

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) requested that the Oak Ridge Institute for Science and Education (ORISE) perform a radiation survey of the properties at 232 North Elm Street (buildings known as Phase I and Phase II, respectively, in Figure 1 within the report) in Waterbury, Connecticut. These properties were once occupied by the former Waterbury Clock Company, which used radium paint in the manufacturing of clocks and watches into the mid-1940s. The objective of this survey was to locate possible discrete sources of radium, if any, that would be associated with former Waterbury Clock Company operations.

ORISE performed radiation surveys on November 29 through December 1, December 16, and December 18, 2016, and identified elevated levels of radiation. Because elevated levels of radiation were identified, most notably on the fifth floor of Bldg. I (Phase I), ORISE concluded that discrete sources of radium are present. Based on these results, it is recommended that the NRC pursue additional action at the 232 North Elm Street properties by working with the owner on site remediation.

SITE STATUS REPORT

Property: New Opportunities Incorporated (NOW)
232 N. Elm Street and 39 Cherry Avenue
Waterbury, CT 06702

Docket Number: 03038960 and 03038964, respectively

Current Property Name(s): New Opportunities of Waterbury, Inc.

Current Property Owner(s): New Opportunities, Inc.

Inspection Dates: November 29 through December 1, 2016 and December 16 and 18, 2016

Inspector(s): Todd Jackson/NRC, assisted by Nick Altic/Oak Ridge Associated Universities (ORAU) and Teresa Brown/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 U.S. Nuclear Regulatory Commission (NRC) regulatory authority as byproduct material. The NRC is evaluating properties where review of historical information has identified Ra-226 use. The property at 232 North Elm Street in Waterbury, Connecticut (CT), was identified as the former Waterbury Clock Company, a clock manufacturing facility, which once operated during the period from 1919 to the mid-1940s (ORNL 2015 and ATSDR 1999). The objectives of the initial site visit were to determine if discrete sources of Ra-226 and/or distributed Ra-226 contamination are present, to identify the areas of highest contamination, to determine if there are any current health and safety concerns, and to determine if a more in-depth scoping survey to better reach a conclusion on whether site cleanup is needed.

Data from the initial site visit are used to plan future actions that may be needed to reduce the exposure to Ra-226 of current or future site occupants to levels that do not exceed the applicable regulatory requirement. Surveys were performed as described within NRC's procedures, Temporary Instruction 2800/043 "Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources" (NRC 2016). It is important to note that destructive testing is not generally performed as described within NRC's procedures.

2.0 PROPERTY DESCRIPTION AND INITIAL SITE VISIT CONSIDERATIONS

Primary references used by this report include the Oak Ridge National Laboratory's (ORNL's) historical assessment (ORNL 2015) and reports by the Agency for Toxic Substances and Disease Registry (ATSDR) (ATSDR 1999) and Sciencetech (Sciencetech 2003).

2.1 Property Description and History

The Waterbury Clock Company was founded in 1857 and moved its base of operations in 1873 to the corner of Cherry Avenue and North Elm Street in Waterbury, CT. The company started

using luminous radium paint in 1919, and that process presumably continued at least until 1944 when the company name changed to U.S. Time Corporation and operations were moved to other facilities. In 1949, the plant was subdivided into parcels that were subsequently acquired by small manufacturing firms or individuals for storage or light industrial uses (ORNL 2015).

2.2 Initial Site Visit Considerations

New Opportunities, Inc. (NOW) owns and occupies Building I and J (see Figure 1), which NOW references as Phase I and Phase II, respectively. Phase I and Phase II are the primary focus of this report. The NOW facility, located at 232 N Elm Street, includes a south wing (Phase I) and north wing (Phase II). Based on interior design features, it is speculated to have been a machine shop for the former Waterbury Clock Company but is now mostly office space (ORNL 2015). Based on historical surveys, Ra-226 would most likely be located on the third, fourth, and fifth floors, where exposure rates exceeding 30 microRoentgens per hour ($\mu\text{R}/\text{h}$) were previously found (ATSDR 1999). The site visit confirms results from the previous investigation, which determined that Ra-226 is present at levels that could produce a radiological dose above NRC's criterion for unrestricted use in 10 CFR Part 20.1402 (i.e., 25 mrem/yr).¹

Prior to commencing survey activities in Phase I and Phase II, the general building layout was examined for consistency with historical information and to identify impediments to conducting the survey and/or health and safety considerations. The facility appears to be original except for an addition of a large theater and an exterior enclosed walkway/entryway on the first floor. The structural integrity is sound, including floors and walls. The majority of the building is office space, with light manufacturing operations on the first and second floors.

3.0 SITE OBSERVATIONS AND FINDING

3.1 Summary of Activities

The inspection team conducted radiological survey activities during the site visit to the 232 North Elm Street property on November 29 through December 1 and on December 16 and 18 of 2016. A pre-inspection meeting was held with Toni Hirst (NOW representative), Mike Firsick (Connecticut Department of Energy and Environmental Protection [CT DEEP]), and Todd Jackson (NRC). Participants discussed the inspection team's intention to re-visit some of the locations identified in the historical assessment as potentially contaminated with radium, and to perform general area scans in other areas of the facility. The inspection team was granted access to all portions of the facility with a few exceptions.

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 sodium iodide detector (2x2) 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 exposure rate measurements using a Ludlum model 192 sodium iodide-based μR ratemeter. Exposure rate measurements were evaluated against an action

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).

level of 40 $\mu\text{R}/\text{h}$ at 1 meter above background, as specified in Temporary Instruction 2800/043 (NRC 2016). Gamma spectroscopy measurements were made with a Berkeley Nucleonics SAM-940 radiation isotope identifier. Table 1 presents the specific instruments used during the site visit. Exposure rate data were recorded on site floor plans for Phase II. However, a useable floor plan was not available for Phase I; therefore, data were recorded in tabular form. Each measurement location was assigned a unique identification number (ID). The format of the ID is X-Y-Z, where X is the building phase, Y is the floor number, and Z is the measurement number.

E-PERM™ passive radon detectors were deployed at various locations throughout Phase I and Phase II on the evening of December 16, 2016. Detectors were retrieved the evening of December 18, 2016. The Sun Nuclear Model 1029 radon monitor was also used during deployments to generate short-term, real-time airborne radon concentrations.

Photos taken during the site visit are presented in Appendix A.



