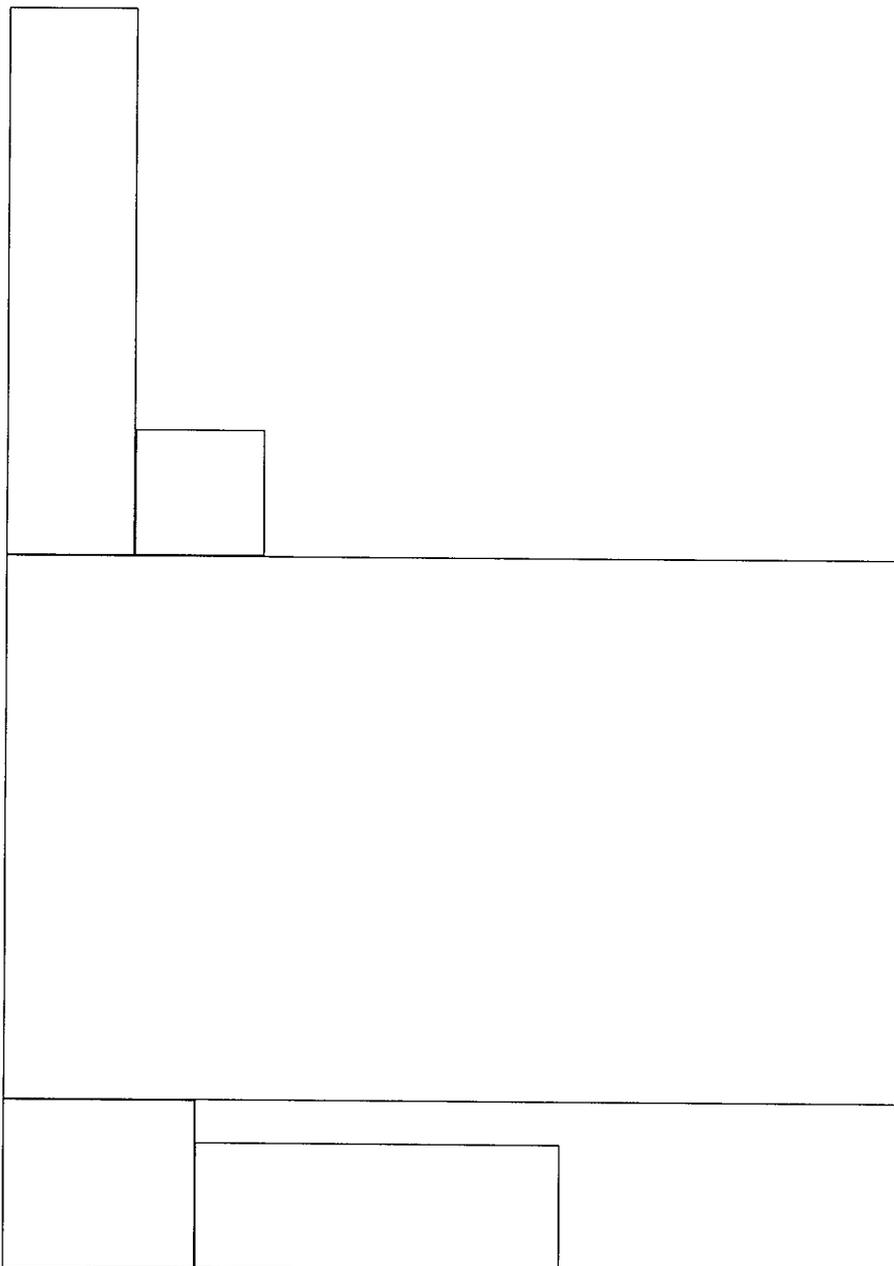
28

SURVEY

Drawing? _____

Map Attached? _____

Units: _____



Cabinet

Refrigerator

Source
Safe

counter

29

Comments: Scoping Survey. Multiple Sources needing disposition. Aqueous ^{86}Rb in hood. ^{33}P and ^3H in refrigerator.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 11/18/2000

30

Radiation Survey
The College of New Jersey

Survey #: 00-04 Location: Crowell Hall, RM 11 Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

