Enclosure

OAK RIDGE ASSOCIATED UNIVERSITIES:

SITE STATUS REPORT FOR THE FORMER WATERBURY CLOCK COMPANY AT 13 CHERRY AVENUE, WATERBURY, CONNECTICUT

NOVEMBER 28, 2017

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) requested that Oak Ridge Associated Universities (ORAU) perform a radiation survey of the Enterprise Apartments property at 13 Cherry Avenue in Waterbury, Connecticut. This property covers part of the footprint once occupied by the former Waterbury Clock Company, which used luminous radium paint in the manufacturing of clocks and/or watches into the mid-1940s. The objective of this survey was to confirm previous (circa late 1990s) cleanup activities and locate possible discrete sources of radium, if any, in select apartments and common spaces associated with historically documented radium contamination from former Waterbury Clock Company operations.

ORAU performed the radiation surveys in accessible portions of 13 apartments, select common areas (e.g., hallways), and the exterior land area on August 1–2, 2017. Surveys confirm that cleanup activities were likely performed that remediated four locations (for three apartments and one hallway previously identified with some of the highest contamination). ORAU also found that most of the contamination originally identified in the late 1990s is still present today, as well as some additional, small, low-level areas of elevated activity. A detailed dose assessment was performed, and results led to the conclusion that identified discrete sources of radium are unlikely to result in a dose above the unrestricted release dose limit of 25 mrem/yr. ORAU therefore recommends that, though discrete sources of radium were positively identified, the NRC should not pursue additional actions at the Enterprise Apartments complex because conservative dose estimates are below the unrestricted release limit.

SITE STATUS REPORT

Property:	Former Waterbury Clock Company 13 Cherry Avenue Waterbury, CT 06710
Docket Number:	03038965
Current Property Name(s):	Enterprise Apartments
Current Property Owner(s):	Conn Associates I Ltd Partnership
Inspection Dates:	August 1–2, 2017
Inspector(s):	Ray Powell, Todd Jackson, Lester Tripp, and Maureen Conley/ U.S. Nuclear Regulatory Commission (NRC), and Mike Firsick/ Connecticut Department of Energy and Environmental Protection (CT DEEP), supported by Kaitlin Engel and Jason Lee/Oak Ridge Associated Universities (ORAU)

1.0 INTRODUCTION

The Energy Policy Act of 2005 amended section 11e.(3) of the Atomic Energy Act of 1954 to place discrete sources of radium-226 (Ra-226) under NRC regulatory authority as byproduct material. The property at 13 Cherry Avenue in Waterbury, Connecticut (CT), was identified as part of the former Waterbury Clock Company, a manufacturing facility that operated from the 1920s to mid-1940s (ORNL 2015). Additional information on the site is also available in the Agency for Toxic Substances and Disease Registry (ATSDR) report (ATSDR 1999). The objectives of the survey were to confirm previous cleanup activities and determine if discrete sources of Ra-226 and/or distributed Ra-226 contamination are still present, to identify the areas of highest contamination, to determine if there are any current health and safety concerns, and to determine if further action by the NRC is needed.

Data collected during the survey are used to either eliminate the property from future NRC consideration or to plan future actions that may be needed to reduce the exposure of Ra-226 to current or future site occupants to levels that do not exceed the applicable regulatory requirement. It is important to note that destructive testing is not generally performed as described within NRC's procedures, Temporary Instruction 2800/043, Revision 1, *Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources* (NRC 2017) (Agencywide Documents Access and Management System [ADAMS] Accession number ML16330A678).

2.0 PROPERTY DESCRIPTION AND INITIAL SITE VISIT CONSIDERATIONS

2.1 Property Description and History

Prior to establishing its autonomy in 1857, the former Waterbury Clock Company was a department of the Benedict and Burnham Manufacturing Company, which began manufacturing

brass clocks in 1850. In 1873, Waterbury separated from Benedict and Burnham and acquired its own facility at the corner of Cherry Avenue and North Elm Street (see Building A in Figure 1) where, between 1873 and 1910, the company expanded by constructing several five- and six-story buildings. In 1919, the company began using luminous radium to paint the dials of various time pieces. Although the extent of radium paint storage and/or use throughout the facility is not completely known, records indicate that the entire industrial complex on the corner of Cherry Avenue and Cherry Street was dedicated to manufacturing time pieces painted with radium until operations were relocated in 1944 (ORNL 2015).

Figure 1. Former Waterbury Clock Company Facilities and Surrounding Areas

1 – 13 Cherry Ave., Buildings A, B, C, D, F, and M, Enterprise Apartments
2 – 0 Cherry Ave, Building #7, vacant
3 – 177 Cherry St., Buildings K and L, vacant
4 – 205 Cherry St., Building O, Ville Swiss Automatics
5 – 215 Cherry St., Buildings R and T, vacant
6 – 232 N Elm St., Buildings I and J, New Opportunities, Inc.
7 – 39 Cherry Ave., Building G, formerly Belco, now vacant and owned by New Opportunities, Inc.
(ORNL 2015)

As of spring 2017, most of the former Waterbury buildings are still standing with original floors and brick walls. Buildings A, B, C, D, F, and M from Figure 1 (aerial view) were converted to apartments in 1983 and now form one complex, Enterprise Apartments, managed by WinnResidential (ATSDR 1999; WinnResidential 2017). Figure 2 shows the apartments looking north by northwest. The five-story structure, located at 13 Cherry Avenue in Waterbury, CT, appears to have the original combination of brick and poured concrete walls. All five floors are occupied by the Enterprise Apartment complex. The first floor is mainly administrative space, while the upper four floors consist of residential apartments.

Previous radiological assessments by the ATSDR and Scientech identified elevated radiation levels in several discrete locations throughout the fourth and fifth floors. ATSDR 1999 specifically identifies small areas of elevated radiation levels in 13 apartments on the fourth and fifth floors and in the fifth floor hallway, with a maximum contact reading of 800 microRoentgen per hour (μR/h) (ATSDR 1999, p. 60 of 436). As a result, the State of CT (now CT DEEP) initiated cleanup efforts to remove Ra-226 contamination, though the extent of cleanup efforts was not known by NRC prior to this survey effort. The site summary included in the "Historical Non-Military Radium Sites Research Effort Addendum" report (ORNL 2015) provides known site details about the type, form, history, potential locations, and other information related to discrete sources of Ra-226 used at the site.

Figure 2. Enterprise Apartments at 13 Cherry Avenue

2.2 Initial Site Visit Considerations

Prior to commencing survey activities, the general apartment layout was examined for consistency with historical information and to identify impediments to conducting the survey and/or health and safety considerations. No health or safety issues were noted. However, it was noted that access was limited due to apartment occupancy (i.e., beds, dressers, couches,

etc.). A schedule for accessing apartments was developed by the property manager and communicated to the affected residents. The schedule allotted 90 minutes per apartment to conduct and document surveys. It is also noted that the original flooring has been covered with carpet, with the exception of kitchens and bathrooms, where tile or other materials were used—original flooring was not directly surveyed during this effort.

3.0 SITE OBSERVATIONS AND FINDINGS

3.1 Summary of Activities

The inspection team conducted a survey at the 13 Cherry Avenue property on August 1–2, 2017. A pre-inspection meeting was held on August 1, 2017, which included the following people: Ray Powell, Todd Jackson, Lester Tripp, and Maureen Conley (NRC); Mike Firsick (CT DEEP); Jason Miller, Alyse Egner, and Caroline Hagen (WinnResidential); and Kaitlin Engel and Jason Lee (ORAU). Participants discussed the inspection team's intention to re-visit the locations identified as potentially contaminated with radium in the historical assessment and to perform general area scans in other portions of the property. Surveys were generally limited to the 13 apartments and common areas identified in the late 1990s as containing elevated radiation levels. Other accessible common (including outdoor) areas were surveyed for completeness, as time permitted.

Radiological surveys performed by the inspection team consisted of gamma radiation scans within the building using a Ludlum model 44-10 2-inch by 2-inch (2×2) sodium iodide detector connected to a Ludlum model 2221 ratemeter/scaler, alpha-plus-beta radiation direct measurements using a Ludlum model 44-142 plastic scintillator connected to a Ludlum model 2221 ratemeter/scaler, and radiation exposure rate measurements using a Ludlum model 192 sodium iodide-based µR ratemeter[1]. Table 1 presents the specific instruments used during the site visit. Smear samples were also collected at selected locations to quantify the removable surface activity levels, though surveyors could not access bare (likely wood) surfaces under the carpet and other coverings, where contamination is expected to reside.

Summary of Daily Activities – August 1, 2017:

The inspection team arrived at 7:50 a.m. and met with representatives from NRC, CT DEEP, and WinnResidential. The site property manager provided a detailed schedule for accessing apartments. Each apartment was allotted 90 minutes to conduct survey activities. Surveyors used 2×2 sodium iodide detectors and model 192 exposure ratemeters to measure gamma radiation levels. Plastic scintillators were used to collect direct alpha-plus-beta radiation measurements from areas of elevated activity identified during gamma scanning. Smears were collected from most areas of elevated activity, when identified. The inspection team surveyed apartments 512, 513, 514, 515, 516, 517, 520, and 525. Surveys were conducted on accessible floor space with an overall coverage of approximately 40 percent. In addition, surveys were conducted on approximately 70 percent of the accessible floor space in the fifth floor hallway. The team departed the site at approximately 5:30 p.m.

[1]Roentgen is a unit of exposure (energy absorbed in air), whereas a rem is a unit of dose delivered to a person (resulting from the radiation energy absorbed in that person). While Roentgen and rem are related, these are different units. Because they are similar for gamma ray energies from Ra-226, NRC makes the simplifying assumption in this case that these units are equivalent (1 Roentgen = 1 rem).

Table 1. Waterbury Clock Company Survey Instruments			
Radiation Type (units)	**Detector Type**	**Detector Model (Number)**	**Ratemeter (Number)**
Alpha-plus-beta (cpm)	Plastic Scintillator	44-142 (1030) Calibrated 07/26/2017 44-142 (689) Calibrated 03/08/2017	2221 (395) Calibrated 04/11/2017 2221 (505) Calibrated 03/16/2017
Gross gamma (cpm)	Sodium Iodide	44-10 (1148) Calibrated 04/13/2017 44-10 (1151) Calibrated 04/13/2017	2221 (395) Calibrated 04/11/2017 2221 (505) Calibrated 03/16/2017
Gross gamma (µR/h)	Exposure Meter	192 (1127) Calibrated 06/02/2017 192 (1128) Calibrated 06/02/2017	N/A

N/A = not applicable
Number = ORAU equipment barcode
cpm = counts per minute
µR/h = microRoentgen per hour

Summary of Daily Activities – August 2, 2017:

The inspection team arrived at 7:50 a.m. and continued surveys using the same equipment. Survey activities were conducted in the third, fourth, fifth floor hallways and common areas, and in apartments 416, 417, 505, 507, and 508. Overall survey coverage was approximately 40 percent in the apartments and 90 percent in the hallways and common areas. Plastic scintillators were used to collect direct alpha-plus-beta radiation measurements from areas of elevated activity identified during gamma scanning. Smears were also collected at multiple areas of elevated activity, when identified.

Outdoor surveys were performed on approximately 40 percent of the land area and included the building's perimeter, grassy areas, sitting areas, and surface drains. The team departed the site at approximately 4:30 p.m.

3.2 Summary of Results

Appendix A presents survey tabulated results and associated data maps. Tables A-1 through A-19 present gross 2×2 sodium iodide responses in cpm, net alpha-plus-beta total surface activity results in units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2), gross exposure rates in µR/h on contact and at 1 meter, and removable alpha-plus-beta surface activity in dpm/100 cm^2, as applicable. Figures A-1 through A-19 present survey data coupled to the respective table, overlaid onto facility floorplans. Note that drawings are not to scale and depictions of furniture or other items are based on the observations of surveyors during the August 2017 investigation.

Smears were submitted for gross alpha and gross beta analysis at a radio-analytical laboratory. Field measurements of total alpha-plus-beta static measurements and smears for removable surface activity in cpm were converted to total surface activity units of dpm/100 cm^2 using the equation below:

$$dpm/100\ cm^2 = \frac{C - B}{\varepsilon_{tot} \times G}$$

Where:

C = measured count rate (cpm)
B = background count rate (cpm)
G = geometry factor (unitless) = $\frac{Physical\ Detector\ Area\ (cm^2)}{100\ cm^2}$ = 1.0

ε_{tot} = total weighted efficiency (unitless) = 0.11

Due to the number of emissions from Ra-226 and its associated progeny, multiple radiation particles are counted during the surface activity measurement. Therefore, a total weighted efficiency for Ra-226 and its associated progeny was calculated by:

$$\varepsilon_{tot} = \sum_{n} F_n \times \varepsilon_{i,n} \times \varepsilon_{s,n}$$

Where:

F_n = fractional abundance of n^{th} emission

$\varepsilon_{i,n}$ = instrument efficiency for n^{th} emission

$\varepsilon_{s,n}$ = surface efficiency (0.25 for low-energy beta particles, 0.5 for high-energy beta particles) for n^{th} emission

A total weighted efficiency of 0.11 was estimated at the ORAU facility after conducting a series of radiation measurements using alpha/beta sources and a piece of low-pile carpet. The objective of these measurements was to mimic conditions encountered at the site and, therefore, calculate a realistic efficiency that would not underestimate true radiological conditions. These measurements demonstrate that all alpha radiation and low-energy beta radiation is shielded by carpet, thus the plastic scintillator is estimated to identify only a small percentage of the total alpha/beta radiation emanating from the source surface.

Table 2 summarizes survey results from the August 2017 survey effort—detailed data tables and maps are presented in Appendix A. In general, background gamma radiation levels ranged from 4,400 to 18,000 cpm on contact and 5 to 15 µR/h at 1 meter (though these values vary by survey unit)—the higher levels associated with naturally occurring radioactive materials (NORM) in exterior brick walls. To the extent possible, each room was divided into quadrants, and systematic contact 2×2 sodium iodide (in cpm) and 1 meter model 192 exposure rate measurements (in µR/h) were collected at the center of each quadrant and at the middle of the room, following the survey design described in ORAU 2017. Surveyors also collected contact cpm and µR/h data, 1 meter µR/h data, plus removable (smear) samples at small areas of elevated activity, when identified. Because Appendix A presents details for the numerous individual survey units, including 13 apartments plus multiple hallway/common segments on each floor, the following discussion presents only high-level, floor-by-floor summaries. The radio-analytical laboratory reported negligible counts on each smear (< 1 dpm/100 cm^2), so the more conservative field count results are used hereafter.

Third Floor. Third floor surveys were limited to common areas. All results are consistent with background—no areas of elevated activity were identified. Radiation levels ranged from 4,400 to 13,000 cpm on contact using the 2×2 sodium iodide detectors and 5 to 14 µR/h at 1 meter using the 192 exposure ratemeter. Areas near exterior walls produced maximum radiation levels likely attributed to NORM in brick. ATSDR 1999 (p. 248 of 436) also notes the absence of elevated radiation levels on the third floor, in agreement with ORAU measurements, though one third-floor tenant recalled the positive identification of Ra-226 during the late 1990s survey—this could not be confirmed. It is presumed that if small areas of elevated activity were identified in the 1990s, radiation levels did not exceed "risk-based cleanup levels" established for that investigation, including 15 µR/h for external gamma, 300 dpm/100 cm^2 fixed contamination, and 20 dpm/100 cm^2 removable contamination (ATSDR 1999).

Fourth Floor. Fourth floor radiation measurements were limited to common areas and apartments 416 and 417. Radiation levels ranged from 4,800 to 176,000 cpm on contact using the 2×2 sodium iodide detector and 5 to 14 µR/h at 1 meter using the 192 exposure ratemeter. Several small (<0.1 m^2) areas of elevated radiation were identified in fourth floor survey units, including two in the hallway, three in apartment 416, and four in apartment 417. The maximum contact exposure rate of 150 µR/h was recorded in apartment 417, noting the exposure rate dropped to 14 µR/h at 1 meter directly above this location. Direct measurements were collected using the model 44-142 plastic scintillator from small areas of elevated activity in both apartments, with maximums of 7,700 dpm/100 cm^2 (total) in apartment 416 and 56,000 dpm/ 100 cm^2 (total) in apartment 417. Smears were also collected and field counted, producing a maximum of 9 dpm/100 cm^2 (removable) in apartment 416—apartments are carpeted, so smears were not collected directly from the radium-contaminated media, presumably the original wood floor. Areas of contamination documented in the ATSDR 1999 report are still present, though additional isolated small areas of elevated activity (<0.1-0.2 m^2) were identified by ORAU. These additional locations may not have been reported in ATSDR 1999 because measured values were below the 15-mrem/yr threshold used at that time.