Figure 1. Aerial Photo of the Former Waterbury Clock Company showing NOW, Phase I (I) and II (J)

Radiation Type (units)	Detector Type	Detector Model (No.)	Ratemeter Model (No.)
Alpha plus beta (cpm)	Plastic Scintillator	44-142 (920)	2221 (1143)
Gross gamma (cpm)	Sodium Iodide	44-10 (908)	2221 (590)
Gross gamma (μ R/h)	Exposure Meter	192 (1127)	N/A
Gamma Spectrum Analyzer (SAM-940)	Lanthanum Bromide	940 (864)	N/A
Radon (pCi/L)	Photodiode	Sun 1029	N/A

N/A = not applicable

No. = ORISE equipment tracking number

μ R/h = microRoentgen per hour

cpm = counts per minute

pCi/L = picoCuries per liter

November 29, 2016

The team began surveys of NOW offices, located at 232 North Elm Street, after the close of normal business hours. In Phase I, the team surveyed the fifth floor, where contamination was previously identified (in the suite of rooms at the eastern end of the fifth floor). The area on the fifth floor with the previously identified contamination was referred to as the “rec room” in previous reports (Sciencetech 2003). The team identified a total of three locations that had elevated direct gamma radiation above the Temporary Instruction threshold for considering controls on the fifth floor, all in the eastern-most suite of rooms. The team surveyed in Room 426, located on the fourth floor, which is directly below one of the areas of elevated gamma radiation identified at the east end on the fifth floor. The team identified one area of elevated direct gamma radiation that approached the Temporary Instruction threshold in Room 426. The team also investigated the remainder of the fourth floor.

In Phase II, the team surveyed the offices belonging to the fiscal group on the fifth floor. Investigations did not reveal any areas of elevated gamma radiation in Phase II on the fifth floor.

November 30, 2016

In Phase I, the team surveyed the first floor reception area and associated auditorium. The team surveyed offices located on the fourth and fifth floors that were previously locked and initiated surveys of the third floor.

In Phase II, the team surveyed the executive offices located on the third floor where elevated direct gamma radiation that approaches (but does not exceed) the Temporary Instruction threshold was identified in one office. Surveys were completed on the fourth floor where one exposure rate measurement approaches the Temporary Instruction threshold. The team identified an area of discrete radium contamination on a column at approximately chest height (1 meter) with an exposure rate measurement of 110 μ R/h on contact with the column, which

exceeds the NRC's 40 $\mu\text{R}/\text{h}$ threshold for controls. The measurement decreased to 25 $\mu\text{R}/\text{h}$ at 1 meter away from the column.

December 1, 2016

In Phase I, the survey team investigated the server room located on the third floor. The fourth floor room on the west side of Room 426 was also investigated. Per NOW staff, this room is leased to a separate company, Madre Latina. The survey team collected gamma spectroscopy measurements from the two previously identified locations of the fifth floor with the highest exposure rates. Radium-226 was identified at one of the two locations on the fifth floor. The survey team also collected gamma spectroscopy measurements from two locations with the highest exposure rates in Room 426. The team performed surveys on the second floor of Phase I. The second floor had several large rooms containing manufacturing operations with multiple workstations per room. The survey team performed exposure rate measurements at each workstation, and recorded the highest value. The team also conducted surveys of the first floor. The offices were not surveyed as these areas were locked and previous historical surveys did not indicate radium contamination on the first floor. The survey team also investigated the basement area, with surveys focusing on the areas primarily occupied by NOW staff.

In Phase II, the survey team investigated the first and second floors. The team surveyed the previously locked weatherization area on the first floor.

December 16, 2016

The survey team deployed E-PERM™ passive radon detectors at various locations throughout the NOW facility. The survey team also used the Sun Nuclear Model 1029 radon monitor to estimate real-time airborne radon concentrations. Deployment began at approximately 16:30 and concluded at approximately 20:30.

December 18, 2016

The team collected the previously deployed E-PERM™ radon detectors. Collection began at approximately 16:30 and concluded at approximately 18:00.

3.2 Summary of Results

An overall summary of gamma radiation and radon concentration measurements for Phase I and Phase II of the NOW facility is presented in Table 2. Individual measurement results are presented in Appendix B. The exposure rate measurements in Table 2 represent values at an offset of 1 meter above the floor—unless otherwise noted—and thereby would be representative of an occupant's whole body exposure rate. Generally, background sodium iodide detector (2x2) responses and exposure rates ranged from approximately 5,000 to 12,000 counts per minute (cpm) and approximately 5 to 12 $\mu\text{R}/\text{h}$, respectively. Measurements made near the building exterior walls were typically about 12 $\mu\text{R}/\text{h}$ due to the presence of red brick containing naturally occurring radioactive material.

Phase	Floor No.	Gamma (cpm)	Exposure Rate ($\mu\text{R/h}$)^a	Radon Concentration (pCi/L)
I	Basement	9,000 to 22,000	9 to 11	N/A
	1	6,000 to 14,000	5 to 10	N/A
	2	8,000 to 13,000	5 to 12	N/A
	3	8,000 to 17,000	6 to 10	0.1 to 1.1
	4	6,000 to 230,000	6 to 40	0.5 to 1.1
	5	6,000 to >1 million	6 to 210	0.8 to 3.7
II	1	8,000 to 15,000	4 to 10	2.6
	2	8,000 to 22,000	5 to 18	0.8
	3	6,000 to 52,000	5 to 14	2.2
	4	10,000 to 250,000	5 to 42	2.3
	5	5,000 to 17,000	4 to 8	N/A
I,II	Background	5,000 to 12,000	5 to 12 $\mu\text{R/h}$	Varies

^aAt 1 m, exposure rates represent an occupant's whole body exposure
cpm= counts per minute
 $\mu\text{R/h}$ = micro roentgen per hour
pCi/L- picocuries per liter

A summary of all locations identified as having an exposure rate measurement above 40 $\mu\text{R/h}$, including background contributions, is provided in Table 3.² In total, 19 locations had an exposure rate above 40 $\mu\text{R/h}$ on contact. Most areas of identified contamination were small, discrete locations with an area no greater than 100 cm².

Exposure Rates for the Phase I Fifth Floor

Of the 19 locations with elevated gamma radiation above 40 $\mu\text{R/h}$ (which is above background values), three had net exposure rates exceeding the Temporary Instruction threshold for working with owners on applying immediate controls, all of which were located in the office suite at the eastern end of the fifth floor with a maximum of 210 $\mu\text{R/h}$ at 1 meter (4,000 $\mu\text{R/h}$ on contact). These locations are identified as measurement IDs 1-5-1, 1-5-2, and 1-5-3 in Table 3. Measurement IDs 1-5-1 and 1-5-2 are of the same source—the center of which was between a wall dividing the two offices (see Appendix A Photo A-2). The results are consistent with historical data which references the “Rec Room” (Sciencetech 2003). The office suite at the east end of the fifth floor is currently unoccupied.