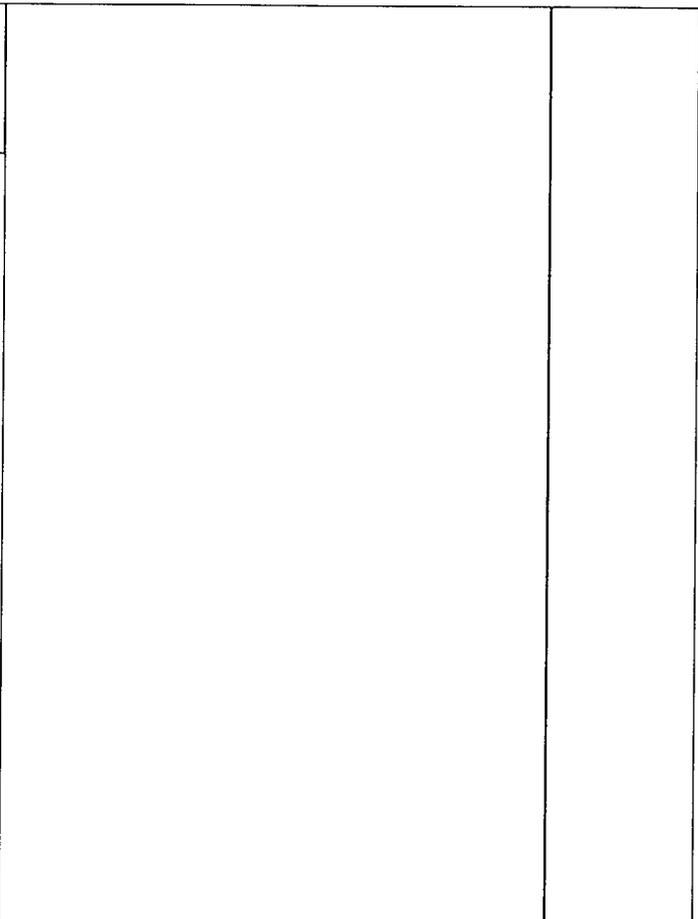
Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

31

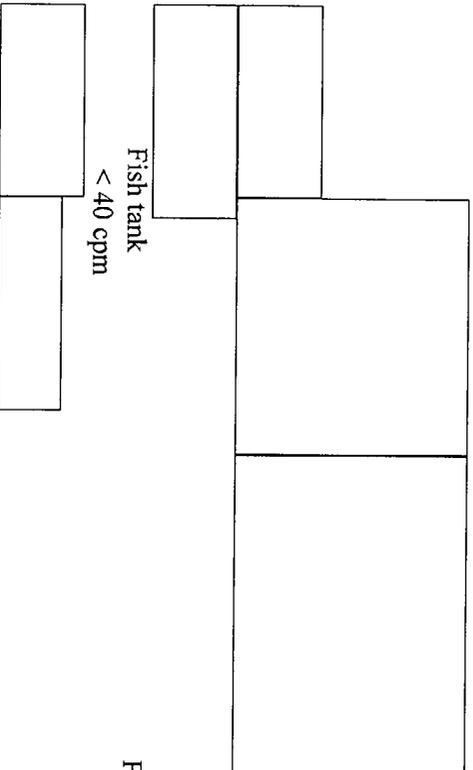
SURVEY

Drawing? _____ Map Attached? _____ Units: _____



X counter < 40 cpm sink

< 40 cpm < 40 cpm



Fish tank

Fish tank

32

Comments: Scoping Survey. At point X, a can opener at 1,000 cpm, put into radwaste. All other areas where less than 40 cpm with GM.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 11/18/2000

33

Radiation Survey
The College of New Jersey

Survey #: 00-05 Location: Crowell Hall, RM 6, 7A and 7D Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