Fifth Floor. Fifth floor radiation measurements were limited to common areas and apartments 505, 507, 508, 512, 513, 514, 515, 516, 517, 520 and 525. Radiation levels ranged from 4,800 to 125,000 cpm on contact using the 2×2 sodium iodide detector and 5 to 15 µR/h at 1 meter using the 192 exposure ratemeter. Several small areas of elevated radiation were identified throughout the fifth floor, including 13 in the hallway and a maximum of 7 in one apartment (517). The maximum contact exposure rate of 110 µR/h was recorded in apartment 517, noting the exposure rate dropped to 13 µR/h at 1 meter directly above the location. Direct

measurements were also collected using the model 44-142 plastic scintillator from small areas of elevated activity in several apartments (see Table 2), producing maximums of 31,000 dpm/ 100 cm^2 (total) at two locations in apartment 517. Smears were also collected and field counted at multiple locations, producing a maximum of 44 dpm/100 cm^2 (removable) in apartment 513—apartments/hallways are carpeted, so smears were not collected directly from the radium-contaminated media. Most of the contaminated areas documented in the ATSDR 1999 report are still present, with the exception of those in apartments 507, 514 and 525 and at least one hallway location, which appear to have been remediated. ORAU did, however, identify additional small areas of elevated activity than those identified in ATSDR 1999. These additional locations may not have been reported in ATSDR 1999 because measured values were below the 15-mrem/yr threshold used at that time.

Outdoor Areas. All outdoor areas produced radiation levels consistent with background—no areas of elevated activity were identified. Radiation levels ranged from 8,000 to 13,000 cpm on contact using the 2×2 sodium iodide detector and 9 to 15 µR/h at 1 meter using the 192 exposure ratemeter. Areas near exterior walls produced maximum radiation levels likely attributed to NORM in brick.

3.3 Summary of Dose Assessment Results

Due to the complexity of the dose assessment described herein, more detail is necessary than is typically required under Temporary Instruction 2800/043. This detail includes descriptions of the calculation method and assumptions used to generate results. Therefore, the discussion is divided into two subsections: Dose Assessment Method and Dose Assessment Results.

Dose Assessment Method. Temporary Instruction 2800/043 presents screening-level exposure rates that the inspection team may use, while on-site, to quickly determine whether gamma radiation levels could result in a dose above the 100 mrem/yr public dose limit in 10 CFR 20.1301. Specifically, an exposure rate at 1-m of 40 µR/h above background conservatively corresponds to 100 mrem/yr assuming 2,300 hours of exposure in an industrial setting, or 15 µR/h at 1-m conservatively corresponds to 100 mrem/yr after 6,800 hours of exposure in a residential setting. These screening values do not consider site-specific conditions or internal exposure pathways (e.g., inhalation and ingestion). Therefore, dose assessment methods described herein rely upon the *Dose Assessment Technical Basis Document for Potential Exposures to Discrete Sources of Radium-226 and Associated Contamination* (hereafter the Technical Basis Document; ORISE 2017) to account for site-specific conditions and all potential pathways.

The Technical Basis Document (ORISE 2017) presents default concentration-based screening levels based on guidance in NUREG-1757 (NRC 2006) using the Decontamination and Decommissioning (DandD) code Version 2.4 (NRC 2001). The Technical Basis Document also presents methods for developing site-specific screening levels and dose estimates, assuming a default conceptual model may not apply at a given site. The average member of the critical group at the Enterprise Apartments is a residential building occupant, who is conservatively assumed to spend up to 5,770 hours in an apartment; and potential exposure pathways include external gamma, inhalation, and secondary ingestion. However, contaminated media (floors) identified during the August 2017 survey are carpeted, or otherwise covered with materials that currently significantly reduce exposure via the inhalation and secondary ingestion pathways. Therefore, the dose assessment for a current occupant considers only the external gamma pathway. Occupants at some time in the future may engage in activities which uncover the original floors, and be exposed via external gamma, inhalation, and indirect ingestion pathways.

Though these conditions are not well suited for using the default screening levels listed in the Technical Basis Document, the guidance does present methods that are used herein to estimate doses based on site-specific conditions encountered during the August 2017 survey. The following discussion describes the dose assessment methods and results, which are presented in more detailed in Appendix B.

Because measured values are preferable to modeled values, measured exposure rate in µR/h are used to estimate dose received via the external gamma pathway (assuming 1 µR/h ~ 1 µrem/h). The Technical Basis Document presents dose-to-source ratios (DSRs) for the inhalation (1.61×10^{-8} mrem/hr per dpm/100 cm^2) and secondary ingestion (4.30×10^{-8} mrem/hr per dpm/100 cm^2) pathways, for a total DSR of 5.91×10^{-8} mrem/hr per dpm/100 cm^2 (see ORISE 2017, Table 4.3). These DSRs are selected for a small area of elevated activity on the order of 0.1 m^2, given only small areas of elevated activity were encountered during the August 2017 survey. The dose estimate method, therefore, consists of the following calculations, which include multiplying the occupancy time by the measured exposure rate (for the external dose), and by multiplying the occupancy time by the measured surface activity and total DSR (for the internal dose):

$$\text{External Dose}\left(\frac{\text{mrem}}{\text{yr}}\right) = Time\left(\frac{h}{yr}\right) \times \frac{Measured\ Exposure\ Rate\ \left(\frac{\mu R}{hr} \sim \frac{\mu rem}{hr}\right)}{1000\ \mu rem/mrem},$$

$$\text{Internal Dose}\left(\frac{\text{mrem}}{\text{yr}}\right) = Time\left(\frac{h}{yr}\right) \times Surface\ Activity\left(\frac{dpm}{100\ cm^2}\right) \times 5.91 \times 10^{-8}\left(\frac{mrem/h}{dpm/100\ cm^2}\right),$$

and finally,

$$\text{Total Dose} = \text{External Dose} + \text{Internal Dose}.$$

Note that even when doses are averaged over a reasonably conservative area, such as a room or apartment, the DSRs for small areas are still used given the sum of the contaminated area is a very small percentage of the total. For example, apartment 517 contains the highest number of small areas of elevated activity (seven), with a total estimated contaminated area of less than 0.25 m^2, compared to a total apartment area of approximately 40-50 m^2. Therefore, an upper estimate of the contaminated area represents less than 1 percent of total living space.

Because only small areas of elevated activity were identified at the Enterprise Apartments, the dose assessment was performed assuming two occupancy duration scenarios. The first scenario assumes an individual would spend the entire 5,770-h/yr occupancy period in the room or area containing the highest-activity small area of elevated activity identified in a survey unit ("maximum room" scenario). This scenario is very conservative given an individual is highly unlikely to spend all modeled time in only the bedroom, or the kitchen, or the hallway section, etc., of a given survey unit. The second scenario assumes an individual would spend the 5,770-h/yr occupancy period averaged over the entire survey unit (e.g., the whole apartment). This scenario is still conservative but more closely aligns with the conceptual model described in the Technical Basis Document (ORISE 2017). Therefore, the first scenario is intended to generate an upper bound of the dose within a given survey unit, and the second scenario is intended to generate a still conservative but more realistic representation of conditions expected to be encountered within a survey unit.

Table 2. Summary of Discrete Areas of Elevated Radiation at the Former Waterbury Clock Company								
Area/Apartment No.	No. Elevated Areas	2×2 Sodium Iodide (cpm)	Gross Exposure Rate (µR/h)		No. Smears Collected	Surface Activity (dpm/100 cm^2)		Max Size (m^2)
			Contact	1 meter		Total Ra-226	Removable[a]	
Outdoor Land Area	0	8,000 to 15,000	NA	9 to 15	0	NA	NA	NA
3rd Floor Hallway	0	4,400 to 13,000	NA	5 to 14	0	NA	NA	NA
4th Floor Hallway	2	4,800 to 22,000	13 to 15	5 to 12	0	NA	NA	NA
416	3	9,500 to 40,000	21 to 34	9 to 15	3	1,400 to 7,700	-7 to 9	0.1
417	4	7,500 to 176,000	35 to 150	7 to 14	2	15,000 to 56,000	-7 to -3	0.1
5th Floor Hallway	13	4,800 to 68,000	13 to 70	5 to 15	8	2,800 to 20,000	-21 to 3	0.1
505	2	5,500 to 26,500	20 to 24	5 to 10	2	4,400 to 5,900	3 to 6	0.1
507	1	6,000 to 14,700	11 to 15	6 to 10	2	750 to 2,700	-11 to 21	0.1
508	2	6,400 to 20,000	16 to 19	6 to 12	2	2,900 to 3,600	6 to 31	0.1
512	3	7,400 to 29,000	24 to 27	6 to 13	3	3,100 to 4,400	-20 to -11	0.1
513	4	7,500 to 68,000	20 to 60	7 to 15	4	2,100 to 15,000	9 to 44	0.1
514	0	5,700 to 8,700	6	5 to 8	1	-310	-18	0.1
515	5	7,100 to 56,000	16 to 50	7 to 14	3	3,600 to 13,000	19 to 25	0.1
516	4	10,000 to 32,000	20 to 29	10 to 13	4	5,300 to 8,700	-12 to 13	0.2
517	7	8,000 to 125,000	26 to 110	7 to 13	6	3,600 to 31,000	-26 to 12	0.1
520	3	5,300 to 21,000	12 to 20	5 to 12	3	1,300 to 4,900	16 to 29	0.1
525	0	5,200 to 9,600	NA	5 to 9	0	NA	NA	NA

NA = not applicable

[a]Based on field count with same detector used for direct measurement.

Note: Negative values are possible in (net) dpm/100 cm^2 calculations when a measured value is less than the average background estimate.

The source term for each scenario is a net value (excludes background) and is also conservatively estimated. The source term in the first ("maximum room") scenario is defined by the highest measured radioactivity within the survey unit. The source term in the second scenario is the average of all measured radioactivity in the survey unit. This value is conservative because results for a given small area of elevated activity are weighted equally with background measurements, though the area containing elevated activity is a very small fraction of the total surface area in any survey unit. Background is likewise estimated by averaging all measurements in the room or area, though excluding locations with elevated activity.

In summary, the dose assessment method described herein uses multiple conservative assumptions. For example, worst-case doses assume the receptor spends 100 percent of the occupancy period in a single room. Additionally, an "average" survey unit source term is biased to the conservative by combining data from measurements of small areas of elevated activity though they represent a very small percentage of the total surface area with larger areas of background measurements in an unweighted manner. As a result of this layered conservatism, dose estimates presented in the following discussion should overestimate the true value.

Dose Assessment Results.

Appendix B presents dose assessment results for all survey units. Table B-1 lists dose estimates for the external gamma pathways only, and represents potential doses to current occupants—recalling that floor covering significantly reduces exposure via inhalation and secondary ingestion pathways. Table B-2 lists dose estimates for internal pathways only, representing potential doses via inhalation and secondary ingestion, assuming floor coverings are removed at some time in the future. These values must be added to the corresponding values in Table B-1 to estimate the total dose to the hypothetical future occupant, who may be exposed through all potential exposure pathways. Table B-3 summarizes dose estimated for both the current occupant (external gamma only) and the hypothetical future occupant (all pathway). As presented in Table B-3, the maximum estimated dose, assuming an individual spends the entire 5,770-hours/yr occupancy period in a single room/area, is 11 mrem/yr (fifth floor hallway outside of apartment 515). Considering apartments only, the highest estimated dose from any room is 7.1 mrem/yr (rooms in apartments 515 and 520), and the highest estimated dose from across an entire apartment is 3.9 mrem/yr (apartment 417).

Two dose limits are considered in this assessment. The first dose limit is the 100 mrem/yr public dose limit in 10 CFR 20.1301. An estimated dose above 100 mrem/yr to the average member of the critical group would require immediate action, such as access controls to limit current occupant exposures to discreet sources of Ra-226. The second dose limit is the 25 mrem/yr unrestricted use limit in 10 CFR 20.1402. An estimated dose above 25 mrem/yr to the average member of the critical group would not require immediate action, though controls, additional characterization, and remediation may be required prior to unrestricted release. In any case, no action is required if the estimated dose is less than 25 mrem/yr.

These results demonstrate that current and potential future occupants are unlikely to receive a dose above the 25 mrem/yr unrestricted use limit in 10 CFR 20.1402. Therefore, although discrete sources of Ra-226 were identified within several survey units at the Enterprise Apartments, none are present at concentrations that would reasonably produce a dose above regulatory limits.

Finally, the inspection team confirmed that four of the most contaminated areas identified by Scientech were remediated (remediation of a portion of the fifth floor hallway also appears to have addressed an adjacent apartment). Beyond those locations, the inspection team generally confirmed the previous surveys. However, some small areas of elevated activity were identified but were not reported in ATSDR 1999. These additional locations may not have been reported in ATSDR 1999 because measured values were below the 15-mrem/yr threshold used at that time. The conclusion is, therefore, that the previous survey results are confirmed, that the highest areas of contamination are confirmed to have been removed, and that the contamination present in the Enterprise Apartments does not cause any resident to exceed the dose limit for the public.

4.0 OBSERVATIONS AND RECOMMENDATIONS

Based on the data collected during the August 2017 survey, the former Waterbury Clock Company property located at 13 Cherry Avenue contains discrete sources of Ra-226. However, the identified sources are not at concentrations or configured in a manner that would reasonably result in a dose in excess of regulatory requirements. This conclusion is based on the following observations:

- Elevated direct gamma and surface radiation due to discrete sources of Ra-226 were identified in multiple survey units on both the fourth and fifth floors.

- Identified Ra-226 contamination is limited to small areas of elevated activity (generally less than 0.1 m^2).

- Results from the August 2017 survey are generally consistent with those documented in the historical record. The recent survey effort identified some additional low-level radioactivity; however, these additional locations may not have been reported in ATSDR 1999 because measured values were below the 15-mrem/yr threshold used at that time. In addition, three small areas of elevated activity identified by ATSDR 1999 appear to have been remediated.

- Dose estimates show that a residential building occupant would receive an estimated dose less than the 25 mrem/yr unrestricted use limit in 10 CFR 20.1402, even if spending up to 5,770 hours/yr in a room containing the maximum observed area of elevated activity in a survey unit. These results are consistent with the dose assessment conclusions presented in ATSDR 1999.

Based on these observations, it is recommended that the NRC not pursue additional actions at the Enterprise Apartments facility. NRC should, however, communicate to the owner the location and magnitude of identified Ra-226 contamination, even though isolated areas of elevated activity are unlikely to exceed NRC's dose standards for unrestricted use.

5.0 REFERENCES

ATSDR 1999. *Public Health Implications of Radiation Contamination at Former Clock Factories Located in Bristol (Hartford County), New Haven, (New Haven County), Thomaston (Litchfield County), and Waterbury (New Haven County), Connecticut*, prepared by the Connecticut Department of Public Health under Cooperative Agreement with The Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, January 29. (Agencywide Documents Access and Management System [ADAMS] Accession No. ML17038A052).

NRC 2001. *Residual Radioactive Contamination from Decommissioning – User's Manual DandD Version 2.1*. NUREG/CR-5512, Vol. 2. U.S. Nuclear Regulatory Commission. April.

NRC 2006. *Consolidated Decommissioning Guidance – Characterization, Survey, and Determination of Radiological Criteria*. NUREG-1757, Vol. 2, Rev. 1. U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. Washington, D.C. September.

NRC 2017. *Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources*, Temporary Instruction 2800/043, Revision 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Washington, D.C., October. (ADAMS Accession No. 16330A678).

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, "Waterbury Clock Company: Site Summary," pp. 82-88, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488).

ORISE 2017. *Dose Assessment Technical Basis Document for Potential Exposures to Discrete Sources of Radium-226 and Associated Contamination*, DCN 5289-TR-01-2, Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, May 30. (ADAMS Accession No. ML17152A204).

ORAU 2017. *Project-Specific Plan for the Survey of the Enterprise Apartments at the Former Waterbury Clock Factory Property at 13 Cherry Avenue in Waterbury, Connecticut*, DCN 5307-PL-01-1, Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, July 30.