² NRC's Temporary Instruction (NRC 2016) identifies 40 $\mu\text{rem/h}$, which as noted earlier is assumed here as equivalent to 40 $\mu\text{R/h}$ at 1-m from the floor, as the exposure threshold for worker areas above which controls may be necessary to ensure public health and safety of current occupants.

Table 3. Elevated Exposure Rate Measurements					
ID	Area	Sodium Iodide (cpm) ^a	Exposure Rate (μR/h)		
			Contact	1 meter ^a	Ceiling (2-3 meters)
Phase I					
1-5-1	5 th Floor East End Office Suite	620,000	750	75	--
1-5-2	5 th Floor East End Office Suite	740,000	950	75	--
1-5-3	5 th Floor East End Office Suite	2.9 million	4,000	210	--
1-5-5	Office	--	40	10	--
1-4-10	Reception	70,000	85	10	--
1-4-11	Room 405	150,000	120	8	--
1-4-12	Room 409	89,000	75	15	--
1-4-13	Room 409	45,000	42	11	--
1-4-14	Room 413S	94,000	75	10	--
1-4-21	Room 426	74,000	60	40	85
1-4-22	Room 426	--	27	33	120
1-4-23	Room 426	230,000	200	15	18
1-4-24	Waiting Room	130,000	165	15	10
1-4-28	Waiting Room	180,000	170	23	11
1-4-32	Madre Latina	55,000	--	20	45
--	Background	5,000 to 12,000	--	5 to 12 μR/h	--
Phase II					
2-4-1	Fatherhood	250,000	270	42	--
2-4-2	Fatherhood	98,000	--	110/25 ^b	--
2-4-3	Fatherhood	32,000	45	12	--
2-3-9	Office	--	--	--	43
--	Background	5,000 to 12,000	--	5 to 12 μR/h	--

ID= Sample location

cpm= counts per minute

μR/h = micro roentgen per hour

^a Distances are referenced from the floor.

^b For measurement ID 2-4-2, 110 μR/h was measured on contact with the column at 1 meter above the floor; 25 μR/h was measured at 1 meter from the column and 1 meter above the floor.

Note: Values that exceed background are highlighted yellow; values that exceed NRC's 40 μR/h above background threshold for controls are in red.

Exposure Rates for the Phase I and Phase II Fourth Floor

One area of discrete contamination was identified on a column approximately in the middle of the room in the area designated as Fatherhood (measurement ID 2-4-2) on the fourth floor, Phase II. This source was approximately chest height with a gross exposure rate of 110 $\mu\text{R/h}$ on contact with the column and 25 $\mu\text{R/h}$ at 1 meter from the column. The gross value of 110 $\mu\text{R/h}$ on contact exceeds NRC's threshold for applying controls because the source is approximately 1 meter above the floor (chest height).

Surveys performed in Phase I, Room 426 identified two locations (measurement IDs 1-4-21 and 1-4-22) that had high exposure rate gradients from the floor to the ceiling. The high exposure rate gradients were due to suspected gamma shine from the location of measurement ID 1-5-3 on the fifth floor above. These two locations were along the north wall in Room 426 (see Appendix A Photo A-3 for measurement ID 1-4-21). The gross exposure rate peaked at 120 $\mu\text{R/h}$ near the ceiling (2-3 meters above the floor). Measurement ID 1-4-21 had a gross exposure rate above the Temporary Instruction threshold; however, when subtracting a conservative background (5 $\mu\text{R/h}$) the resulting exposure rate is below the Temporary Instruction threshold for applying immediate controls. An area of discrete contamination with a gross exposure rate of approximately 200 $\mu\text{R/h}$ on contact was identified on the floor under an occupant's desk in Room 426 (measurement ID 1-4-23). This workspace is the third cubicle (see Appendix A Photo A-4) from the east end of the room. The exposure rate where the occupant would sit at this workspace was 23 $\mu\text{R/h}$ measured at chest level and 15 $\mu\text{R/h}$ at 1 meter, which is below the Temporary Instruction threshold for applying immediate controls.

All exposure rate measurements representative of occupants sitting at their desks were below the 40 $\mu\text{R/h}$ threshold for applying immediate controls in the Madre Latina office. However, an area of elevated gamma radiation in the upper northeast corner of the room, measuring 45 $\mu\text{R/h}$ (gross), was identified (measurement ID 1-4-32 in Table 3). The elevated gamma radiation is due to suspected shine from the location of measurement IDs 1-5-1 and 1-5-2 (in Table 3) on the fifth floor directly above.

Other areas of discrete contamination producing a gross contact exposure rate greater than 40 $\mu\text{R/h}$ were identified throughout the fourth floor, Phase I (see Table 3). However, measurements made at a distance—i.e., 1 meter above the floor that would be representative of an occupant's whole body exposure—were less than 40 $\mu\text{R/h}$.

Exposure Rates for the Phase II Third Floor

One area of elevated direct gamma radiation nearing the Temporary Instruction threshold was identified on the third floor, which was located in an empty office (measurement ID 2-3-9). This elevated gamma radiation was due to suspected gamma shine from the hot spot (measurement ID 2-4-1) on the fourth floor above.

Surface Activity Measurements

The alpha-plus-beta static measurements were converted to total surface activity units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2) using the equation below:

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

Where:

C = measured count rate (cpm),

B = background count rate (cpm),

G = geometry factor (unitless) = $\frac{\text{Physical Detector Area (cm}^2\text{)}}{100\text{ cm}^2}$ = 1.00, and

ϵ_{tot} = total weighted efficiency (unitless) = 1.6.

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:

$$\epsilon_{tot} = \sum_n F_n \times \epsilon_{i,n} \times \epsilon_{s,n}$$

Where:

F_n = fractional abundance of n^{th} emission,

ϵ_n = instrument efficiency for n^{th} emission, and

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

Total and removable surface activity levels are presented in Table 4. The highest surface activity measurement was collected in the office suite at the east end of Phase I, fifth floor (referred to as the “rec room” in the Scientech report). The highest removable activity of all smears collected was 4 dpm/100 cm² (beta), which is below the analytical minimum detectable concentration, indicating that contamination is not readily removable in the current configuration. It should be noted that the original building surfaces could not be accessed; therefore, surface activity measurements are not representative of the contamination on the original surface. Total surface activity was calculated with an efficiency assuming surface contamination and no radon loss. Using these surface activity values during future dose assessments may not be appropriate.