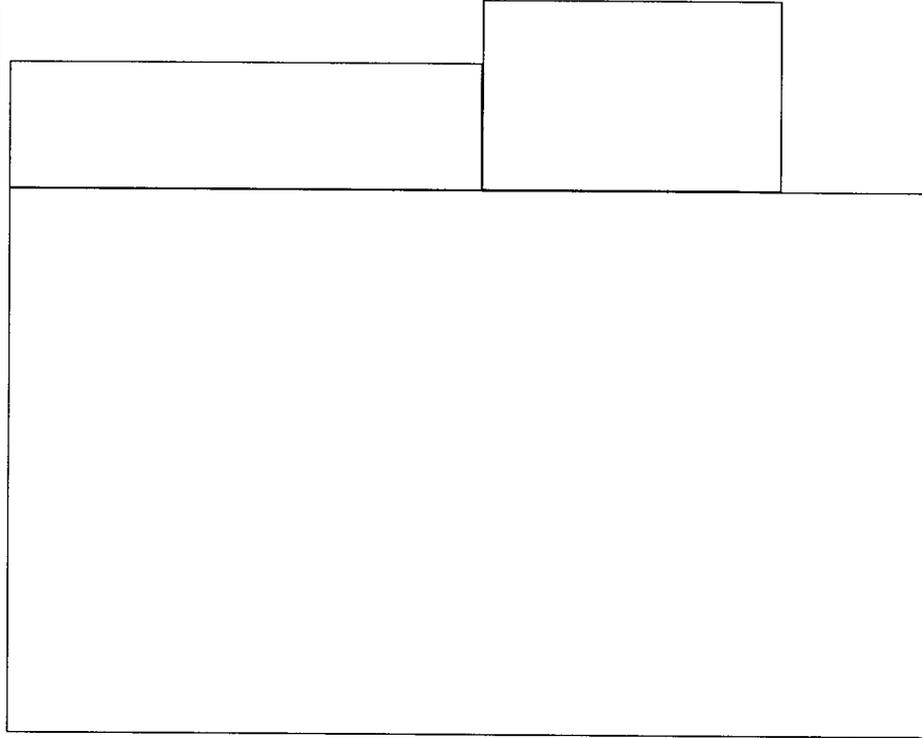
34

SURVEY

Drawing? _____

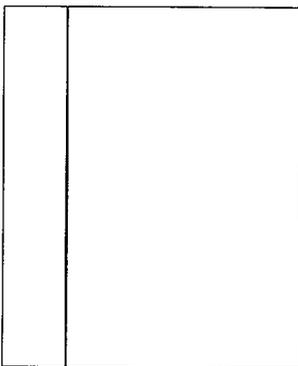
Map Attached? _____

Units: _____



Counter and shelves

RM 7D



Counter &
shelves

RM 6

Rm 7A

35

**Comments: Scoping Survey. All areas in Rooms 6, 7B and 7D less than 40 cpm.
Radioactive labels to be removed from drawer.**

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 11/18/2000

36

Radiation Survey
The College of New Jersey

Survey #: 00-06 Location: Crowell Hall RM 5, Radwaste Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

37

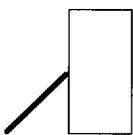
SURVEY

Drawing? _____

Map Attached? _____

Units: _____

Room 5, Radwaste



a

b

38

Comments: Scoping Survey. Radwaste Room has some waste. Behind lead bricks the field at "a" and "b" is on the order of 0.2-0.3 mR per hour.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 11/18/2000

39

Radiation Survey
The College of New Jersey

Survey #: 00-07 Location: Crowell Hall RM 14 Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencel Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

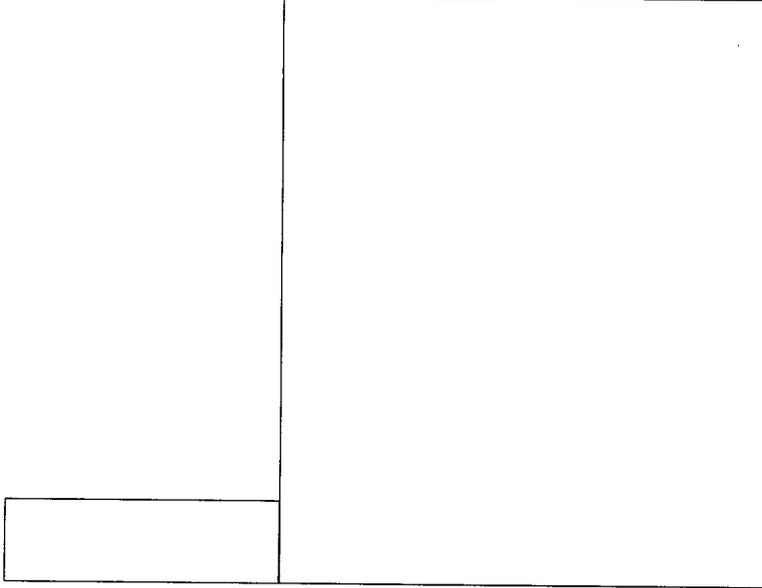
40

SURVEY

Drawing? _____

Map Attached? _____

Units: _____



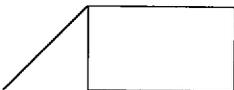
Counter



Shelves



Centri-
fudge



41

Comments: Scoping survey. All areas less than 40 cpm on GM, nothing found with beta scintillator either. Check sources placed in Room 12.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 11/18/2000