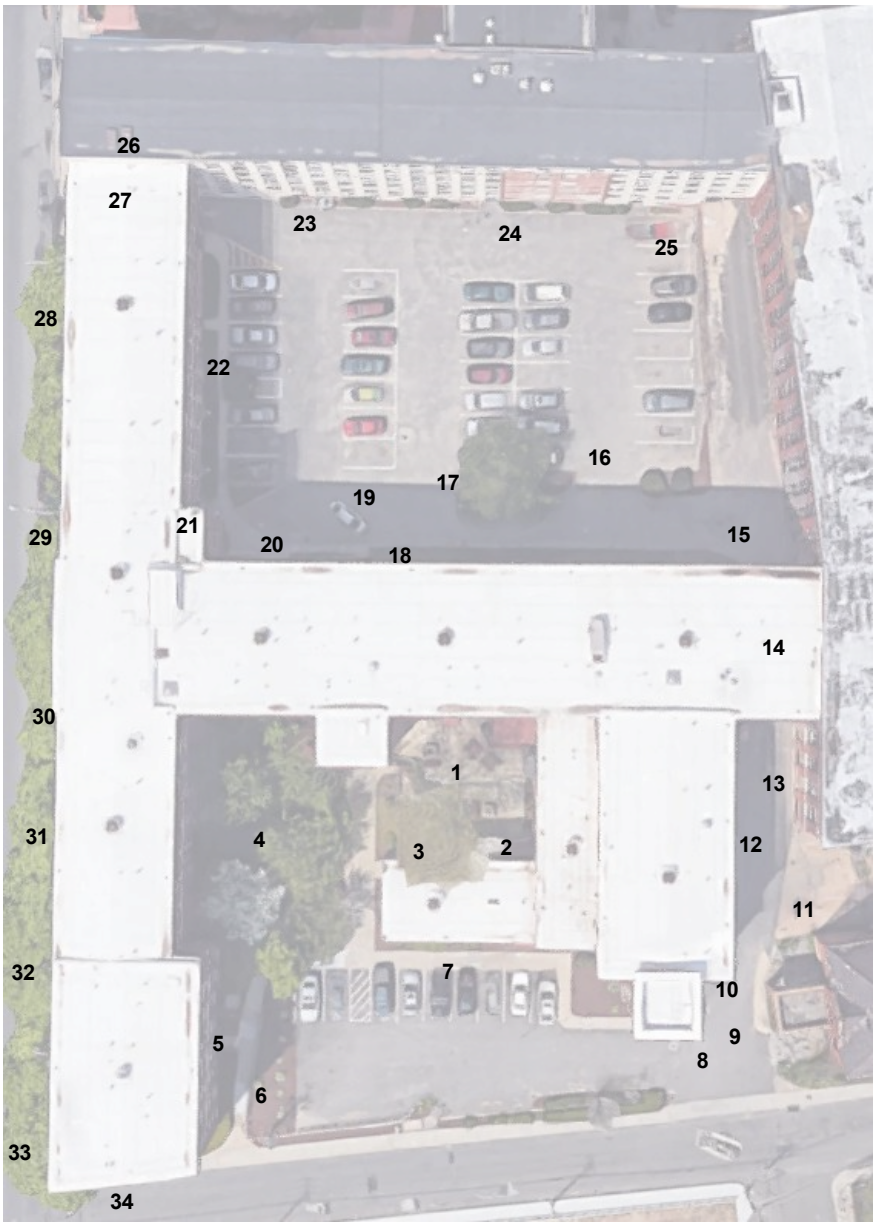
WinnResidential 2017. Enterprise Apartments and Abbott Towers. Boston, Massachusetts. http://www.enterpriseabbott.com/.

APPENDIX A
SURVEY RESULTS FROM THE FORMER WATERBURY CLOCK COMPANY SURVEY

Site: Waterbury-Enterprise Apt.	**Area:** Outside	**Date(s):** 08/02/2017	**Time:** 1315/1430
Surveyor(s): KME		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/505	44-10/1151	8-15 kcpm[a]
Gamma	192/1128	NA	9-15 µR/h[a]
NA	NA	NA	NA

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

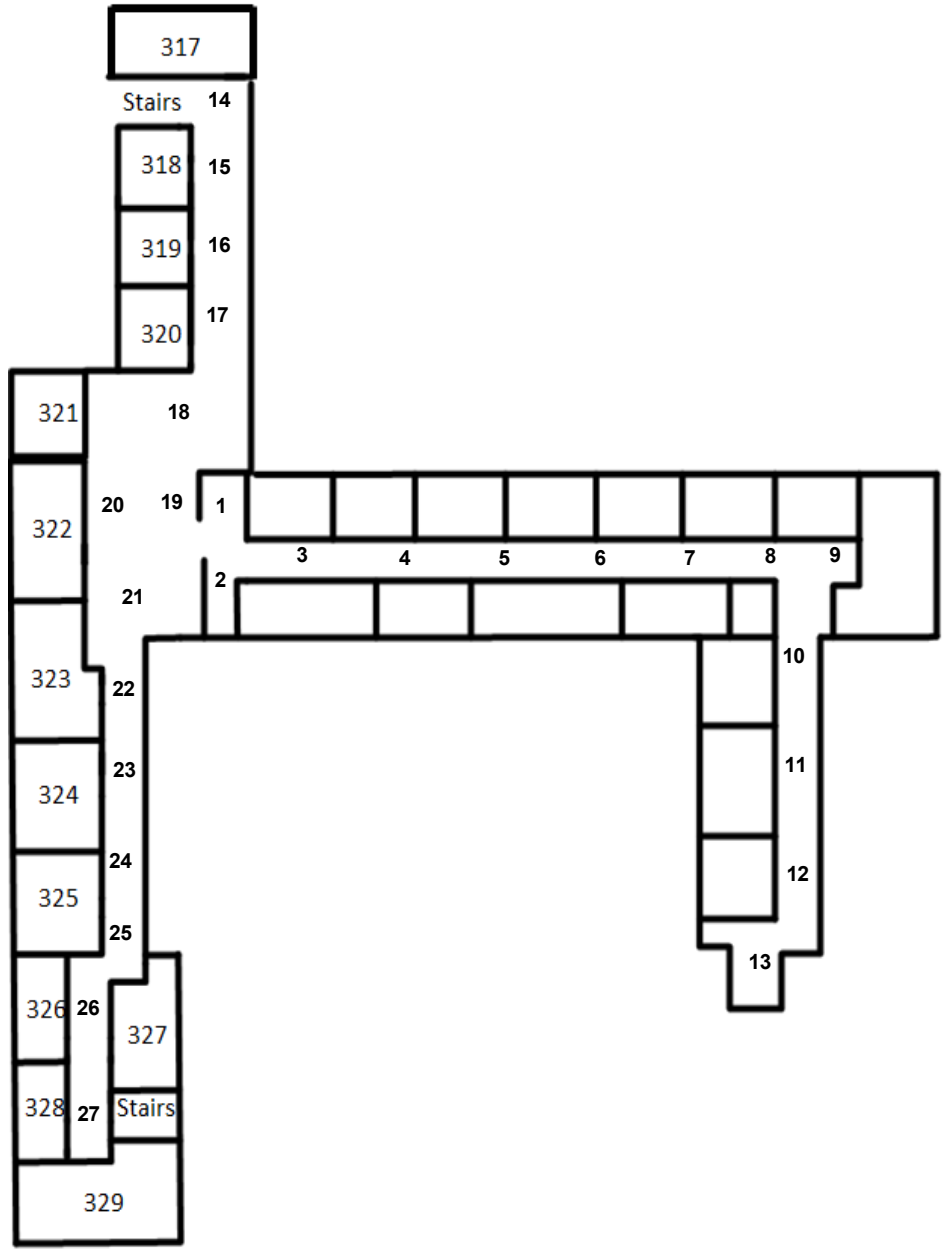
Figure A-1. Survey Map of Outside Areas

Table A-1. Waterbury Enterprise Apts. - Outside			
Location No.	Gamma[a]		Comments
	cpm	µR/h at 1 meter	
1	11,000	10	
2	14,000	15	
3	11,000-12,000	10	
4	12,000-13,000	12	
5	9,800	10	
6	8,000	9	
7	9,800	10	
8	11,000	10	
9	10,000	10	
10	12,000	12.5	
11	15,000	15	
12	13,000	13	
13	12,000	11.5	
14	12,000	12	Drive thru to inner parking lot
15	11,000	10	
16	10,000	10	
17	9,000	9	
18	14,000	15	
19	11,000	12	
20	11,000	12	
21	13,000	14	
22	10,000-11,000	10	
23	11,000	11	
24	10,000	10	
25	13,000	14	
26	15,000	14.5	
27	13,600	14	
28	10,000	10	
29	10,300	10	
30	10,600	9.5	
31	10,200	9	
32	11,000	10	
33	9,900	10	
34	10,600	10	
a) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI			

Site: Waterbury-Enterprise Apt.	**Area:** 3rd Floor Hallway	**Date(s):** 08/02/2017	**Time:** 1440/1502
Surveyor(s): KME/ JDL		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/395, 505	44-10/1148, 1151	4.4-13 kcpm[a]
Gamma	192/1127, 1128	NA	5-14 µR/h[a]

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.
#s written in boxes along the wall are apartment

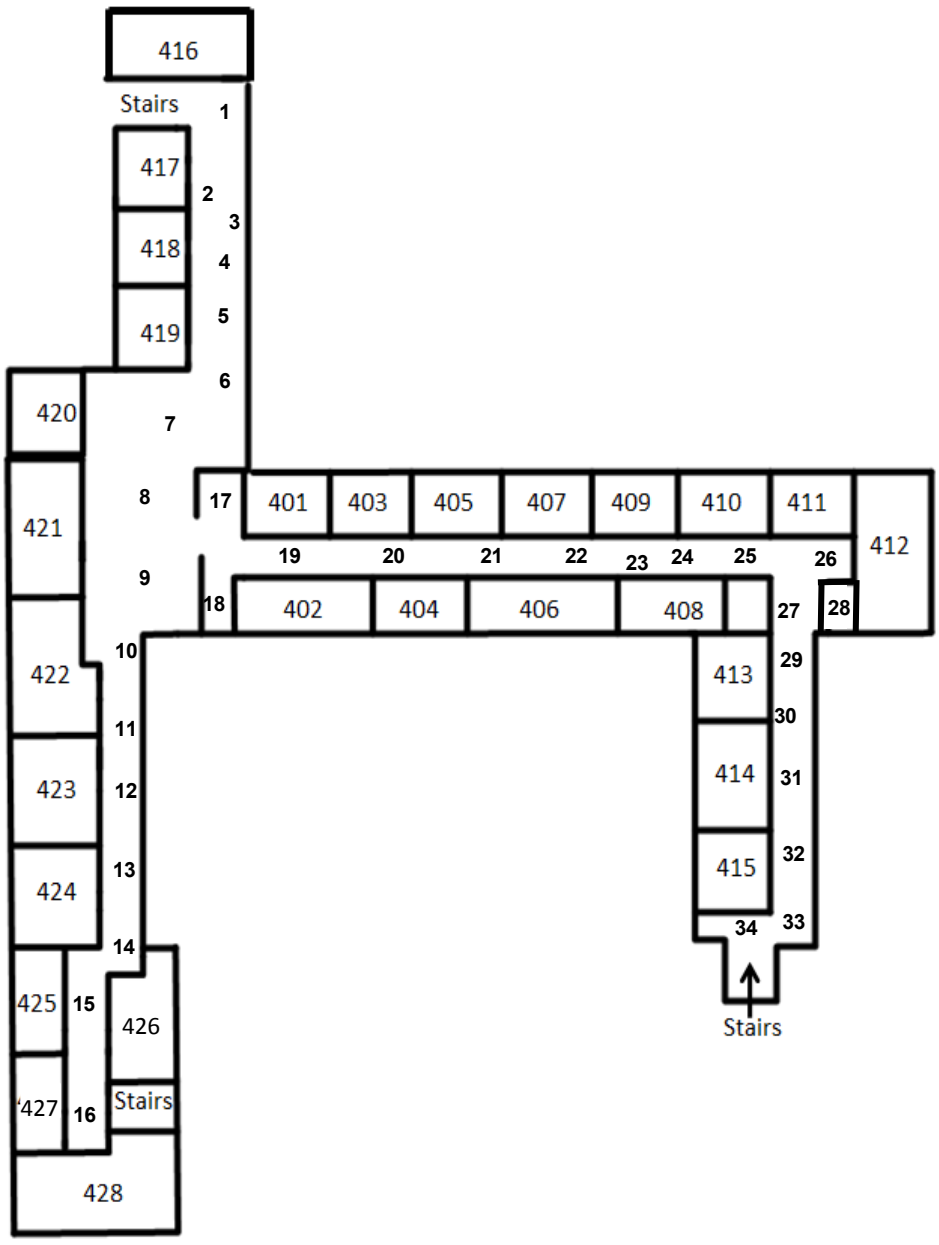
Figure A-2. Survey Map of 3rd Floor Hallway

Table A-2. Waterbury Enterprise Apts. - Third Floor Hallway			
Location No.	Gamma[a]		Comments
	cpm (contact)	µR/h (1 meter)	
1*	8,300 - 9,200	8 - 9	
2	6,000	6	
3*	5,400 - 6,400	5 - 6	
4*	4,600 - 6,000	5 - 6	
5*	4,600 - 5,500	5 - 6	
6*	4,500 - 5,900	5 - 6	
7*	4,700 - 5,400	5	
8*	5,300 - 5,900	5 - 6	
9*	5,600 - 8,800	6 - 9	
10*	5,600 - 10,200	6 - 10	
11*	5,700 - 10,400	6 - 11	
12*	5,700 - 9,700	6 - 10	
13*	10,600 - 10,900	11	
14	9,500	10	
15	9,200	9	
16	8,500	8	
17	8,900	9	
18	9,700	10	
19	9,500	9.5	
20	10,000	9	
21	13,000	14	
22	8,400	9	
23	9,400	9	
24	9,800	10	
25	8,700	9	
26	4,800	5	
27	4,400	5	
a) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI * General area measurement range			

Site: Waterbury-Enterprise Apt.	Area: 4th Floor Hallway	Date(s): 08/02/2017	Time: 0950/1022,
Surveyor(s): KME		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/505	44-10/1151	4.8-14 kcpm[a]
Gamma	192/1128	NA	5-12 µR/h[a]

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.
#s written in boxes along the wall are apartment

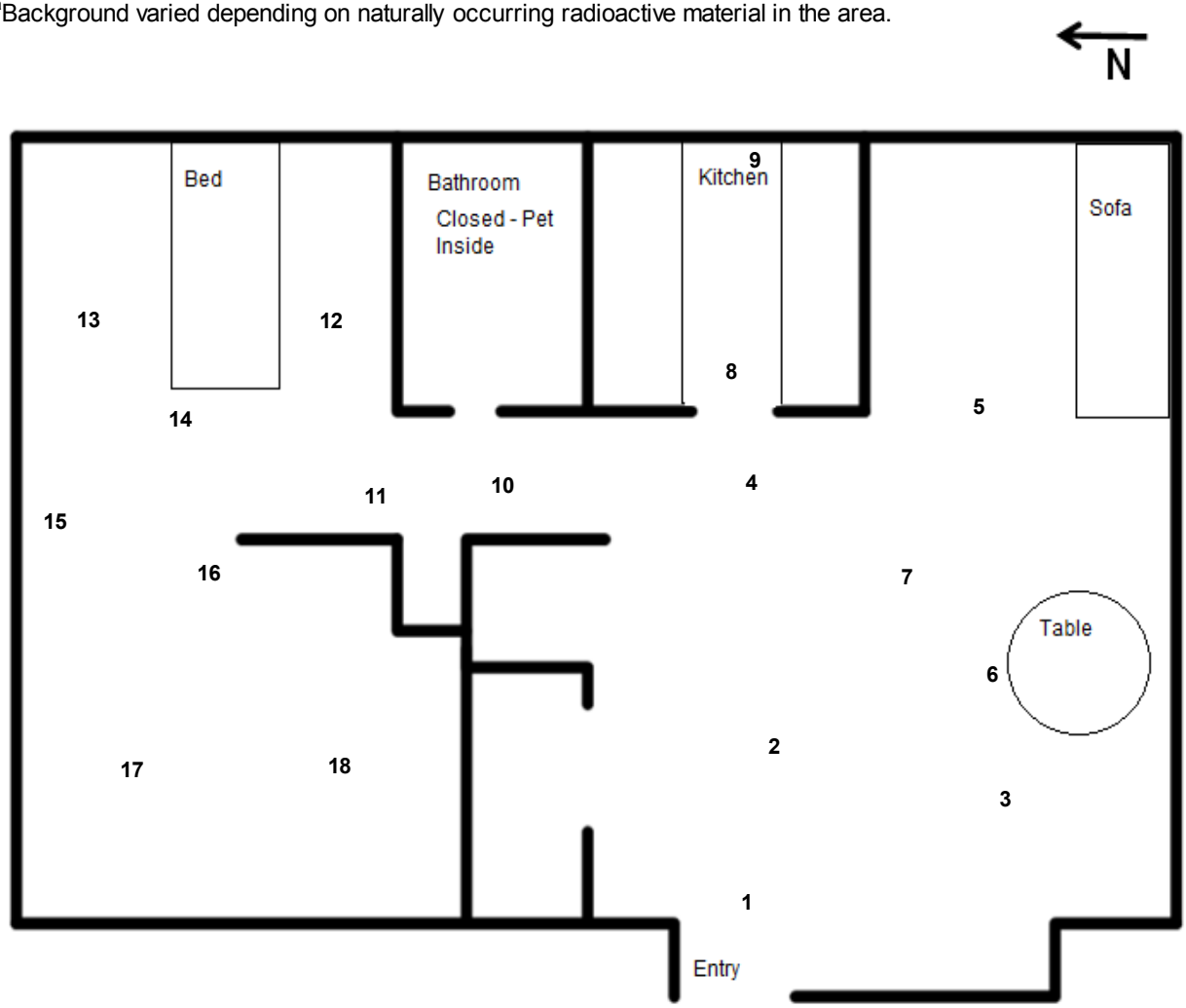
Figure A-3. Survey Map of 4th Floor Hallway