NRC staff discussed the following with the site manager, Ms. Hirst:

- 1) Identified areas where direct gamma radiation approached or exceeded NRC’s Temporary Instruction threshold of 40 µR/h at 1 meter (which included the Phase I fifth floor East End, the Phase I Room 426, and the Phase II fourth floor column inside of the Fatherhood office); and
- 2) Actual occupancy in the aforementioned areas (Phase I, fifth floor East End is currently unoccupied with locked access; Phase I Room 426 is occupied for less than 8 hours a day; and Phase II fourth floor column inside of the Fatherhood office is occupied for less than 8 hours a day).

Ms. Hirst agreed to maintain the current occupancy in the areas identified and to not increase occupancy.

Table 4. Surface Activity Assessment						
ID	Area	Smear ID	Gross Count (cpm)	Surface Activity (dpm/100 cm²)		
				Total		Removable
				Alpha+Beta	Alpha	Beta
Phase I						
1-5-1	5th Floor East End Office Suite	--	98,767	62,000	--	--
1-5-2	5th Floor East End Office Suite	--	72,032	45,000	--	--
1-5-3	5th Floor East End Office Suite	--	356,369	220,000	--	--
1-4-10	Reception	R0016	4619	2,800	0	4
1-4-11	Room 405	R0017	7684	4,700	0	-3
1-4-12	Room 409	R0018	1464	790	0	-1
1-4-13	Room 409	R0019	567	230	0	-2
1-4-14	Room 413S	R0020	4732	2,800	0	-1
1-4-21	Room 426	--	3,444	2,000	--	--
1-4-23	Room 426	R0013	13,082	8,100	0	2
1-4-24	Room 426	--	15,438	9,500	--	--
1-4-28	Room 426	R0012	6,333	3,800	0	0
Window sill near 1-4-21		R0015	--	--	0	0
Phase II						
2-4-1	Fatherhood	R0021	3,703	2,200	2	2
2-4-2	Fatherhood	R0022	3,148	1,800	2	0
2-4-3	Fatherhood	R0023	978	490	0	-1

Radon Concentration Measurements

Individual radon measurements are provided in Appendix C and summarized in Table 2. Overall, the radon concentration measurements ranged from 0.1 to 3.7 pCi/L. The highest radon concentration measurement (3.7 pCi/L) was from the Rec Room, located on the fifth floor of Phase I. Radon measurements, which are indicative of the range of background, varied by floor from 0.8 pCi/L to 2.6 pCi/L.

3.3 Summary of Dose Assessment Results

To date, a site-specific dose assessment has not been performed for the NOW facility. However, the exposure rate measurements on the fourth and fifth floors of Phase I, and fourth floor of Phase II, exceed the 40 µR/h Temporary Instruction threshold, suggesting that a site worker could receive a dose in excess of 100 mrem/yr solely from the external gamma exposure pathway if they occupied those areas for greater than 8 hours a day on an annual basis.

4.0 OBSERVATIONS AND RECOMMENDATIONS

Based on the information provided in this report, portions of the former Waterbury Clock Company currently owned by NOW contain discrete sources of Ra-226 in excess of NRC regulatory requirements, as determined by the following observations:

- Elevated direct gamma radiation was identified during the site visit and in the historical reports in portions of Phase I and II. Gamma radiation levels were near or exceeded the Temporary Instruction threshold of 40 μ R/h (above background at 1 meter) suggesting that potential doses may exceed the 25 mrem/yr and 100 mrem/yr limits to future occupants (i.e., 10 CFR 20.1402 and 10 CFR 20.1301).
- The survey team located contamination consistent with historical surveys (ATSDR 1999 and Scientech 2003), though this initial site visit should not be considered a full characterization of the site. The historical reports did not provide sufficient information for the NRC to perform comprehensive dose calculations. All datasets, however, strongly suggest that remedial actions may be required to limit doses below the NRC's release criterion for unrestricted use in 10 CFR 20.1402 (25 mrem/yr).

Based on the above observations, it is recommended that the NRC not perform a scoping survey, but should maintain oversight by working with the owners to control and mitigate risks from exposure to discrete sources of Ra-226 at the former Waterbury Clock Company until remediation can be performed. The inspector recommended that the owner maintain the controls implemented at the end of the site visit to protect public health and safety and reconsider those controls if materials are moved or removed from the affected areas. The site should perform long-term radon monitoring at the NOW offices since the measurements discussed in this document are short-term and, therefore, do not represent an average, long-term exposure value. Additional, longer-term integrated measurements to assess annual exposures are recommended at locations that had radon concentrations which were slightly elevated, such as the Phase I fifth floor office suite at the east end, Room 426, third floor executive offices; and the Fatherhood room of the Phase II fourth floor.

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. ML17038A052, 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).

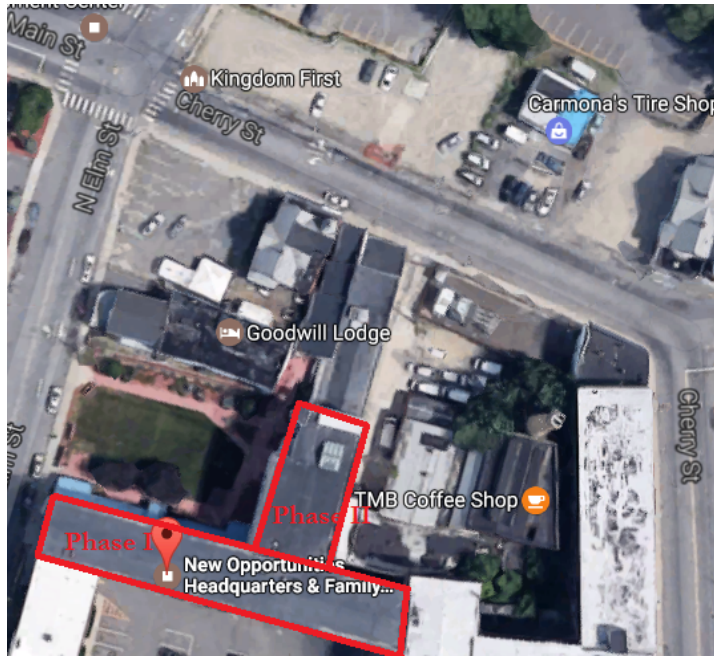
NRC 2016. *Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources*, ML16035A053, Temporary Instruction 2800/043, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Washington, D.C., October. (ADAMS Accession No. ML16035A053).