42

Radiation Survey
The College of New Jersey

Survey #: 00-08 Location: Room 213/213A Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencel Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

43

SURVEY

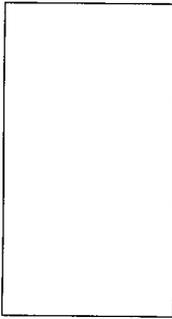
Drawing? _____

Map Attached? _____

Units: _____



Rm 213A



Rm 213



44

**Comments: Scoping Survey. Room less than 40 cpm at all locations on GM counter.
Need to remove radioactive sticker from Room 213A door.**

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 11/18/2000

45

Radiation Survey
The College of New Jersey

Survey #: 00-09 Location: RM 215 & 216 Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 11/18/00: 1110

Calibration Date: 6-2000

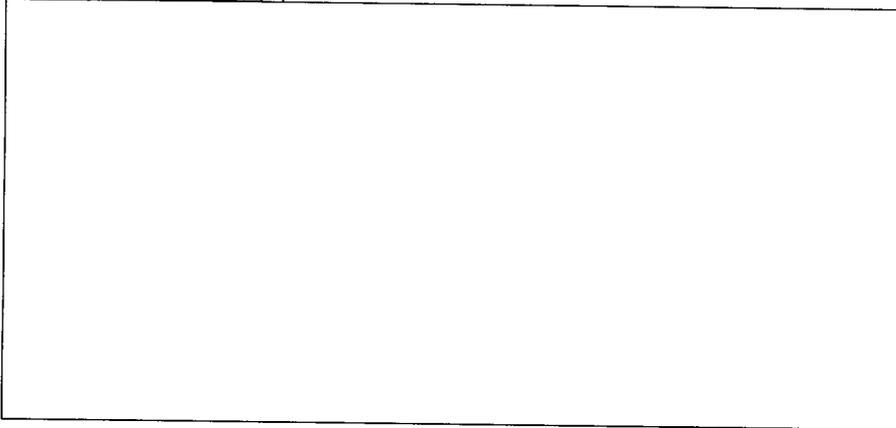
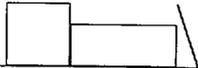
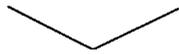
46

SURVEY

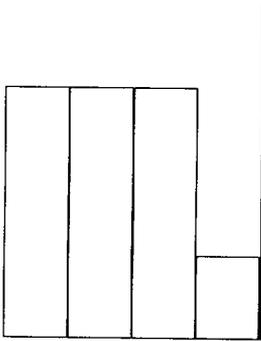
Drawing? _____

Map Attached? _____

Units: _____



RM 215



RM 216

X



47

Comments: Scoping Survey. All areas are less than 40 cpm on GM, no indications on beta scintillator either. One radioactive label at point X will be removed.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 11/18/2000

48

Radiation Survey
The College of New Jersey

Survey #: 00-10 Location: RM -203 Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta
Battery Check: OK Source Check: OK Meter Condition: OK
Instrument Checked by: J. Stencel Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