Table A-3. Waterbury Enterprise Apts. - Fourth Floor Hallway				
Location No.	Gamma[a]			Comments
	contact		1 m	
	cpm	µR/h	µR/h	
1	11,000	—	11	
2	12000	—	11	
3	9,000	—	8	
4	8,000	—	8	
5	9,000	—	9	
6	10,200	—	10	
7	9,000	—	8	
8	12,000	—	12	
9	10,000	—	10	
10	8,000	—	8	
11	14,000	—	12	
12	9,000	—	8	
13	8,000	—	8	
14	9,000	—	9	
15	6,000	—	6	
16	4,800	—	5	
17	5,100	—	5	
18	6,300	—	6	
19	6,100	—	6	
20	5,600	—	5	
21	6,100	—	6	
22	14,000	13	8	Small areas < 0.1 m^2
23	5,600	—	5	
24	5,400	—	5	
25	6,600	—	6	
26	9,200	—	10	
27	10,000	—	10	
28	10,000	—	10	
29	9,000	—	9	
30	9,800	—	9	
31	10,000	—	10	
32	11,300	—	10	
33	10,700	—	10	
34	22,000	15	12	Small areas <0 .1 m^2
a) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI				

Site: Waterbury-Enterprise Apt.	Area: Apt. 416	Date(s): 08/02/2017	Time: 1030/1111
Surveyor(s): KME		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/505	44-10/1151	9.5-15 kcpm[a]
Gamma	192/1128	NA	9-15 µR/h[a]
α+β	2221/505	44-142/689	408 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached

Figure A-4. Survey Map of Apt. 416

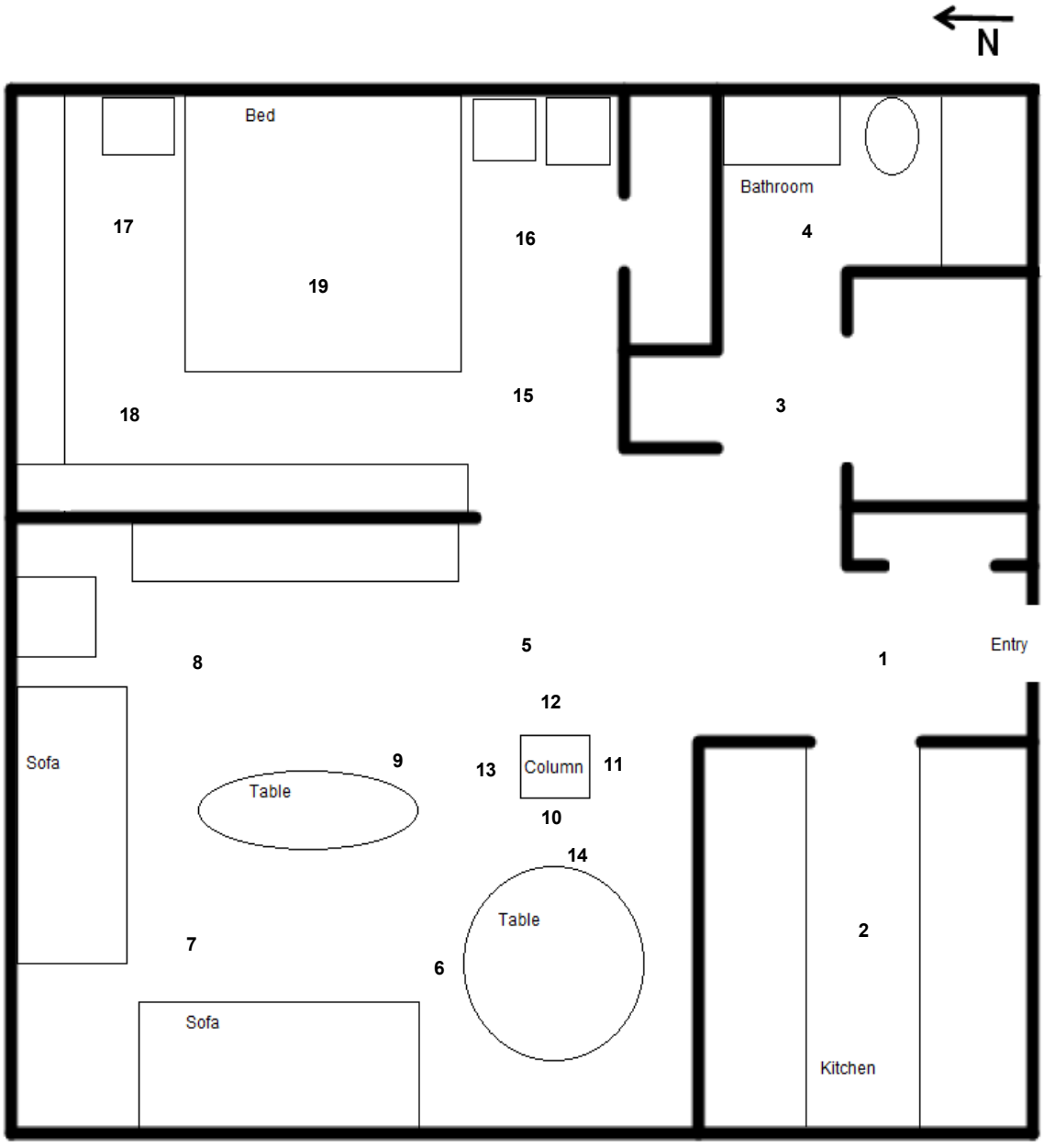
Table A-4. Waterbury Enterprise Apts. - Apt. 416								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	10,000	—	9	
2	—	—	—	—	9,600	—	9	
3	—	—	—	—	12,000	—	11	
4	—	—	—	—	9,800	—	10	
5	—	—	—	—	11,900	—	11	
6	5307R0035	9	563	1,400	22,000	21	12	small areas < 100 cm^2
7	—	—	—	—	10,000	—	10	
8	—	—	—	—	11,000	—	10	
9	—	—	—	—	12,000	—	12	
10	—	—	—	—	9,500	—	10	
11	—	—	—	—	11,400	—	11	
12	—	—	—	—	13,000	—	12	
13	—	—	—	—	15,000	—	15	
14	5307R0036	-1	1,255	7,700	40,000	34	14	small areas < 0.1 m^2
15	5307R0037	-7	826	3,800	32,000	29	15	small areas < 0.1 m^2
16	—	—	—	—	11,600	—	12	
17	—	—	—	—	12,500	—	10	
18	—	—	—	—	10,700	—	9.5	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** Apt. 417	**Date(s):** 08/02/2017	**Time:** 0900/0940
Surveyor(s): KME		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/505	44-10/1151	7.5-10 kcpm[a]
Gamma	192/1128	NA	7-10 µR/h[a]
α+β	2221/505	44-142/689	385 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached

Figure A-5. Survey Map of Apt. 417

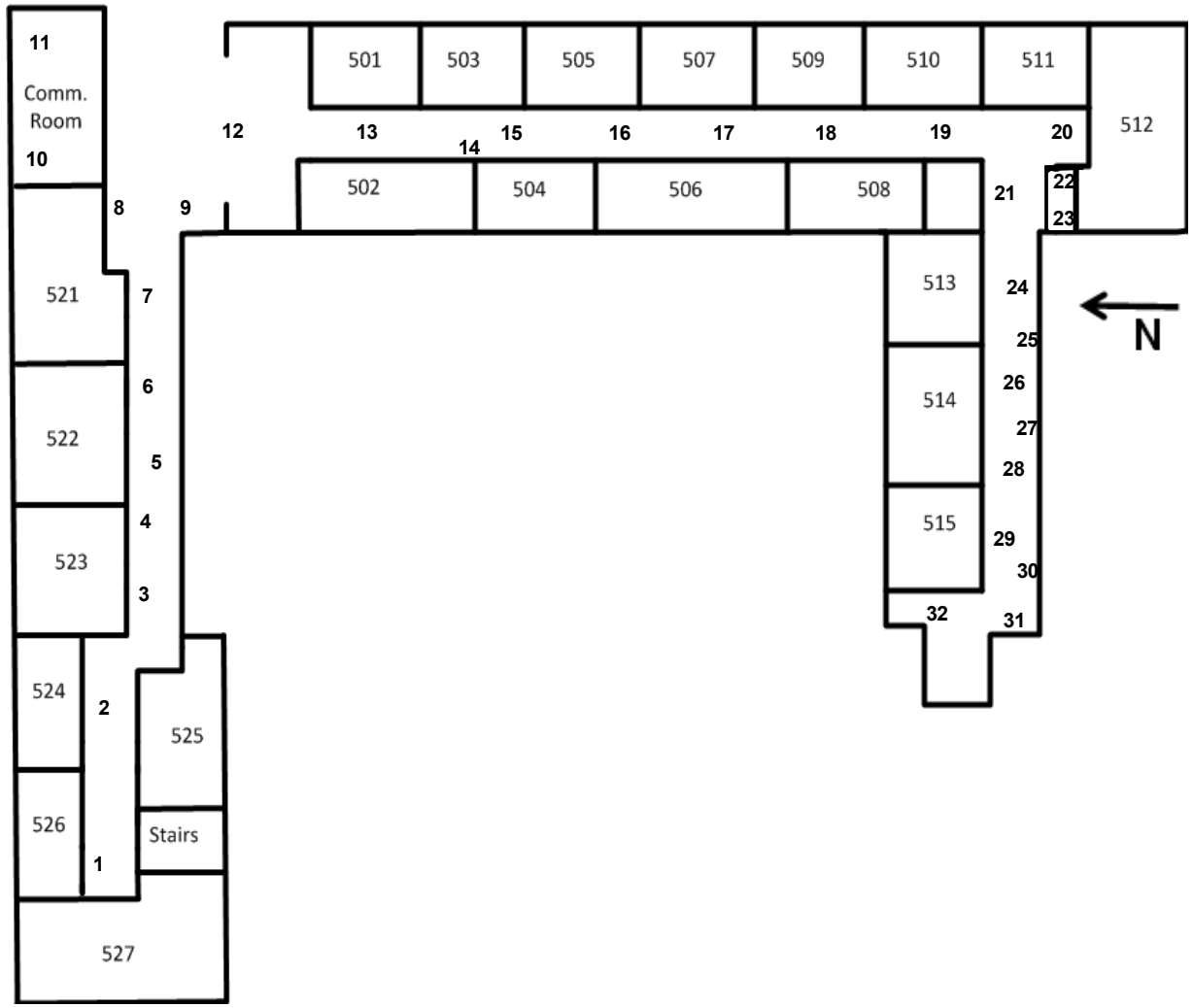
Table A-5. Waterbury Enterprise Apts. - Apt. 417								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	9,000	—	9.5	
2	—	—	—	—	7,500	—	7	
3	—	—	—	—	9,000	—	7.5	
4	—	—	—	—	8,400	—	8	
5	—	—	—	—	10,000	—	10	
6	—	—	—	—	9,000	—	9	
7	—	—	—	—	8,800	—	9	
8	—	—	—	—	9,800	—	10	
9	—	—	—	—	9,100	—	10	
10	5307R0033	-7	6,508	56,000	176,000	150	14	Small areas extend less than 0.1 m^2 around column
11	5307R0034	-3	2,080	15,000	51,000	42	10.5	Small areas extend less than 0.1 m^2 around column
12	—	—	—	—	30,000	28	10	Small areas extend less than 0.1 m^2 around column
13	—	—	—	—	37,000	35	10	Small areas extend less than 0.1 m^2 around column
14	—	—	—	—	—	—	12	Measured in chair at table
15	—	—	—	—	8,900	—	8	
16	—	—	—	—	8,500	—	9	
17	—	—	—	—	8,900	—	8	
18	—	—	—	—	8,800	—	8	
19	—	—	—	—	—	—	9	Over bed

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** 5th Floor Hallways	**Date(s):** 08/01/2017 08/02/2017	**Time:** 1600/1700, 0810/0900
Surveyor(s): KME		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/505	44-10/1151	4.8-15 kcpm[a]
Gamma	192/1128	NA	5-13 µR/h[a]
α+β	2221/505	44-142/689	322 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.
#s written in boxes along the wall are apartment

Figure A-6. Survey Map of 5th Floor Hallways

Table A-6. Waterbury Enterprise Apts. - Fifth Floor Hallway								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	4,800	—	5	
2	—	—	—	—	5,300	—	6	
3	—	—	—	—	9,300	—	8	
4	—	—	—	—	9,000	—	9	
5	—	—	—	—	10,200	—	10	
6	—	—	—	—	8,900	—	8	
7	5307R0032	3	1,017	6,300	31,000	29	10	small areas < 0.1 m^2
8	—	—	—	—	9,000	—	9	
9	—	—	—	—	12,000	—	12	
10	—	—	—	—	7,100	—	7	
11	—	—	—	—	9,000	—	7	
12	—	—	—	—	7,700	—	8	
13	—	—	—	—	7,000	—	6	
14	—	—	—	—	13,800	13	8	
15	—	—	—	—	6,300	—	6	
16	—	—	—	—	5,800	—	5	
17	—	—	—	—	6,000	—	6	
18	—	—	—	—	9,000	—	9	
19	—	—	—	—	8,700	—	7	
20	—	—	—	—	7,500	—	7	
21	5307R0031	-7	1,226	8,200	46,000	38	10	carpet floor near trash room, small areas ~ 4 m^2
22	—	—	—	—	22,000	23	14	trash room with tile floor
23	—	—	—	—	15,000	—	13	
24	—	—	—	—	9,700	—	7	