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, ML16291A488, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488)

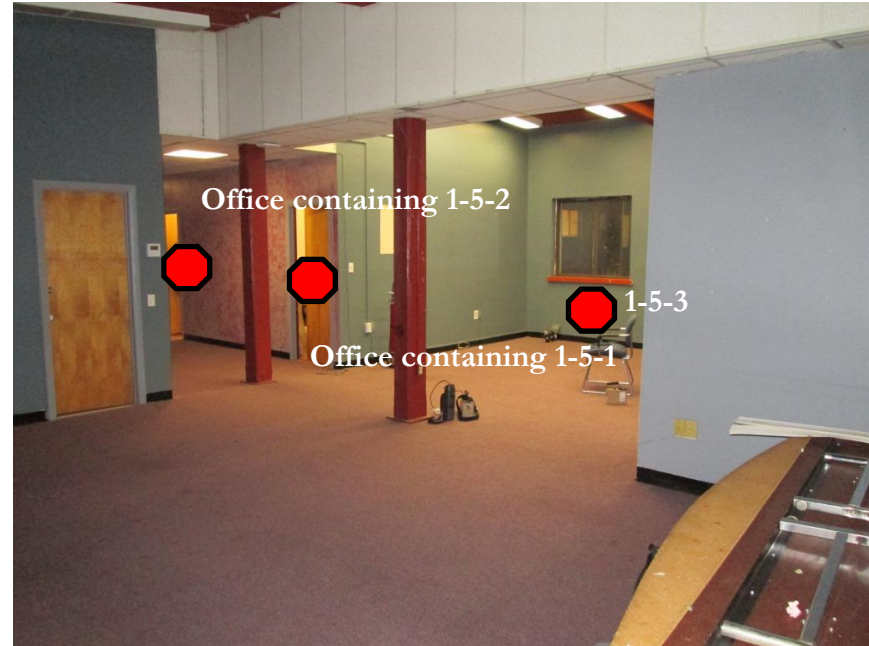
Sciencetech 2003. *Connecticut Radium Sites Verification Survey*, prepared for: Valley Council of Governments, prepared by: Sciencetech, Inc., New Milford, Connecticut, ML17039A514, October.

APPENDIX A
PHOTOS FROM THE NOW SITE VISIT

Photos from the NOW Site



A-1. General layout of the NOW site.



A-2. Highest location identified on the fifth floor, Phase I (looking approximately North). ID 1-5-3 is below the window and IDs 1-5-1 and 1-5-2 are between the two offices immediately to the left of the window.

Photos from the NOW Site



A-3 Rm 426 looking North. ID 1-4-21 located under chair. Cube with ID 1-4-23 is located on the right.



A-4 Rm 426 looking East from chair in Photo A.3. Cubicle with ID 1-4-23 is first on the right.

APPENDIX B
EXPOSURE RATE MEASUREMENTS AT THE NOW SITE

Exposure Rate Measurements From Phase I

ID	Area	Room	Exposure Rate ($\mu\text{R/h}$) ^a	Remarks
1-B-1	Work Area	N/A	9	None
1-B-2	Work Area	N/A	11	None
1-B-3	Work Area	N/A	10	None
1-B-4	Work Area	N/A	9	None
1-B-5	Work Area	N/A	10	None
1-1-1	Reception	Front Desk	7	None
1-1-2	Reception	Front Desk	7	None
1-1-3	Reception	Cubicles	9	None
1-1-4	Reception	Cubicles	6	None
1-1-5	Storage		7	None
1-1-6	Storage		5	None
1-1-7	Storage		8	None
1-1-8	Storage		9	None
1-1-9	Storage		7	None
1-1-10	Workspace		10	None
1-1-11	Workspace		9	None
1-2-1		Door 1	10	None
1-2-2		Door 2	9	None
1-2-3		Door 3	8	Multiple workstations; highest recorded
1-2-4		Door 6	6	None
1-2-5		Door 7	5	None
1-2-6		Door 9, 11, 12	7	Multiple workstations; highest recorded
1-2-7		Door 8	6	None
1-2-8		Door 10	7	None
1-2-9		Door 13, 15	8	Multiple workstations; highest recorded
1-2-10		Door 16	7	Multiple workstations; highest recorded
1-2-11		Door 18	8	Multiple workstations; highest recorded
1-2-12		Door 22	7	Multiple workstations; highest recorded
1-2-13		Door 24, classroom	12	Multiple workstations; highest recorded
1-3-1	Nutrition		10	None
1-3-2	Sr Nutrition Serv.		7	None
1-3-3	C. Watson		7	None
1-3-4		4th door	6	Referenced from elevator on S side of hallway
1-3-5		5th door	7	Referenced from elevator on S side of hallway
1-3-6		7th door	6	Referenced from elevator on S side of hallway

Exposure Rate Measurements From Phase I

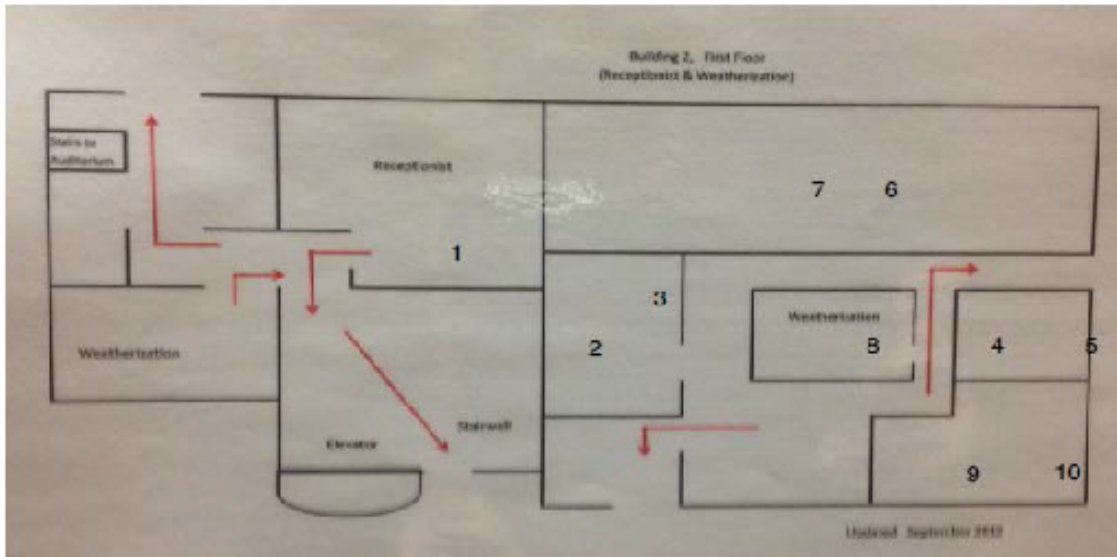
ID	Area	Room	Exposure Rate ($\mu\text{R/h}$) ^a	Remarks
1-3-7		9th door	8	Referenced from elevator on S side of hallway
1-3-8		14th door	10	Referenced from elevator on S side of hallway
1-3-9		15th door	7	Referenced from IT on N side of hallway
1-3-10		1st door	7	Referenced from IT on N side of hallway
1-3-11		2nd door	10	Referenced from IT on N side of hallway
1-3-12		7th door	6	Referenced from IT on N side of hallway
1-3-13		8th door	6	Referenced from IT on N side of hallway
1-3-14	IT Server room		10	Occupant in IT
1-4-1	Reception		9	None
1-4-2	Office	406	7	None
1-4-3	Office	406	8	None
1-4-4	Office	407	8	None
1-4-5	Office	409	7	None
1-4-6	Office	410	6	None
1-4-7	Office	411	6	None
1-4-8	Office	414	8	None
1-4-9	Office	414	7	None
1-4-10	Reception		10	None
1-4-11	Copy room	405	8	Not occupied
1-4-12	Office	409	15	None
1-4-13	Office	409	11	None
1-4-14	Office	413s	10	None
1-4-15	Office	418	9	None
1-4-16	Office		11	None
1-4-17	Office	420	9	None
1-4-18	Office	424	8	None
1-4-19	Office	415	7	None
1-4-20	Hallway		9	None
1-4-21	Middle of north wall	Rm 426	40	Contamination on floor and potential shine from above desk
1-4-22	Middle of north wall	Rm 426	33	Potential shine from fifth floor
1-4-23	Workspace/Cubicles	Rm 426	15	Contamination identified under desk
1-4-24	Workspace/Cubicles	Rm 426	15	None
1-4-25	Workspace/Cubicles	Rm 426	17	None
1-4-26	Workspace/Cubicles	Rm 426	22	None
1-4-27	Workspace/Cubicles	Rm 426	22	None
1-4-28	Workspace/Cubicles	Rm 426	23	None
1-4-29	Workspace/Cubicles	Rm 426	19	None