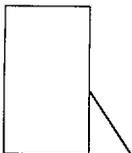
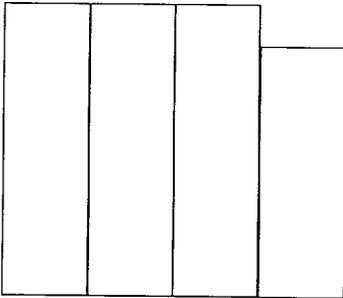
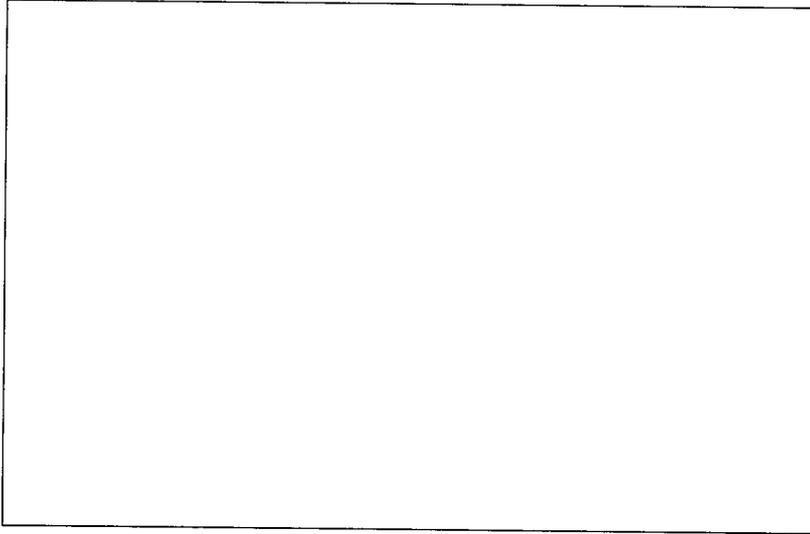
49

SURVEY

Drawing? _____

Map Attached? _____

Units: _____



50

Comments: Scoping survey. All areas less than 40 cpm on GM, no indications on beta scintillator either.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 11/18/2000

51

Radiation Survey
The College of New Jersey

Survey #: 00-11 Location: Room 233 Date/Time: 11/18/2000

SURVEY INSTRUMENT

Model: Ludlum 3,3,19 Serial #: 35216/34929/65907 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 11/18/00: 1110
Calibration Date: 6-2000

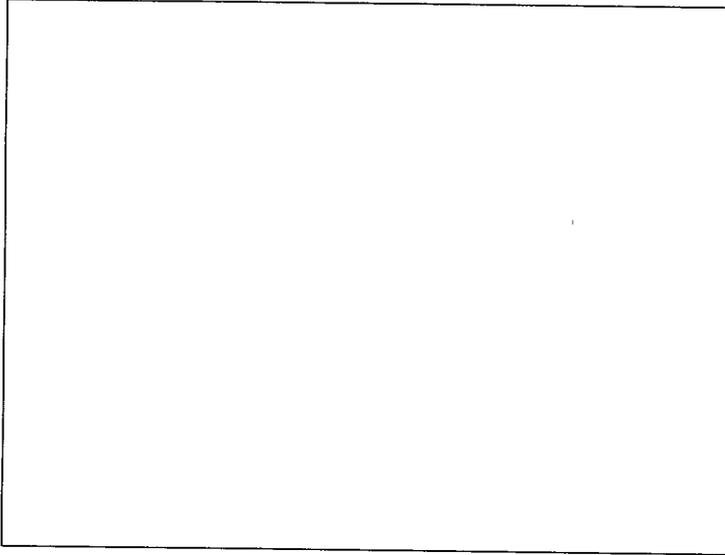
52

SURVEY

Drawing? _____

Map Attached? _____

Units: _____



53

Comments: Scoping survey. All areas less than 40 cpm in all areas. Nothing found on beta scintillator either.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 11/18/2000