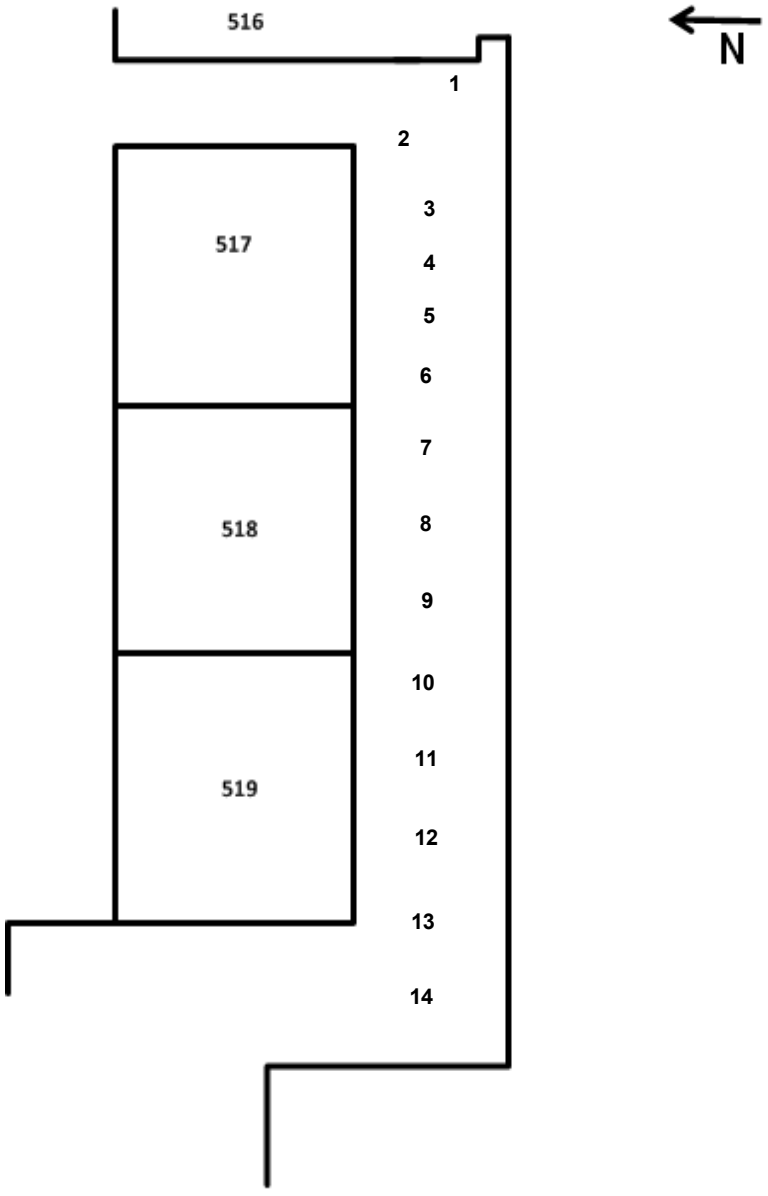
Table A-6. Waterbury Enterprise Apts. - Fifth Floor Hallway								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
25	5307R0030	-21	634	2,800	23,000	22	11	carpet floor near apt. 514, small areas < 0.1 m^2
26	—	—	—	—	11,000	—	10	
27	5307R0029	3	2,127	16,000	52,000	55	13	carpet floor east of apt. 515, small areas < 0.2 m^2
28	—	—	—	—	13,000	—	10	
29	5307R0028	-10	1,053	6,600	34,000	32	13	carpet floor near apt. 515, small areas < 0.1 m^2
30	—	—	—	—	14,000	—	13	
31	—	—	—	—	12,000	—	11	
32	—	—	—	—	11,000	—	10	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: 5th Floor Hallway Near Apt. 517	Date(s): 08/01/2017 08/02/2017	Time: 1430-1700, 0800-0855
Surveyor(s): JDL		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/395	44-10/1148	7.5-10.6 kcpm[a]
Gamma	192/1127	NA	8-11µR/h[a]
α+β	2221/395	44-142/1030	412 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-7. Survey Map of 5th Floor Hallway Near Apt. 517

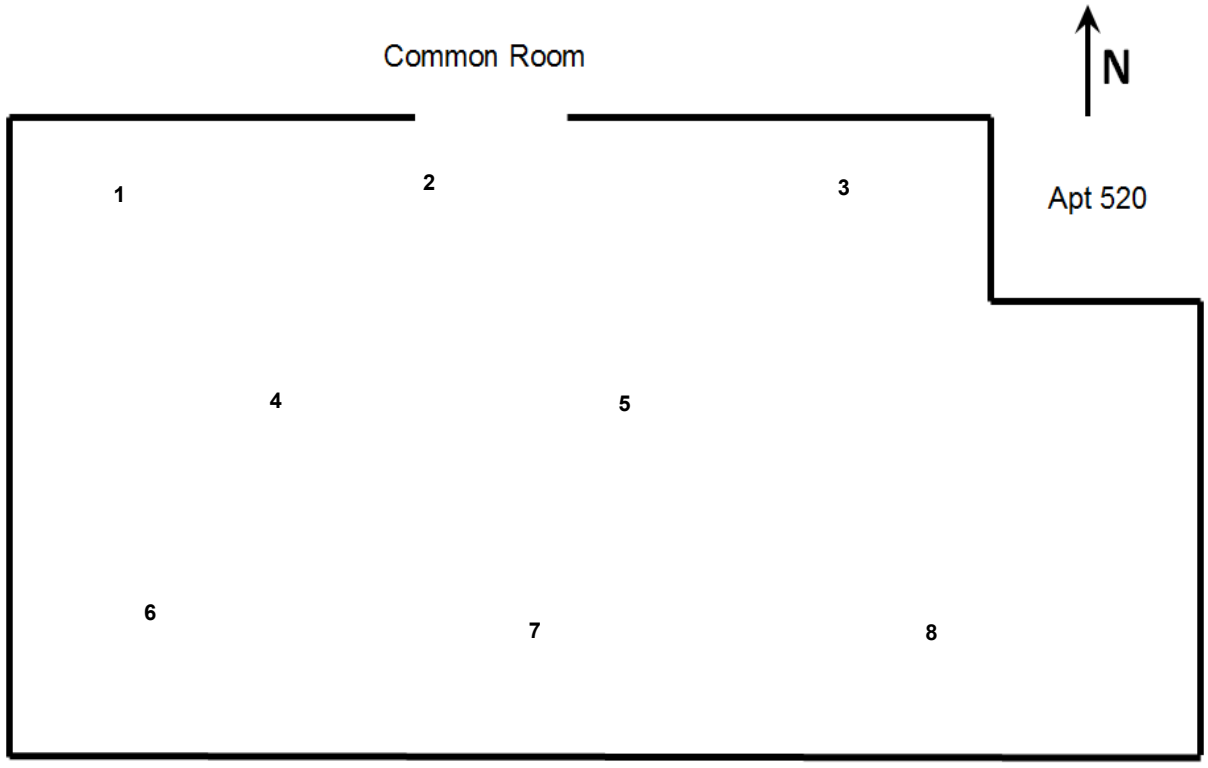
Table A-7. Waterbury Enterprise Apts. - Fifth Floor Hallway Near Apt. 517								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	1,499	9,900	38,000	35	12	Small areas < 0.1m^2
2	—	—	956	4,900	31,000	26	14	Small areas < 0.1m^2
3	5307R0044[d]	—	2,424	18,000	54,000	60	15	Small areas <0.1 m^2
4	—	—	—	—	31,000	29	11	Small areas < 0.1 m^2
5	5307R0045[d]	—	2,375	18,000	64,000	60	12	Small areas < 0.1 m^2
6	5307R0046[d]	—	2,628	20,000	68,000	70	11	Small areas < 0.1 m^2
7	—	—	—	—	8,900	—	9	
8	—	—	—	—	7,900	—	8	
9	—	—	—	—	7,500	—	8	
10	—	—	—	—	7,800	—	8	
11	—	—	—	—	7,700	—	8	
12	—	—	—	—	7,800	—	8	
13	—	—	—	—	9,400	—	10	
14	—	—	—	—	10,600	—	11	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
d) Smear not field counted
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** 5th Floor Hallway Near Apt. 520	**Date(s):** 08/02/2017	**Time:** 1250/1300
Surveyor(s): JDL		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/395	44-10/1148	8.4-10.8 kcpm[a]
Gamma	192/1127	NA	8-10 µR/h[a]

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-8. Survey Map of 5th Floor Hallway Near Apt. 520

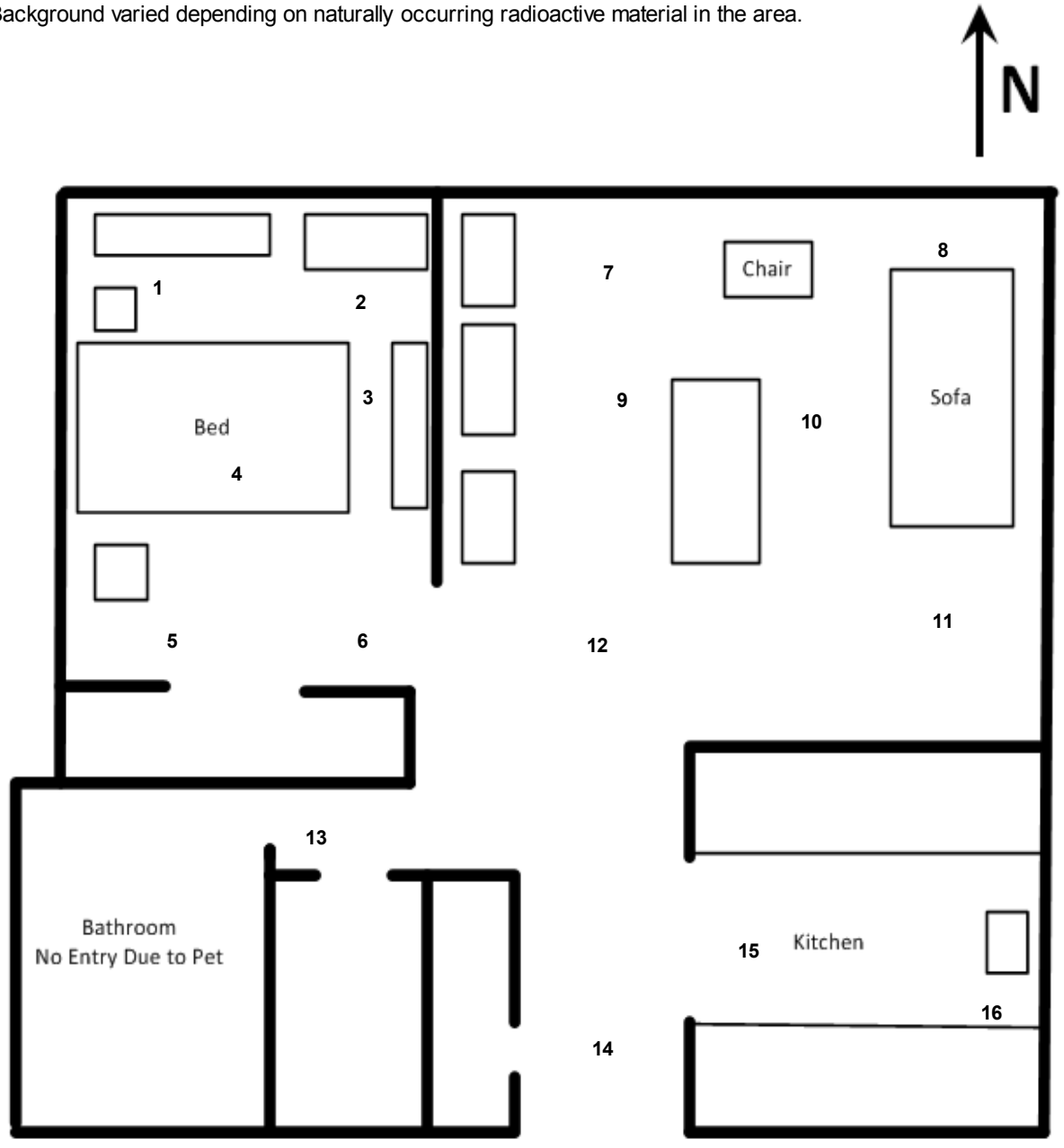
Table A-8. Waterbury Enterprise Apts. - Fifth Floor Hallway Near Apt. 520								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	8,900	—	9	
2	—	—	—	—	8,400	—	8	
3	—	—	—	—	8,900	—	9	
4	—	—	—	—	9,100	—	9	
5	—	—	—	—	9,000	—	9	
6	—	—	—	—	10,100	—	10	
7	—	—	—	—	10,800	—	10	
8	—	—	—	—	10,300	—	10	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** Apt. 505	**Date(s):** 08/02/2017	**Time:** 1315/1430
Surveyor(s): JDL		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/395	44-10/1148	5.5-11.5 kcpm[a]
Gamma	192/1127	NA	5-10 µR/h[a]
α+β	2221/395	44-142/1030	412 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached

Figure A-9. Survey Map of Apt. 505

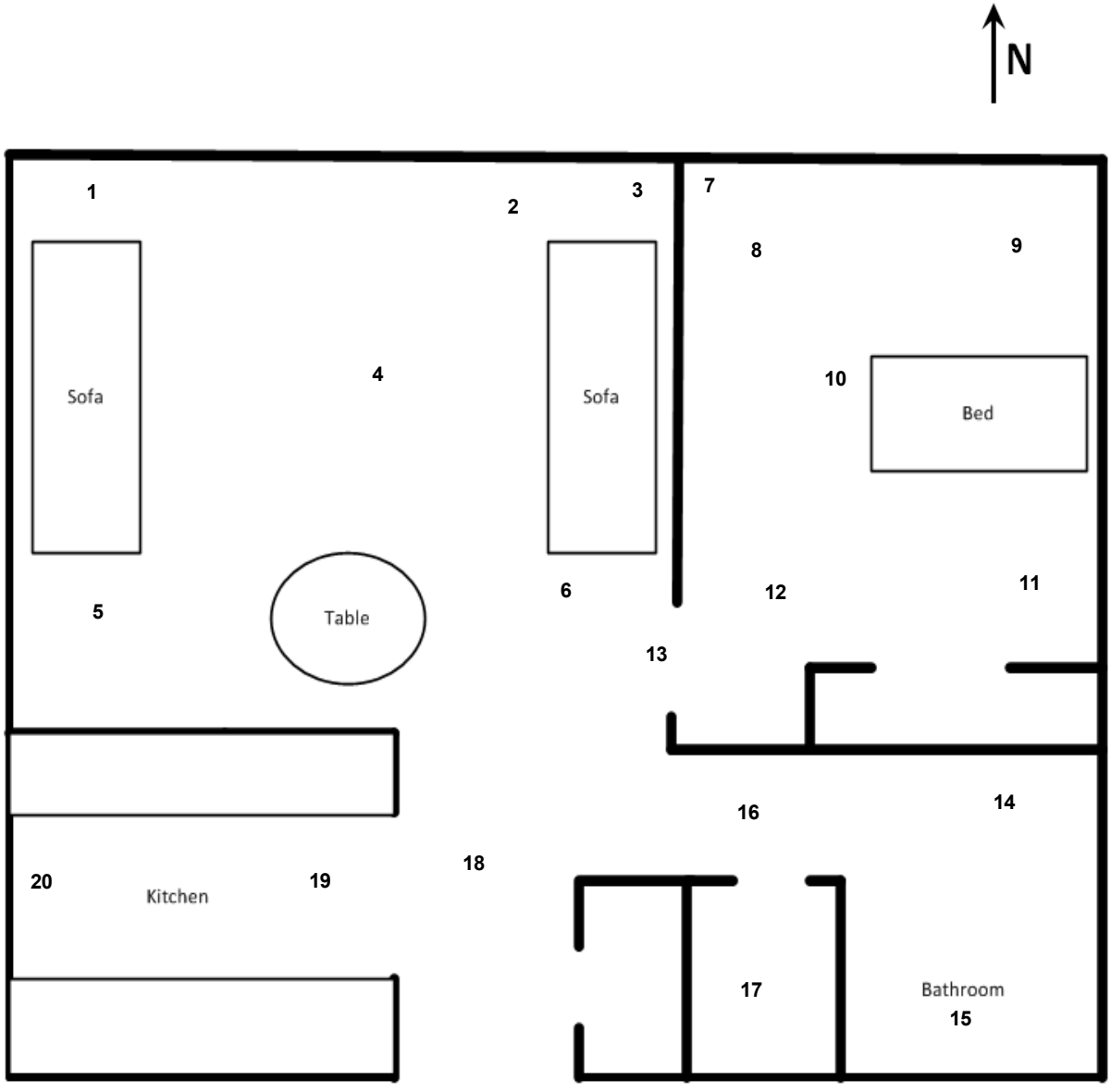
Table A-9. Waterbury Enterprise Apts. - Apt. 505								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	9,300	—	9	
2	—	—	—	—	10,500	—	9	
3	5307R0043	3	897	4,400	26,500	24	10	Small areas < 0.1 m^2
4	—	—	—	—	8,600	—	8	
5	—	—	—	—	9,500	—	7	
6	—	—	—	—	8,600	—	7	
7	—	—	—	—	11,500	—	10	
8	—	—	—	—	9,100	—	10	
9	5307R0042	6	1,065	5,900	21,000	20	10	Small areas < 0.1 m^2
10	—	—	—	—	9,500	—	9	
11	—	—	—	—	8,600	—	7	
12	—	—	—	—	8,500	—	7	
13	—	—	—	—	6,000	—	6	
14	—	—	—	—	5,500	—	5	
15	—	—	—	—	5,800	—	5	
16	—	—	—	—	6,100	—	6	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: Apt. 507	Date(s): 08/2/2017	Time: 1025/1200
Surveyor(s): JDL		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/395	44-10/1148	6-10.2 kcpm[a]
Gamma	192/1127	NA	6-9 µR/h[a]
α+β	2221/395	44-142/1030	325 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-10. Survey Map of Apt. 507