Exposure Rate Measurements From Phase I

ID	Area	Room	Exposure Rate ($\mu\text{R/h}$) ^a	Remarks
1-4-30	Workspace/Cubicles	Rm 426	15	None
1-4-31	Office	Rm 426	15	None
1-4-32	Madre Latina Office		20	None
1-4-33	Madre Latina Office		17	None
1-4-34	Madre Latina Office		12	None
1-5-1	5th Floor Rec room office		75	None
1-5-2	5th Floor Rec room office		75	None
1-5-3	5th Floor Rec room office		210	None
1-5-4	Conference room		10.5	None
1-5-5	Office		10	None
1-5-6	Office		7	None
1-5-7	Reception		6	None
1-5-8	Office		8	None
1-5-9	Office		6	None
1-5-10	Open area with desks		7	None
1-5-11	Office		6	None
1-5-12	Office		6	None
1-5-13	Office		7	None
1-5-14	Office		6	None
1-5-15	Office		6	None
1-5-16	Office		8	None
1-5-17	Office		7	None
1-5-18	Office		6	None
1-5-19	Office		7	None

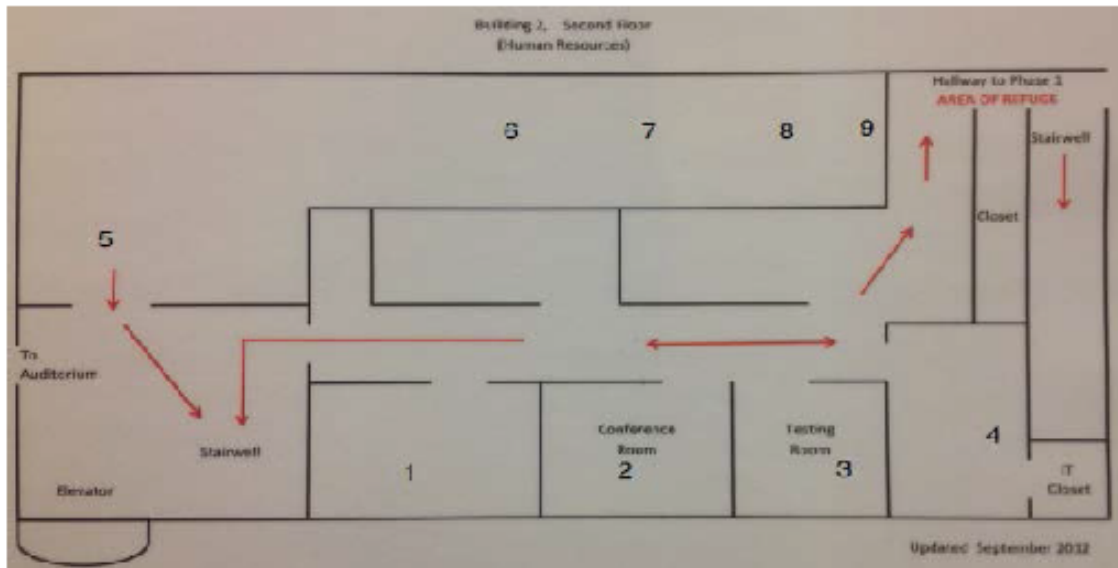
^aAt 1 m, exposure rates represent an occupant's whole body exposure

First Floor, Phase II



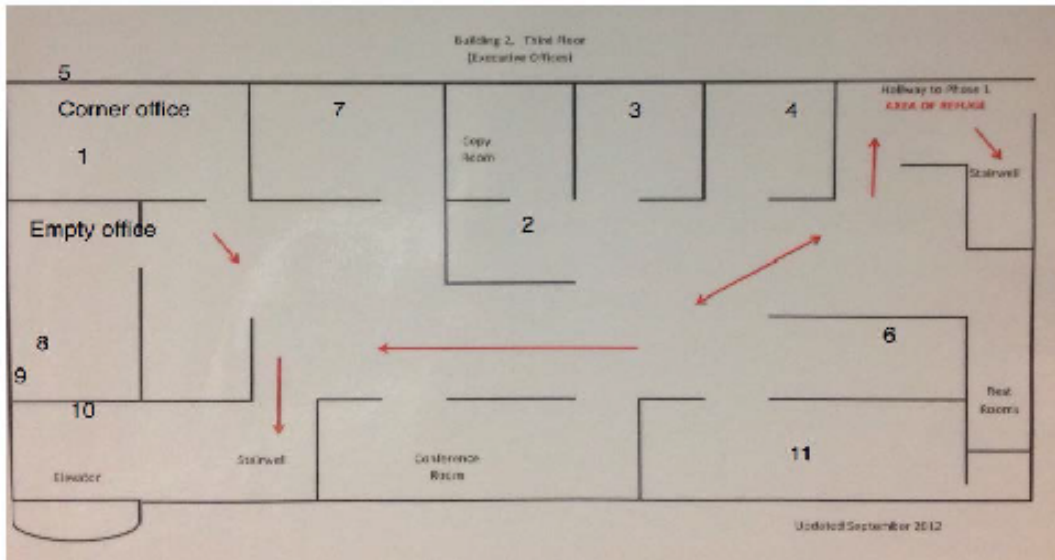
ID	Exposure Rate ($\mu\text{R/hr}$)	Remarks
2-1-1	4	None
2-1-2	10	None
2-1-3	7	None
2-1-4	6	None
2-1-5	7	None
2-1-6	8	None
2-1-7	9	None
2-1-8	6	None
2-1-9	10	None
2-1-10	9	None