54

Radiation Survey
The College of New Jersey

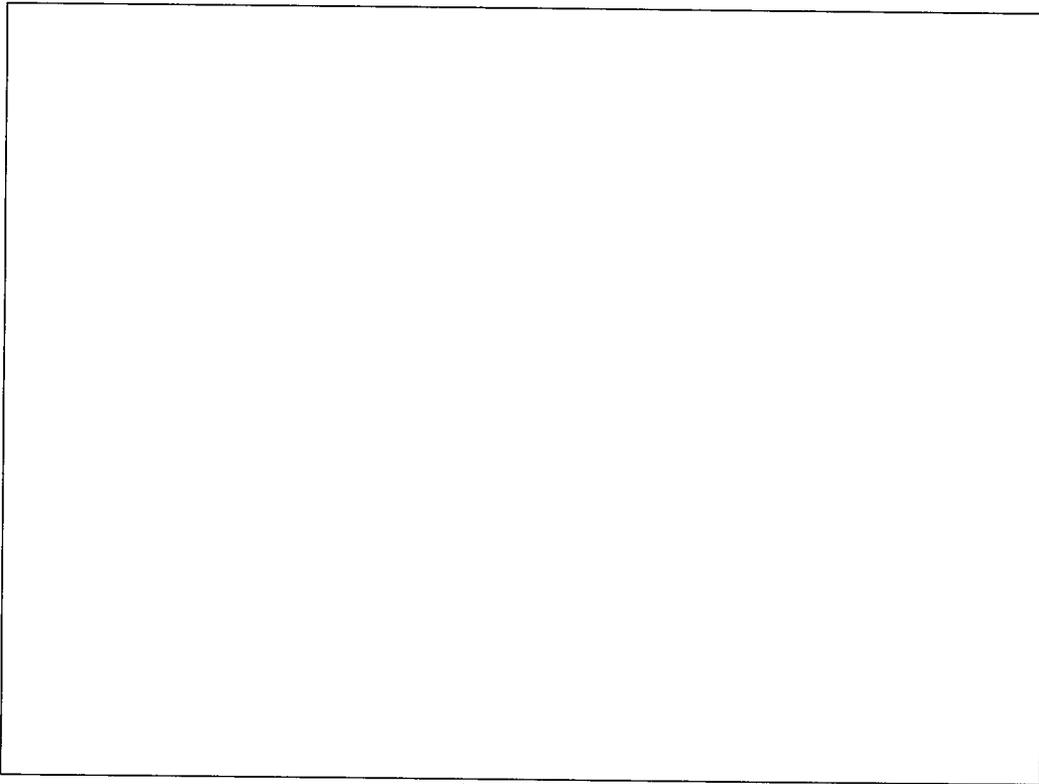
Survey #: 00-12 Location: Room 331/332 Date/Time: 4/11/2002

SURVEY INSTRUMENT

Model: Ludlum 3, 19 Serial #: 38377 & 37450 Probe: GM pancake and uR Meter

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 4/11/02: 1400
Calibration Date: 11-01



SURVEY

Drawing? Map Attached? Units: see comments

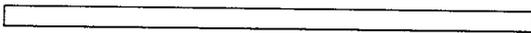


55

Hallway

Computer Room

outside
windows



Block Wall

Comments: Final Survey. Background readings. Pancake <40 cpm. uR-meter at

56

1-meter: 9-15 uR/hr with highest readings at concrete block walls.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 4/11/2002

57

Radiation Survey
The College of New Jersey

Survey #: 00-13 Location: Room 333 Date/Time: 4/11/2002

SURVEY INSTRUMENT

Model: Ludlum 3, 19 Serial #: 38377 & 37450 Probe: GM pancake and uR Meter

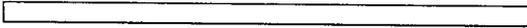
Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 4/11/02: 1400
Calibration Date: 11-01

SURVEY

Drawing? Map Attached? Units: see comments

58



Hallway

Room 333

outside
windows

Comments: Final Survey. Background readings. Pancake <40 cpm. uR-meter at 1-meter: 9-14 uR/hr with highest readings at concrete block walls. Physics storage area.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 4/11/2002



59

Radiation Survey
The College of New Jersey

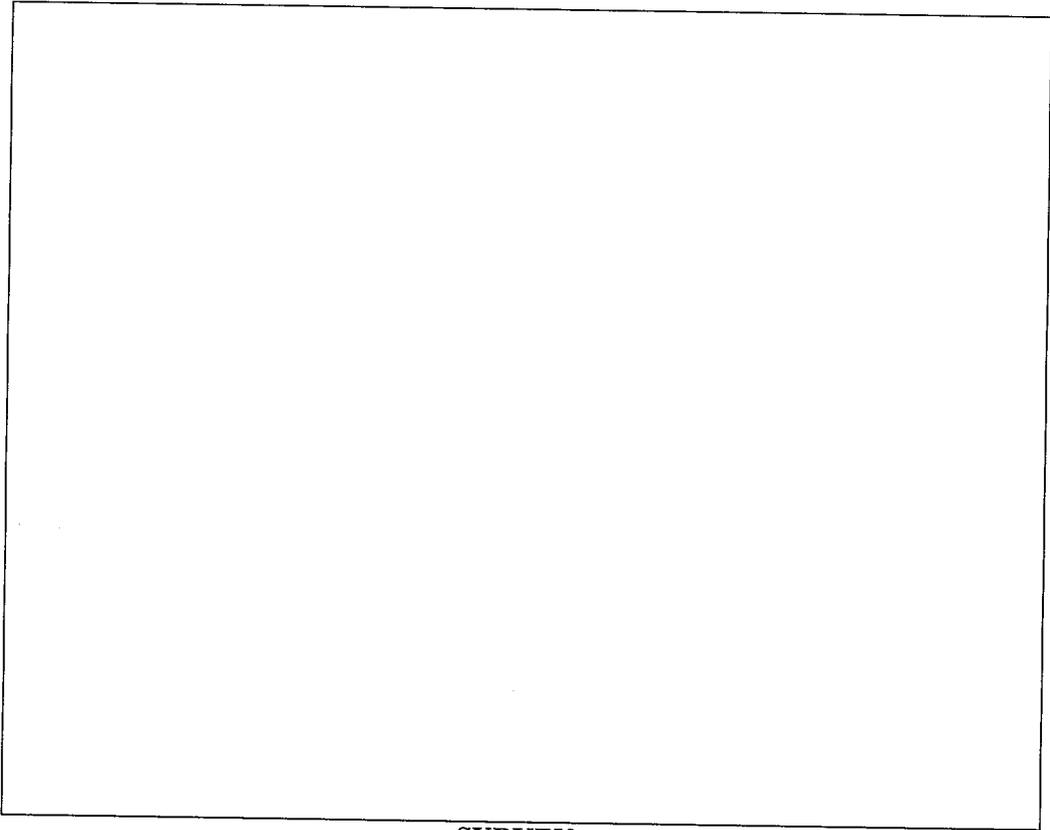
Survey #: 00-14 Location: Room 312 Date/Time: 4/11/2002