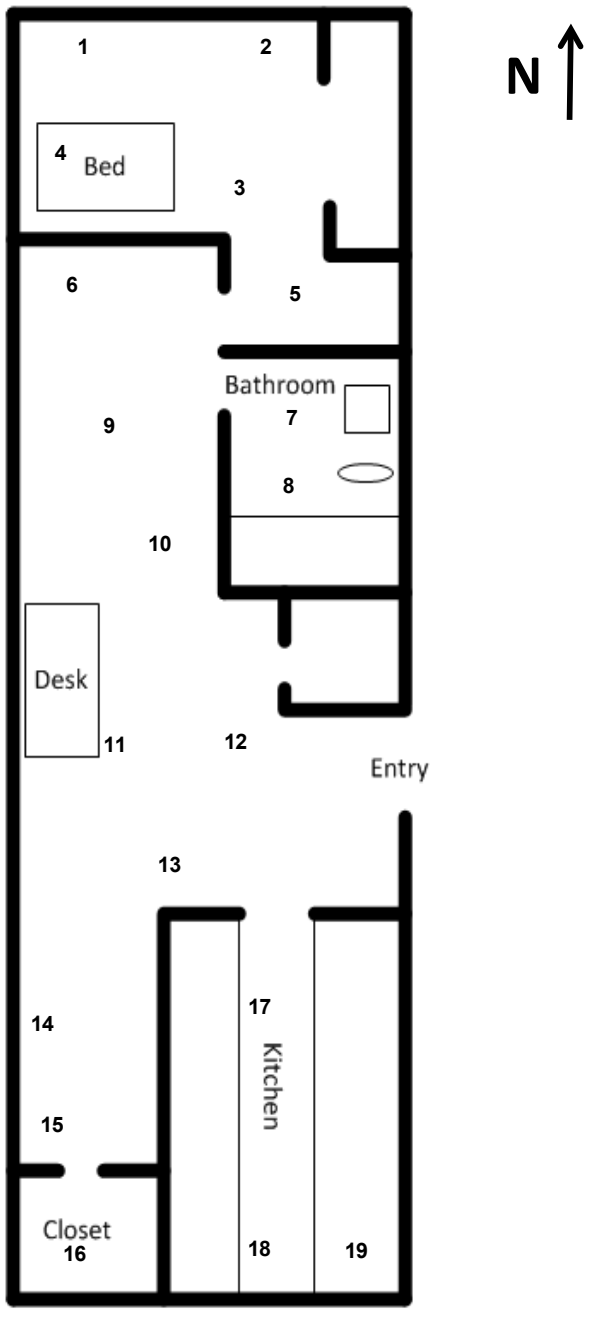
Table A-10. Waterbury Enterprise Apts. - Apt. 507								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	9,800	—	9	
2	—	—	—	—	9,800	—	9	
3	5307R0041	21	408	750	12,100	11	10	Previously surveyed small areas.
4	—	—	—	—	8,300	—	7	
5	—	—	—	—	8,300	—	7	
6	—	—	—	—	8,300	—	7	
7	—	—	—	—	10,200	—	9	
8	—	—	—	—	9,700	—	9	
9	—	—	—	—	9,700	—	9	
10	—	—	—	—	8,100	—	8	
11	—	—	—	—	8,300	—	7	
12	5307R0040	-11	619	2,700	14,700	15	8	Small areas < 0.1m^2
13	—	—	—	—	8,600	—	7	
14	—	—	—	—	7,200	—	6	
15	—	—	—	—	7,200	—	7	
16	—	—	—	—	6,500	—	6	
17	—	—	—	—	6,300	—	6	
18	—	—	—	—	7,100	—	6	
19	—	—	—	—	6,000	—	6	
20	—	—	—	—	6,200	—	6	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** Apt. 508	**Date(s):** 08/2/2017	**Time:** 0900/1030
Surveyor(s): JDL		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/395	44-10/1148	6.4-12 kcpm[a]
Gamma	192/1127	NA	6-11 µR/h[a]
α+β	2221/395	44-142/1030	328 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached

Figure A-11. Survey Map of Apt. 508

Table A-11. Waterbury Enterprise Apts. - Apt. 508								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	8,700	—	8	
2	—	—	—	—	7,000	—	7	
3	—	—	—	—	6,400	—	7	
4	—	—	—	—	8,400	—	7	
5	—	—	—	—	6,900	—	7	
6	—	—	—	—	8,900	—	10	
7	—	—	—	—	7,000	—	7	
8	—	—	—	—	6,700	—	6	
9	—	—	—	—	8,600	—	10	
10	—	—	—	—	9,500	—	9	
11	—	—	—	—	11,000	—	10	
12	—	—	—	—	8,200	—	10	
13	—	—	—	—	10,000	—	8	
14	—	—	—	—	12,000	—	11	
15	5307R0038	31	726	3,600	20,000	19	12	Small areas < 0.1m^2
16	—	—	—	—	9,500	—	9	
17	—	—	—	—	9,600	—	8	
18	—	—	—	—	10,400	—	8	
19	5307R0039	6	652	2,900	16,000	16	10	Northeast corner of kitchen, small areas < 100 cm^2

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: Apt. 512	Date(s): 08/01/2017	Time: 1440/1530
Surveyor(s): KME		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/505	44-10/1151	7.4-14 kcpm[a]
Gamma	192/1128	NA	6-13 µR/h[a]
α+β	2221/505	44-142/689	393 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.

= General area measurements provided in attached table.

Figure A-12. Survey Map of Apt. 512

Table A-12. Waterbury Enterprise Apts. - Apt. 512								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	7,400	—	6	
2	—	—	—	—	12,000	—	10	
3	5307R0021	-20	875	4,400	29,000	27	12	small areas < 100 cm^2
4	5307R0022	-11	834	4,000	25,000	24	13	Measured at a height of 0.5 m due to table; small areas < 0.1 m^2
5	—	—	—	—	12,000	—	11	
6	—	—	—	—	12,500	—	11	
7	—	—	—	—	11,000	—	10	
8	—	—	—	—	14,000	—	13	
9	—	—	—	—	10,500	—	10	
10	—	—	—	—	8,000	—	9	
11	—	—	—	—	10,000	—	9	
12	—	—	—	—	12,000	—	12	
13	—	—	—	—	7,800	—	7	
14	—	—	—	—	7,700	—	6	
15	—	—	—	—	8,400	—	7	
16	—	—	—	—	8,300	—	8	
17	—	—	—	—	11,000	—	10	
18	—	—	—	—	14,000	—	10	
19	5307R0023	-17	731	3,100	23,000	24	12	small areas < 0.1 m^2
20	—	—	—	—	—	—	9	
21	—	—	—	—	10,000	—	9	
22	—	—	—	—	9,700	—	9	
23	—	—	—	—	12,700	—	11	
24	—	—	—	—	12,400	—	10	

Table A-12. Waterbury Enterprise Apts. - Apt. 512								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
25	—	—	—	—	—	—	9.5	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

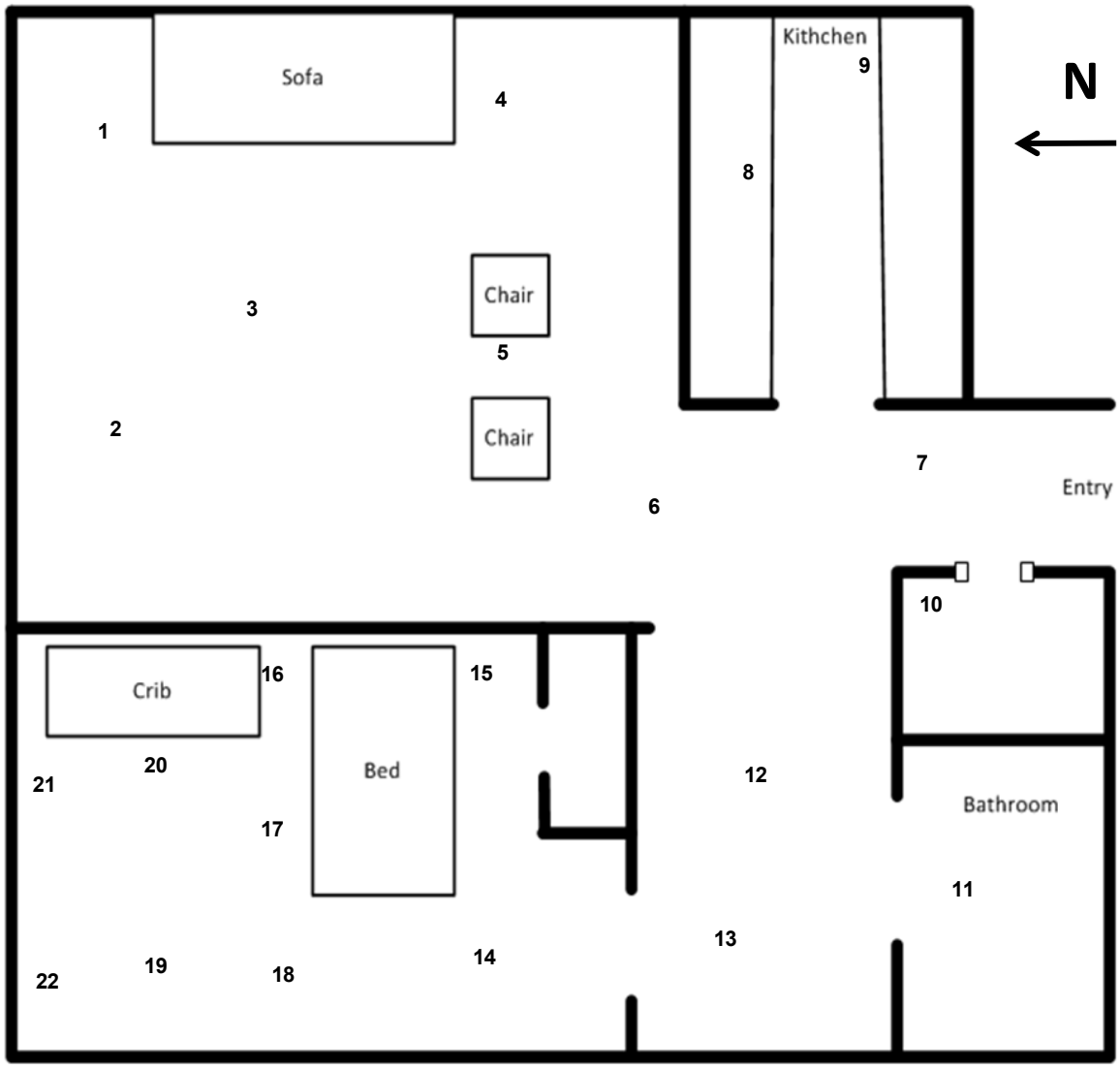
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** Apt. 513	**Date(s):** 08/01/2017	**Time:** 1430/1600
Surveyor(s): JDL		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/395	44-10/1148	7.5-11.8 kcpm[a]
Gamma	192/1127	NA	7-12 µR/h[a]
α+β	2221/395	44-142/1030	402 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-13. Survey Map of Apt. 513

Table A-13. Waterbury Enterprise Apts. - Apt. 513								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	10,600	—	12	
2	—	—	—	—	10,700	—	10	
3	—	—	—	—	10,200	—	10	
4	—	—	—	—	10,000	—	10	
5	5307R0025	20	1,004	5,500	25,000	22	12	Small areas < 0.1m^2
6	—	—	—	—	10,300	—	10	
7	—	—	—	—	9,100	—	8	
8	—	—	—	—	9,200	—	9	
9	5307R0024	9	2,042	15,000	52,000	48	11	Small areas < 0.1m^2
10	—	—	—	—	7,500	—	7	
11	—	—	—	—	8,000	—	7	
12	—	—	—	—	9,500	—	7	
13	—	—	—	—	8,300	—	7	
14	—	—	—	—	7,500	—	8	
15	—	—	—	—	8,500	—	9	
16	—	—	—	—	10,800	—	9	
17	—	—	—	—	11,500	—	10	
18	—	—	—	—	9,600	—	9	
19	5307R0027	22	726	2,100	20,000	20	10	Small areas < 0.1m^2
20	5307R0026	44	1,875	13,000	68,000	60	15	Small areas < 0.1m^2
21	—	—	—	—	11,200	—	10	
22	—	—	—	—	11,800	—	12	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

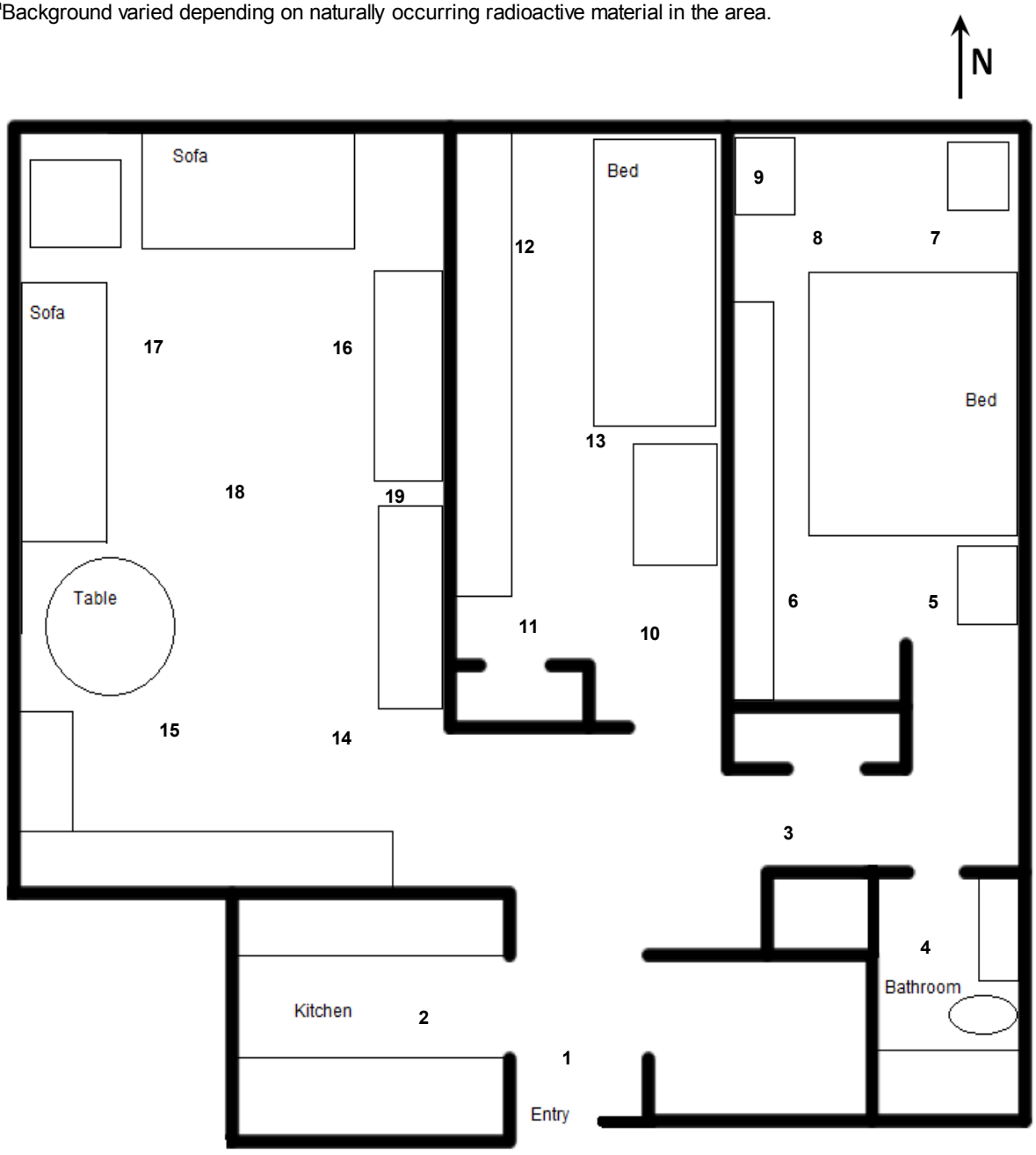
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: Apt. 514	Date(s): 08/01/2017	Time: 1315/1355
Surveyor(s): KME		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/505	44-10/1151	5.7-8.7 kcpm[a]
Gamma	192/1128	NA	5-8 µR/h[a]
α+β	2221/505	44-142/689	332 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-14. Survey Map of Apt. 514