Second Floor, Phase II



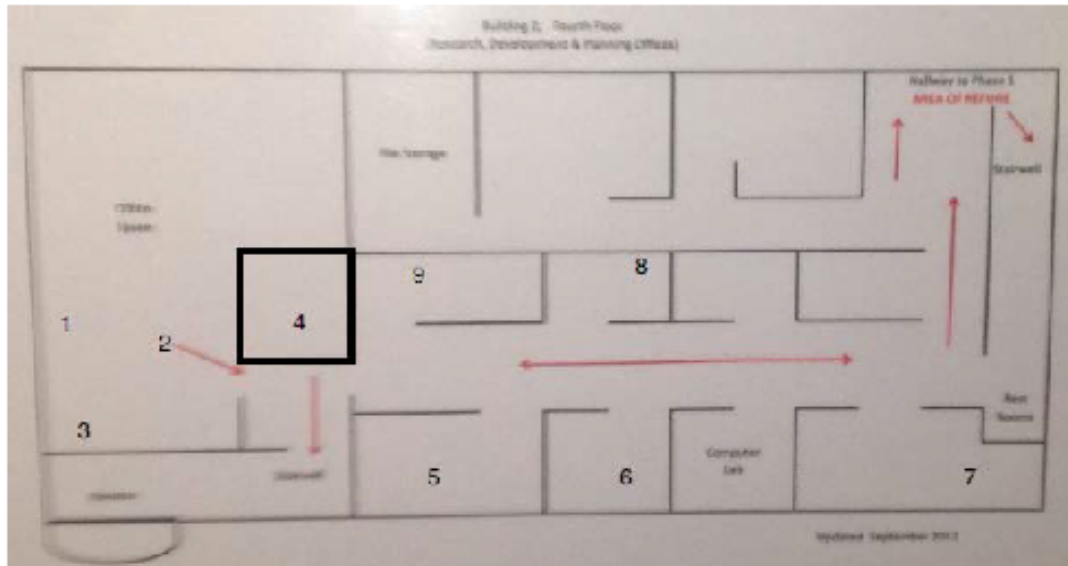
ID	Exposure Rate ($\mu\text{R/hr}$)	Remarks
2-2-1	10	None
2-2-2	7	None
2-2-3	6	None
2-2-4	7	None
2-2-5	18	None
2-2-6	8	None
2-2-7	6	None
2-2-8	6	None
2-2-9	5	None

Third Floor, Phase II



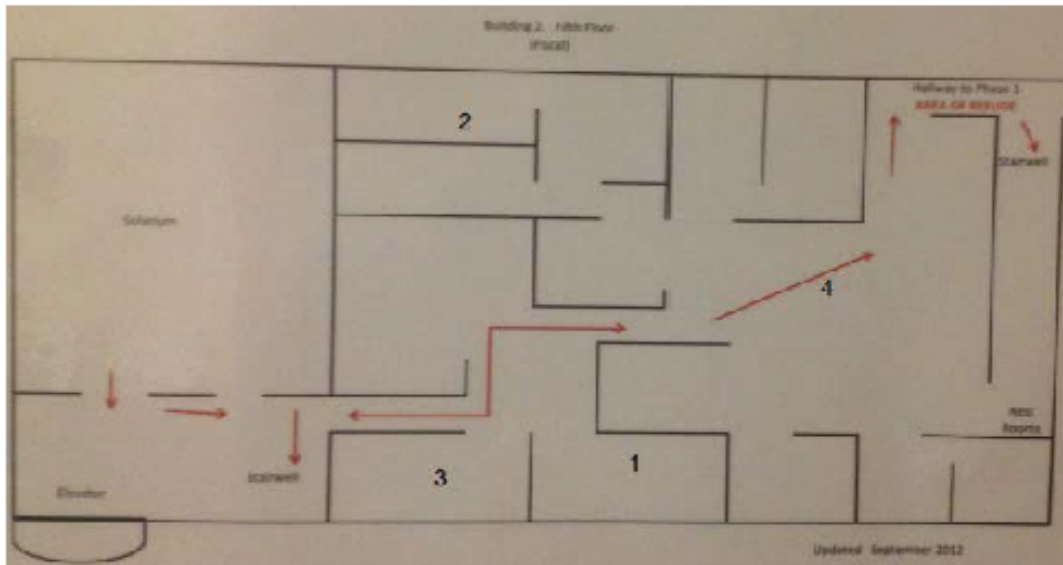
ID	Exposure Rate ($\mu\text{R/hr}$)	Remarks
2-3-1	14	None
2-3-2	6	None
2-3-3	5	None
2-3-4	7	None
2-3-5	20	Measurement collected on the floor
2-3-6	5	None
2-3-7	9	None
2-3-8	26	Measurement made near the ceiling; suspected shine from Fatherhood (ID 2-4-1)
2-3-9	43	Measurement made near the ceiling; suspected shine from Fatherhood (ID 2-4-1)
2-3-10	15	None
2-3-11	5	None

Fourth Floor, Phase II



ID	Exposure Rate ($\mu\text{R/hr}$)		Remarks
	Contact	1 m	
2-4-1	270	42	Contact measurement was made on the floor
2-4-2	110	25	Contact measurement was made on the pillar
2-4-3	45	12	Contact measurement was made on the floor
2-4-4	--	9	None
2-4-5	--	9	None
2-4-6	--	6	None
2-4-7	--	10	None
2-4-8	--	5	None
2-4-9	--	6	None

Fifth Floor, Phase II



ID	Exposure Rate ($\mu\text{R/hr}$)	Remarks
2-5-1	5	None
2-5-2	6	None
2-5-3	8	None
2-5-4	4	None

APPENDIX C
RADON MEAUREMENTS AT THE NOW SITE

E-PERM Radon Measure Data for NOW at the Former Waterbury Clock Company

Site: 232 N. Elm St (NOW), Waterbury, Conn.