SURVEY INSTRUMENT

Model: Ludlum 3, 19 Serial #: 38377 & 37450 Probe: GM pancake and uR Meter

Battery Check: OK Source Check: OK Meter Condition: OK

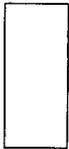
Instrument Checked by: J. Stencil Date/Time: 4/11/02: 1400
Calibration Date: 11-01



SURVEY

Drawing? _____ Map Attached? _____ Units: see comments

60

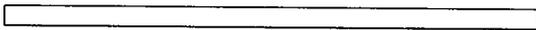


outside
windows

Room 312

Hallway

Hoods



61

Comments: Final Survey. Background readings. Pancake <40 cpm. uR-meter at 1-meter: 9-14 uR/hr with highest readings at concrete block walls.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencel 4/11/2002

62

Radiation Survey
The College of New Jersey

Survey #: 00-15 Location: Room 110 Date/Time: 4/11/2002

SURVEY INSTRUMENT

Model: Ludlum 3, 19 Serial #: 38377 & 37450 Probe: GM pancake and uR Meter

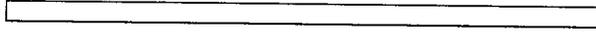
Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencil Date/Time: 4/11/02: 1400
Calibration Date: 11-01

SURVEY

Drawing? _____ Map Attached? _____ Units: see comments

63



Room 110

Hallway

Counting Room



Comments: Final Survey. Background readings. Pancake <40 cpm. uR-meter at 1-meter: 13-18 uR/hr. Small room with concrete block walls on each side. Slightly contaminated small collimator (200 cpm) removed from room to rad waste.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 4/11/2002

64

Radiation Survey
The College of New Jersey

Survey #: 016 Location: Crowell Hall, RM 302 Date/Time: 5/03/2002

SURVEY INSTRUMENT

Model: Ludlum 3, 19 Serial #: 38377/37450 Probe: GM/uR-meter

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencel Date/Time: 5/03/02: 1115

Calibration Date: 11-01

65

SURVEY

Drawing? _____

Map Attached? _____

Units: _____

10



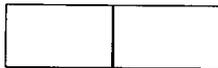
counter



windows

10 cabinets

15



12

66

Comments: Final Survey. All GM < 40 cpm; uR-meter 10-15 uR/hr. Higher values near concrete walls.

Survey Performed by: J. Gilbert Reviewed by/Date: J. Stencil 5/03/2002

67

Radiation Survey
The College of New Jersey

Survey #: 00-17 Location: Crowell Hall RM 5, Radwaste Date/Time: 5/13/2002

SURVEY INSTRUMENT

Model: Ludlum 3, 19 Serial #: 38377/37450 Probe: GM/uR,/Beta

Battery Check: OK Source Check: OK Meter Condition: OK

Instrument Checked by: J. Stencel Date/Time: 5/13/02: 1530

Calibration Date: 11-01