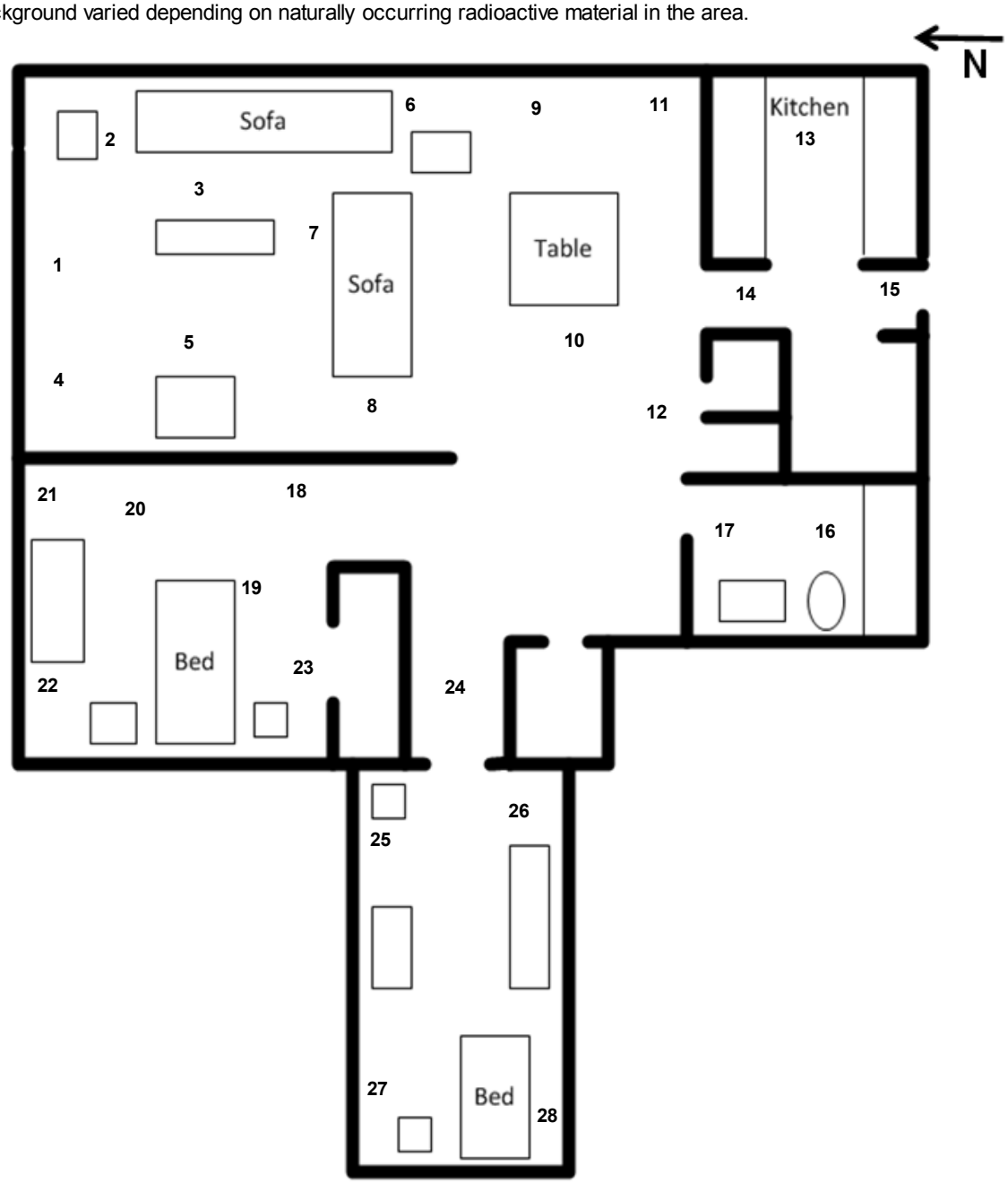
Table A-14. Waterbury Enterprise Apts. - Apt. 514								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	7,300	—	6	
2	—	—	—	—	6,600	—	6	
3	—	—	—	—	6,500	—	5	
4	—	—	—	—	6,500	—	5	
5	—	—	—	—	6,600	—	6	
6	—	—	—	—	6,800	—	5	
7	—	—	—	—	8,400	—	8	
8	—	—	—	—	8,700	—	7	
9	—	—	—	—	8,000	—	7	
10	—	—	—	—	6,800	—	5	
11	—	—	—	—	6,300	—	5	
12	—	—	—	—	6,900	—	7	
13	—	—	—	—	6,100	—	6	
14	—	—	—	—	5,700	—	5	
15	—	—	—	—	6,500	—	6	
16	—	—	—	—	7,800	—	7	
17	—	—	—	—	8,200	—	8	
18	—	—	—	—	7,400	—	6	
19	5307R0017	-18	298	-310	6,500	6	6	Previously surveyed small areas.

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: Apt. 515	Date(s): 08/01/2017	Time: 1315/1430
Surveyor(s): JDL		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/395	44-10/1148	7.1-13.1 kcpm[a]
Gamma	192/1127	NA	7-11 µR/h[a]
α+β	2221/395	44-142/1030	339 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached

Figure A-15. Survey Map of Apt. 515

Table A-15. Waterbury Enterprise Apts. - Apt. 515								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	5307R0018	25	1,111	7,000	35,000	32	12	Small areas < 0.1m^2
2	5307R0020	19	1,752	13,000	56,000	50	14	Small areas < 0.1 m^2
3	—	—	—	—	15,000	16	10	
4	—	—	—	—	—	—	9	
5	—	—	—	—	—	—	8	
6	—	—	—	—	10,500	—	10	
7	—	—	—	—	10,500	—	10	
8	—	—	—	—	8,300	—	8	
9	—	—	—	—	9,800	—	9	
10	—	—	—	—	8,000	—	7	
11	—	—	—	—	7,200	—	7	
12	—	—	—	—	8,300	—	7	
13	—	—	—	—	9,300	—	8	
14	—	—	—	—	7,100	—	7	
15	5307R0019	21	733	3,600	19,000	19	9	Small areas < 0.1m^2
16	—	—	—	—	9,000	—	8	
17	—	—	—	—	8,200	—	8	
18	—	—	—	—	9,400	—	8	
19	—	—	—	—	9,300	—	9	
20	—	—	—	—	9,900	—	9	
21	—	—	—	—	17,000	16	9	
22	—	—	—	—	11,100	—	9	
23	—	—	—	—	9,200	—	9	
24	—	—	—	—	9,000	—	9	
25	—	—	—	—	12,300	—	10	
26	—	—	—	—	11,000	—	11	

Table A-15. Waterbury Enterprise Apts. - Apt. 515								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
27	—	—	—	—	13,100	—	11	
28	—	—	—	—	12,500	—	11	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

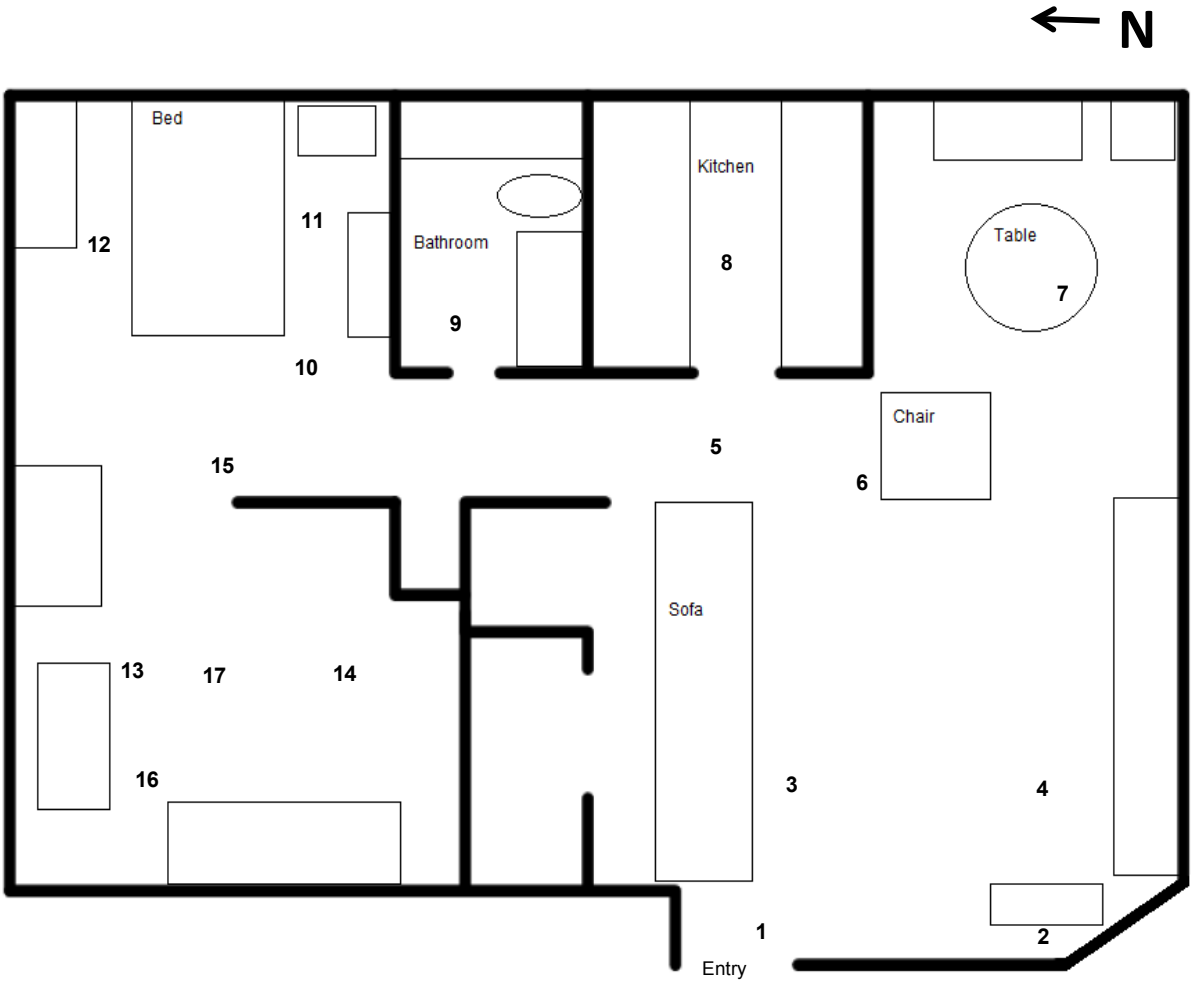
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** Apt. 516	**Date(s):** 08/01/2017	**Time:** 1100/1200
Surveyor(s): KME		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/505	44-10/1151	10-14 kcpm[a]
Gamma	192/1127	NA	10-12 µR/h[a]
α+β	2221/505	44-142/689	401 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-16. Survey Map of Apt. 516

Table A-16. Waterbury Enterprise Apts. - Apt. 516								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	10,000	—	10	
2	5307R0013	-6	1,359	8,700	24,000	24	11	small areas < 0.2 m^2
3	—	—	—	—	12,000	—	10	
4	—	—	—	—	13,000	—	12	
5	—	—	—	—	10,000	—	10.5	
6	—	—	—	—	13,000	—	10	
7	—	—	—	—	11,000	—	10	
8	—	—	—	—	11,000	—	10	
9	—	—	—	—	11,000	—	10	
10	5307R0014	13	982	5,300	32,000	29	12	small areas < 0.1 m^2
11	—	—	—	—	14,000	—	12	
12	—	—	—	—	12,000	—	12	
13	—	—	—	—	14,000	—	12	
14	—	—	—	—	13,000	—	10	
15	—	—	—	—	14,000	—	12	
16	5307R0016	-12	985	5,300	26,000	20	12	small areas < 100 cm^2
17	5307R0015	-3	1,270	7,900	26,000	26	13	small areas < 100 cm^2

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

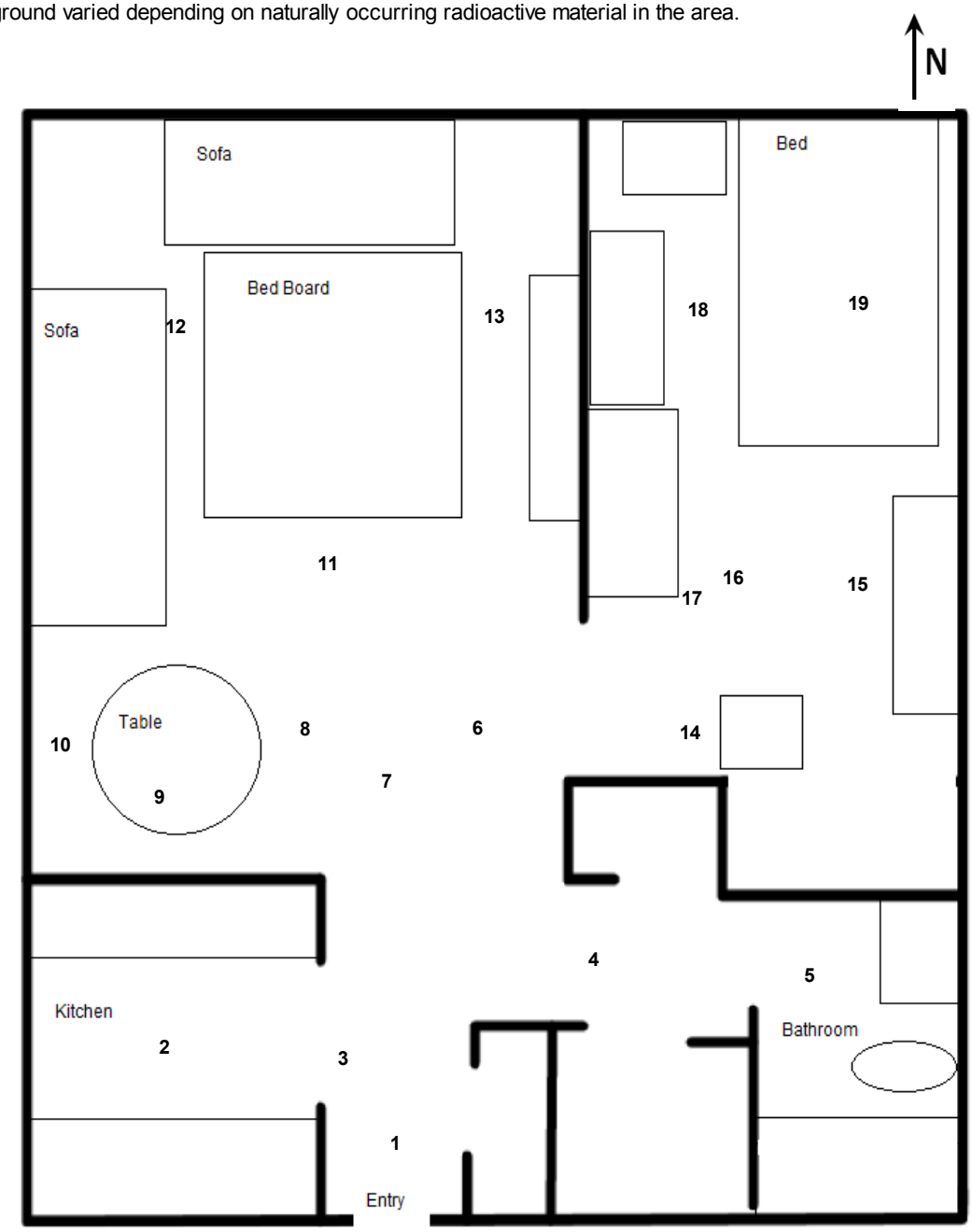
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: Apt. 517	Date(s): 08/01/201	Time: 0900/1100
Surveyor(s): KME		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/395	44-10/1148	8-18 kcpm[a]
Gamma	192/1127	NA	7-11 µR/h[a]
α+β	2221/505, 395	44-142/1030, 689	336 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-17. Survey Map of Apt. 517

Table A-17. Waterbury Enterprise Apts. - Apt. 517								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	15,000	—	10	
2	—	—	—	—	9,500	—	10	
3	5307R0004	-12	1,121	7,200	47,000	36	10	small areas < 100 cm^2
4	—	—	—	—	10,000	—	10	
5	—	—	—	—	12,000	—	11	
6	5307R0006	—	3,708	31,000	81,000	80	12	small areas < 100 cm^2
7	—	—	—	—	18,000	—	11	
8	5307R0005	12	1,118	7,200	73,000	60	10	small areas < 100 cm^2
9	5307R0008	-3	1,163	7,600	27,000	26	8	Measured at a height of 0.75 m due to table; small areas < 100 cm^2
10	—	—	—	—	8,000	—	7	
11	5307R0007	-26	717	3,600	24,000	27	11	small areas < 100 cm^2
12	—	—	—	—	10,000	—	10	
13	—	—	—	—	12,000	—	10	
14	5307R0009	-19	3,734	31,000	125,000	110	13	small areas < 0.1 m^2
15	—	—	—	—	9,000	—	9	
16	—	—	—	—	16,000	—	10	
17	—	—	—	—	73,000	70	12	Not enough time to collect direct measurement or smear; small areas < 0.1 m^2
18	—	—	—	—	10,000	—	10	
19	—	—	—	—		—	10	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter

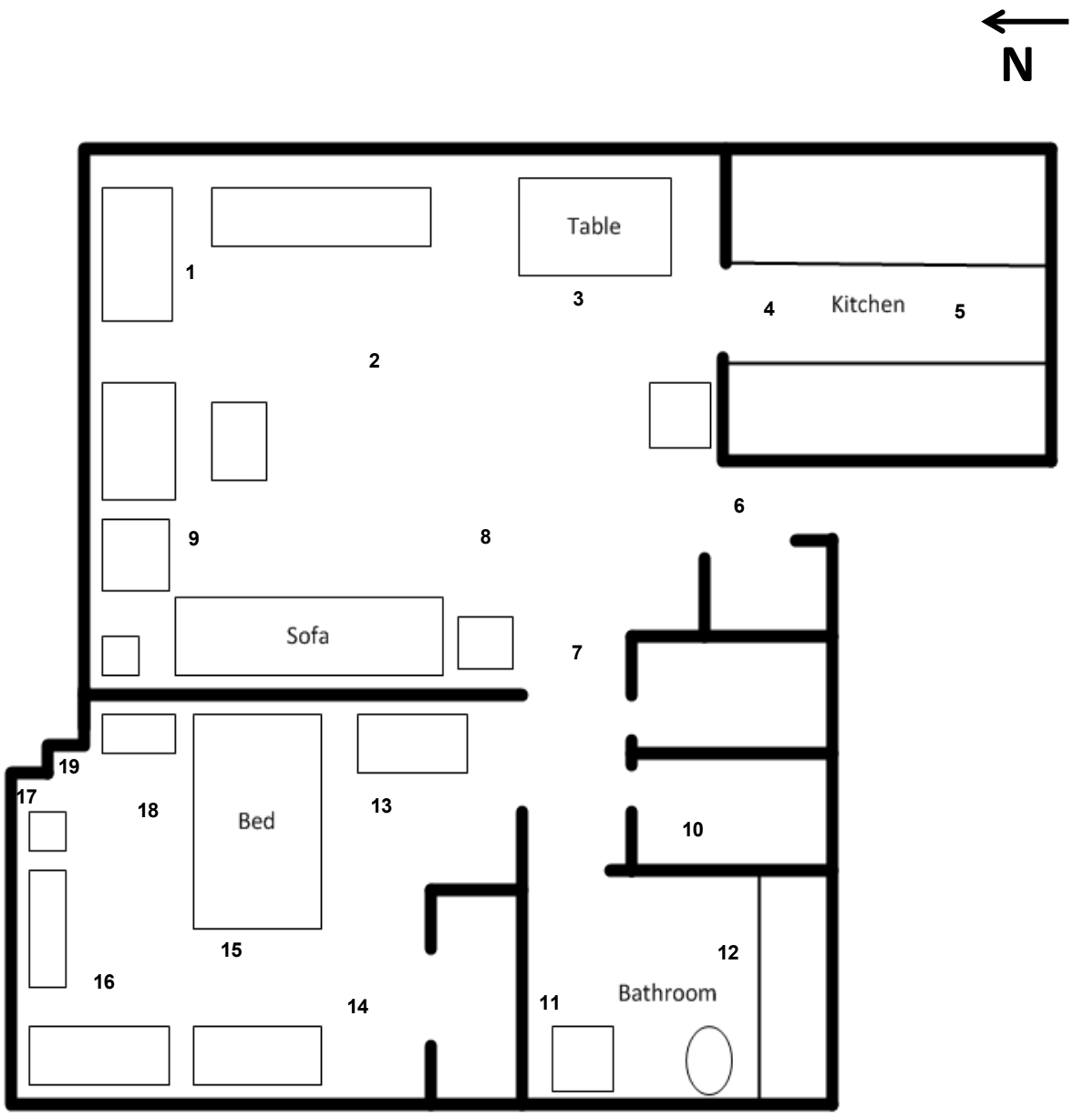
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI

— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	Area: Apt. 520	Date(s): 08/01/2017	Time: 0900/1030
Surveyor(s): JDL		Purpose: Site Visit	

Radiation Type	Instrument	Detector	Background
Gamma	2221/505	44-10/1151	5.3-15.2 kcpm[a]
Gamma	192/1128	NA	5-8 µR/h[a]
α+β	2221/505	44-142/1030	334 cpm

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-18. Survey Map of Apt. 520

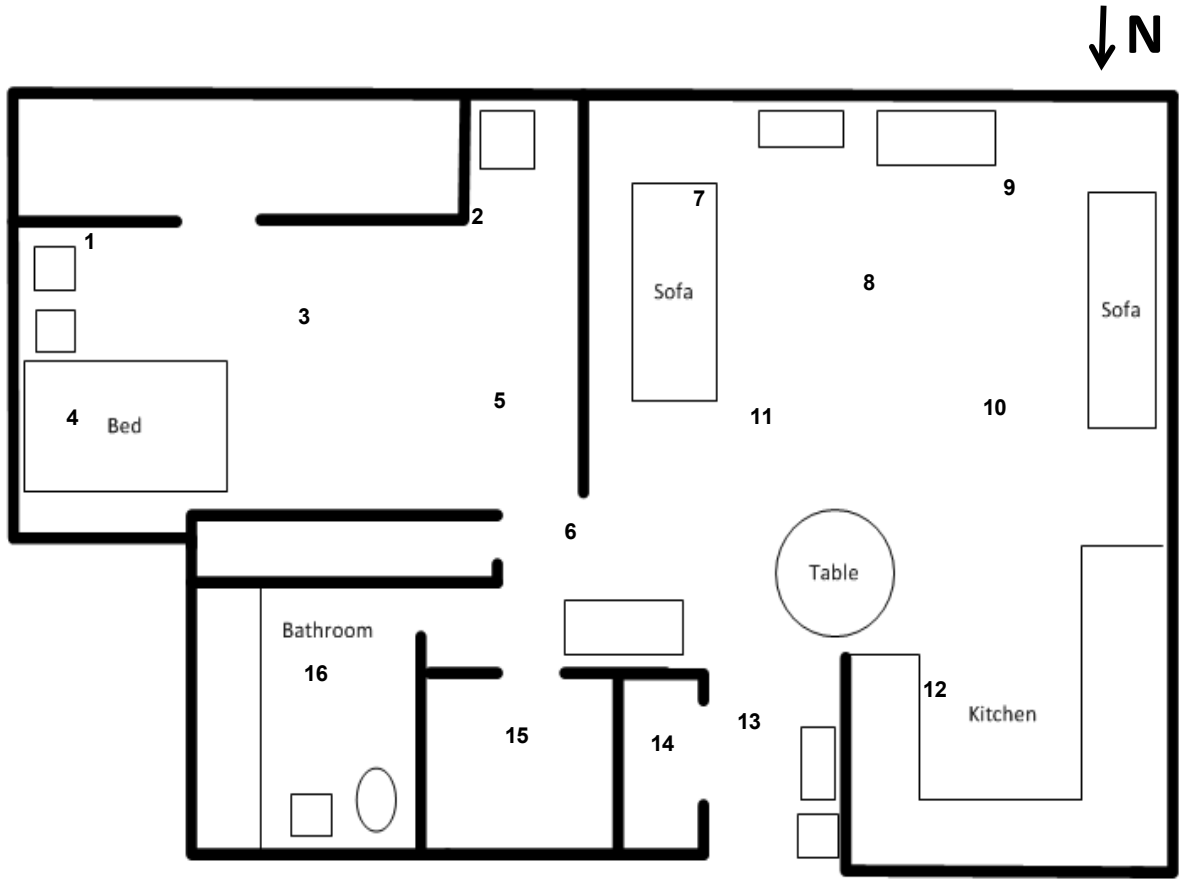
Table A-18. Waterbury Enterprise Apts. - Apt. 520								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	6,700	—	6	
2	—	—	—	—	7,200	—	6	
3	—	—	—	—	6,000	—	6	
4	—	—	—	—	5,300	—	5	
5	—	—	—	—	6,200	—	7	
6	—	—	—	—	7,300	—	5	
7	5307R0011	29	472	1,300	13,000	12	7	Small areas < 0.1m^2
8	—	—	—	—	7,500	—	6	
9	—	—	—	—	7,500	—	6	
10	—	—	—	—	8,100	—	7	
11	—	—	—	—	8,400	—	7	
12	—	—	—	—	8,200	—	8	
13	—	—	—	—	8,000	—	7	
14	—	—	—	—	9,000	—	7	
15	—	—	—	—	12,000	—	8	
16	—	—	—	—	10,200	—	7	
17	5307R0010	16	869	4,900	21,000	20	11	Small areas < 0.1m^2
18	—	—	—	—	15,200	—	8	
19	5307R0012	28	674	3,100	21,000	20	12	Small areas < 0.1m^2

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

Site: Waterbury-Enterprise Apt.	**Area:** Apt. 525	**Date(s):** 08/01/2017	**Time:** 1050/1200
Surveyor(s): JDL		**Purpose:** Site Visit	

Radiation Type	**Instrument**	**Detector**	**Background**
Gamma	2221/395	44-10/1148	5.2-9.6 kcpm[a]
Gamma	192/1128	NA	5-9 µR/h[a]
α+β	2221/505	44-142/1030	N/A

[a]Background varied depending on naturally occurring radioactive material in the area.



= General area measurements provided in attached table.

Figure A-19. Survey Map of Apt. 525

Table A-19. Waterbury Enterprise Apts. - Apt. 525								
Location No.	Removable[a]		Alpha-plus-Beta[b]		Gamma[c]			Comments
	Smear No.	(dpm/100 cm^2)	Gross	Total	Contact		1 m	
		Alpha-plus-Beta	Cpm	dpm/100 cm^2	cpm	µR/hr	µR/hr	
1	—	—	—	—	9,600	—	9	
2	—	—	—	—	8,700	—	7	
3	—	—	—	—	9,300	—	—	
4	—	—	—	—	8,600	—	7	
5	—	—	—	—	7,300	—	6	
6	—	—	—	—	5,600	—	5	
7	—	—	—	—	7,100	—	6	
8	—	—	—	—	6,900	—	6	
9	—	—	—	—	7,000	—	5	
10	—	—	—	—	5,200	—	5	
11	—	—	—	—	6,400	—	6	
12	—	—	—	—	5,300	—	5	
13	—	—	—	—	6,000	—	5	
14	—	—	—	—	5,700	—	5	
15	—	—	—	—	9,100	—	5	
16	—	—	—	—	8,100	—	6	

a) Smear field counted with Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
b) Ludlum 44-142 plastic scintillator with Ludlum 2221 ratemeter
c) Ludlum 44-10 NaI with Ludlum 2221 ratemeter; Ludlum 192 NaI
— indicates measurement not collected at this location

APPENDIX B
DOSE ASSESSMENT FROM THE FORMER WATERBURY CLOCK COMPANY SURVEY

Table B-1. Estimated Dose form the External Pathway Only							
Area/Apartment No.	Measured µr/hr at 1 m				Gamma-only Dose (mrem/yr)		Locations used in max room calculations[a]
	Survey Unit Avg		Max Room Avg				
	All Data	Bkg	All Data	Bkg	Survey Unit	Max Room	
Outdoor Land Area	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified
3rd Floor Hallway	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified
4th Floor Hallway	8.4	8.3	6.4	6.1	0.6	1.3	Locations 19-26; hall near apartments 401-412
416	11.3	10.8	12.3	11.6	2.8	4.2	Locations 11-18; bedroom
417	9.4	8.9	10.5	10.0	2.7	2.6	Locations 5-14; living room
5th Floor Hallway	10.4	8.8	10.4	8.8	9.3	9.3	Locations 1-14, hall near apartment 517
505	7.8	7.5	8.8	8.6	1.8	1.3	Locations 7-12; living room
507	7.5	7.4	8.1	8.2	0.2	<0.1	Locations 7-13; bedroom
508	8.6	8.4	10.0	9.3	1.6	3.8	Locations 13-16, living room area near closet
512	9.7	9.4	11.4	10.7	2.0	4.2	Locations 2-6; dining area
513	9.6	9.1	10.2	9.6	3.0	3.8	Locations 14-22; bedroom
514	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified
515	9.1	8.8	10.1	9.2	1.7	5.5	Locations 1-8; living room
516	11.1	10.8	11.8	11.3	1.6	2.7	Locations 13-17; bedroom
517	10.2	9.8	10.7	9.8	2.2	5.3	Locations 14-19; bedroom
520	7.2	6.6	8.6	7.4	3.1	6.8	Locations 13-19; bedroom
525	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified

Survey Unit Avg = the average value considering all data collected in the survey unit (apartment or common area).
Max Room Avg = the average value for the room or area with the highest measured radioactivity.
All Date = results from across the entire apartment or room, as applicable.
Bkg = all results excluding results from small areas of elevated activity.
[a]See Appendix A for gross measurement data by location.

Table B-2. Estimated Dose from the Internal Pathways Only							
Area/Apartment No.	Measured dpm/100 cm^2				Internal Dose (mrem/yr)		Locations used in max room calculations[a]
	Survey Unit Avg		Max Room Avg				
	All Data	Bkg	All Data	Bkg	Survey Unit	Max Room	
Outdoor Land Area	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified
3rd Floor Hallway	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified
4th Floor Hallway	N/A	N/A	N/A	N/A	N/A	N/A	No data available
416	717	0	1,438	0.0	0.2	0.5	Locations 11-18; bedroom
417	3,737	0	7,100	0.0	1.3	2.4	Locations 5-14; living room
5th Floor Hallway	5,057	0	5,057	0.0	1.7	1.7	Locations 1-14, hall near apartment 517
505	644	0	983	0.0	0.2	0.3	Locations 7-12; living room
507	173	0	386	0.0	<0.1	0.1	Locations 7-13; bedroom
508	342	0	900	0.0	0.1	0.3	Locations 13-16, living room area near closet
512	460	0	1,680	0.0	0.2	0.6	Locations 2-6; dining area
513	1,618	0	1,678	0.0	0.6	0.6	Locations 14-22; bedroom
514	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified
515	843	0	2,500	0.0	0.3	0.9	Locations 1-8; living room
516	1,600	0	2,640	0.0	0.5	0.9	Locations 13-17; bedroom
517	4,611	0	5,167	0.0	1.6	1.8	Locations 14-19; bedroom
520	489	0	1,143	0.0	0.2	0.4	Locations 13-19; bedroom
525	N/A	N/A	N/A	N/A	N/A	N/A	No elevated activity identified

Survey Unit Avg = the average value considering all data collected in the survey unit (apartment or common area).
Max Room Avg = the average value for the room or area with the highest measured radioactivity.
All Date = results from across the entire apartment or room, as applicable.
Bkg = all results excluding results from small areas of elevated activity.
[a]See Appendix A for gross measurement data by location.

Table B-3. Total Estimated Dose for Current or Future Occupants				
	Current Dose[a] (mrem/yr)		Future Dose[b] (mrem/yr)	
Area/Apartment No.	Survey Unit	Max Room	Survey Unit	Max Room
Outdoor Land Area	N/A	N/A	N/A	N/A
3rd Floor Hallway	N/A	N/A	N/A	N/A
4th Floor Hallway	0.6	1.3	0.6	1.3
416	2.8	4.2	3.0	4.7
417	2.7	2.6	3.9	5.0
5th Floor Hallway	9.3	9.3	11	11
505	1.8	1.3	2.0	1.7
507	0.2	<0.1	0.2	0.1
508	1.6	3.8	1.7	4.2
512	2.0	4.2	2.2	4.8
513	3.0	3.8	3.6	4.3
514	N/A	N/A	N/A	N/A
515	1.7	5.5	2.0	6.4
516	1.6	2.7	2.2	3.6
517	2.2	5.3	3.7	7.1
520	3.1	6.8	3.2	7.1
525	N/A	N/A	N/A	N/A

[a]Current dose is due to the external pathway only (values from Table B-1).
[b]Future dose is comprised of all pathways and is a summation of the values from Tables B-1 and B-2.