Purpose: Scoping

Deployed by: T. Jackson (NRC)/N. Altic (ORAU)

Proj: 5289 Radium Program

Electret Reader S/N: 0540

Collected by: O. Bailey (NRC)/N. Altic (ORAU)

Loc. No	Location	E-PERM Serial No.	Deployment Date & Time	Retrieval Date & Time	Days	Voltage (Volts)		Exp. Rate (µR/hr)	CF	Radon Conc. (pCi/L)	
						Initial	Final			Loc.	Avg.
1	3rd floor Next to T. Hirst's office	SJM 767	12/16/16 17:10:00	12/18/16 17:22:00	2.01	768	752	20.0	2.134	2.0	2.2
2	Dup of 1	SJM 764	12/16/16 17:10:00	12/18/16 17:22:00	2.01	769	751	20.0	2.134	2.4	
3	5th Flr. "Rec Rm" Ph I	SJM 649	12/16/16 17:20:00	12/18/16 17:32:00	2.01	766	747	11.5	2.132	3.4	3.7
4	Dup of 3	SJM 730	12/16/16 17:20:00	12/18/16 17:32:00	2.01	776	754	11.5	2.137	4.1	
5	5th floor hot spot <i>closed</i>	SJM 709	12/16/16 NA	12/18/16 17:33:00	N/A	775	754	3,500	2.137	N/A	N/A
6	4th fl. Madre Latina	SJM 691	12/16/16 17:38:00	12/18/16 17:52:00	2.01	761	752	17.0	2.132	0.6	0.7
7	Dup of 6	SJM 814	12/16/16 17:38:00	12/18/16 17:52:00	2.01	768	758	17.0	2.136	0.8	
8	Rm 426 W. End	SJM 736	12/16/16 17:49:00	12/18/16 17:48:00	2.00	775	763	20.0	2.139	1.0	0.5
9	Dup of 8	SJM 653	12/16/16 17:49:00	12/18/16 17:48:00	2.00	765	758	20.0	2.135	-0.1	
10	Rm 426 E. End	SJM 761	12/16/16 17:53:00	12/18/16 17:50:00	2.00	772	763	15.0	2.138	0.8	1.0
11	Dup of 10	SJM 611	12/16/16 17:53:00	12/18/16 17:50:00	2.00	777	766	15.0	2.141	1.2	
12	<i>Blank @ 8 and 9</i>	SJM 633	12/16/16 18:02:00	12/18/16 17:48:00	1.99	767	766	20.0	2.138	N/A	
13	4th fl. W.End Waiting Rm	SJM 818	12/16/16 18:11:00	12/18/16 17:42:00	1.98	766	756	13.5	2.135	1.2	1.0
14	Dup of 13	SJM 796	12/16/16 18:11:00	12/18/16 17:42:00	1.98	755	746	13.5	2.129	0.9	
15	Phase II 4th Floor Farther Hood	SJM 710	12/16/16 18:22:00	12/18/16 17:55:00	1.98	775	764	13.5	2.140	1.4	2.3
16	Dup of 15	SJM 738	12/16/16 18:22:00	12/18/16 17:55:00	1.98	772	753	13.5	2.136	3.3	
17	5th fl. Phase 1 ; center	SJM 663	12/16/16 19:03:00	12/18/16 17:36:00	1.94	768	761	7.5	2.137	1.0	0.8
18	Dup of 17	SJM 606	12/16/16 19:03:00	12/18/16 17:36:00	1.94	766	761	7.5	2.136	0.5	
19	5th Fl Phase 1 ; W. End	SJM 640	12/16/16 19:12:00	12/18/16 17:39:00	1.94	763	754	8.0	2.133	1.5	1.2
20	Dup of 19	SJM 628	12/16/16 19:12:00	12/18/16 17:39:00	1.94	766	759	8.0	2.136	1.0	
21	4th Fl. Phase 1 ; center	SJM 690	12/16/16 19:27:00	12/18/16 17:45:00	1.93	757	749	7.0	2.130	1.3	1.1
22	Dup of 21	SJM 803	12/16/16 19:27:00	12/18/16 17:45:00	1.93	764	758	7.0	2.135	0.8	
23	3rd fl. Center, kitchen	SJM 825	12/16/16 19:36:00	12/18/16 18:05:00	1.94	777	775	5.5	2.143	0.0	1.1
24	Dup of 23	SJM 662	12/16/16 19:36:00	12/18/16 18:05:00	1.94	780	769	5.5	2.142	2.1	
25	1st floor; Phase 1; W.end	SJM 667	12/16/16 19:45:00	12/18/16 18:08:00	1.93	784	780	6.0	2.147	0.4	1.0
26	Dup of 25	SJM 835	12/16/16 19:45:00	12/18/16 18:08:00	1.93	768	759	6.0	2.136	1.6	
27	3rd floor Ph 1; W.End	SJM 757	12/16/16 19:53:00	12/18/16 18:03:00	1.92	761	757	7.0	2.134	0.3	0.1
28	Dup of 27	SJM 907	12/16/16 19:53:00	12/18/16 18:03:00	1.92	755	753	7.0	2.131	-0.2	
29	3rd floor Ph1; center	SJM 744	12/16/16 20:00:00	12/18/16 18:02:00	1.92	771	764	5.0	2.138	1.2	0.9
30	Dup of 29	SJM 892	12/16/16 20:00:00	12/18/16 18:02:00	1.92	768	764	5.0	2.138	0.5	
31	3rd floor Ph 1; E.End	SJM 688	12/16/16 20:04:00	12/18/16 18:00:00	1.91	781	776	7.0	2.145	0.6	0.9
32	Dup of 31	SJM 677	12/16/16 20:04:00	12/18/16 18:00:00	1.91	771	763	7.0	2.138	1.3	
33	2nd floor Ph II; HR; <i>Blank</i>	SJM 641	12/16/16 20:12:00	12/18/16 18:12:00	1.92	771	775	5.0	2.142	N/A	0.8
34	Same as 33	SJM 782	12/16/16 20:12:00	12/18/16 18:12:00	1.92	762	757	5.0	2.134	0.8	
35	Dup of 34	SJM 675	12/16/16 20:12:00	12/18/16 18:12:00	1.92	761	756	5.0	2.133	0.8	
36	1st fl Ph II in the office	SJM 824	12/16/16 20:25:00	12/18/16 18:16:00	1.91	775	763	9.0	2.139	2.1	2.6
37	Dup of 36	SJM 811	12/16/16 20:25:00	12/18/16 18:16:00	1.91	770	754	9.0	2.135	3.1	