UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 10, 2017

Mr. Robert Potter
Lead Property Manager
West Michigan Field Office
Michigan Property Management
Operations Branch
GSA/PBS Northern Service Center
Operations Division
74 North Washington Ave, Room 2-1-6
Battle Creek, Michigan 49037

SUBJECT: BATTLE CREEK SANITARIUM – 1, 2, AND 3—RESULTS AND CONCLUSIONS OF THE U.S. NUCLEAR REGULATORY COMMISSION'S INITIAL SITE VISIT

Dear Mr. Potter:

I am writing to provide you with the results of the U.S. Nuclear Regulatory Commission (NRC) staff's initial site visit to the property at 74 North Washington Avenue, Battle Creek, Michigan, performed March 3-5, 2017. The purposes of the initial site visit were to: 1) determine if there are health and safety concerns to current property occupants or site visitors; and 2) identify the locations with the potential for contamination and gather information for a scoping survey plan, should it be needed. The results of the initial site visit are summarized below and are discussed in further detail in the enclosed report.

During NRC staff's initial site visit, the inspection team was granted access to an estimated 75 percent of the total facility footprint. Of that percentage, about half (33 percent of the total footprint) was surveyed. Our ability to survey the other portions was limited because it was covered by office equipment.

No radium contamination was found over nearly all of the areas of your building that we surveyed. However, one small isolated location in Building 2, level 1, was found that exhibited characteristics consistent with a discrete source of radium-226. In the area where we identified elevated radiation levels, we conducted additional measurements to test for transferable contamination. Data collected from the area of elevated measurement shows that there is no removable surface contamination in that area.

None of the contamination identified exceeds the NRC's dose limit of 25 millirem per year for unrestricted use in Title 10 of the *Code of Federal Regulations* Section 20.1402. Therefore, based on the results of this site visit, a follow-up scoping survey was determined to not be necessary. This is discussed in further detail in the enclosed report.

Although not required, should you wish to cleanup the identified area, we suggest that you consider consulting with an NRC or Agreement State licensed service provider to minimize the spread of any radiological contamination. Please be aware that activities at your site may also be subject to State requirements and standards.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions concerning this letter, please contact Mr. Stephen Koenick, Chief, Materials Decommissioning Branch, Division of Decommissioning, Uranium Recovery and Waste Programs, Office of Nuclear Materials Safety and Safeguards, at (301) 415-6631, or Mr. Jeffrey Whited, Project Manager, at (301) 415-4090.

Sincerely,

/RA/

John R. Tappert, Director
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket Nos.: 03038940, 03038941, and 03038942

Enclosure:
Site Status Report for the Battle Creek Sanitarium (74 North Washington Avenue)

REGISTERED LETTER – RETURN RECEIPT REQUESTED

SUBJECT: BATTLE CREEK SANITARIUM – 1, 2, AND 3—RESULTS AND CONCLUSIONS OF THE U.S. NUCLEAR REGULATORY COMMISSION'S INITIAL SITE VISIT

DISTRIBUTION:
RidsRgn3MailCenter M. Kunowski, RIII B. Lin, RIII J. Whited, NMSS

ADAMS Accession No.: ML17080A446 ***via e-mail**

OFFICE	DUWP/MDB/PM	DUWP/LA	DUWP/MDB	DUWP/MDB
NAME	JWhited	CHolston	CGrossman*	RNelson*
DATE	03/27/2017	03/22/2017	06/08/2017	06/16/2017
OFFICE	RIII/DNMS/BC	DUWP/MDB/BC	OGC (NLO)	DUWP
NAME	MKunowski*	SKoenick	AWase*	JTappert
DATE	07/06/2017	08/31/2017	08/28/2017	10/10/2017

OFFICIAL RECORD COPY

Enclosure

OAK RIDGE ASSOCIATED UNIVERSITIES:

SITE STATUS REPORT FOR THE BATTLE CREEK SANITARIUM AT 74 NORTH WASHINGTON AVENUE, BATTLE CREEK, MICHIGAN

October 10, 2017

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) requested that the Oak Ridge Associated Universities (ORAU) perform a radiation survey of the property at 74 N. Washington Avenue in Battle Creek, Michigan. This property contains a structure that was once part of the former Battle Creek Sanitarium, which provided radium therapy to patients in the early 1900s. The objective of this survey was to locate possible discrete sources of radium, if any, that would be associated with the former Battle Creek Sanitarium operations.

ORAU performed the radiation survey of the building interiors and exterior land areas on March 3-5, 2017, and identified one area with elevated levels of radiation due to radium-226 on the first floor in Building 2. Based on the elevated levels of radiation that were identified associated with radium-226, ORAU concluded that a discrete source of radium is present. The NRC inspector communicated to the site contact during the close-out meeting that direct contact with the elevated area should be limited.

SITE STATUS REPORT

Property: Battle Creek Sanitarium – 1, 2, and 3
74 N. Washington Avenue
Battle Creek, MI 49037

Docket Number: 03038940, 03038941, and 03038942

Current Property Name(s): Hart-Dole-Inouye Federal Center

Current Property Owner(s): United States General Services Administration

Inspection Dates: March 3-5, 2017

Inspector(s): Matthew Learn, Bill Lin, and Mike Kunowski/ U.S. Nuclear Regulatory Commission (NRC), supported by Nick Altic, Teresa Brown, and Kaitlin Engel/ 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 NRC is evaluating properties where Oak Ridge National Laboratory's (ORNL) review of historical information has identified Ra-226 use. The property at 74 N. Washington Avenue in Battle Creek, Michigan, was identified as the former Battle Creek Sanitarium. The sanitarium, which operated from 1866 to 1942, had used Ra-226 in their patient treatments beginning in the early 1900s (ORNL 2015). The objectives of the initial site visit were to determine if discrete sources of Ra-226 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 scoping survey is needed. Surveys were performed as described within NRC's procedure, Temporary Instruction (TI) 2800/043, "Inspection of Facilities Potentially Contaminated with Discrete Radium-226 Sources" (NRC 2016).

Data collected during the March 3-5, 2017, site visit, which included gamma radiation scans and exposure rate measurements, are used to plan future actions that may be needed to reduce Ra-226 exposure 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 TI 2800/043.

2.0 PROPERTY DESCRIPTION AND INITIAL SITE VISIT CONSIDERATIONS

2.1 Property Description and History

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. As of November 2015, current levels of radium are unknown (ORNL 2015).

The Battle Creek Sanitarium, a facility that used Ra-226 in their patient treatments, was located at 74 N. Washington Avenue in Battle Creek, Michigan. The facility was originally named the

Western Health Reform Institute of Battle Creek; the name was changed to Battle Creek Sanitarium in 1876. A fire in 1902 destroyed the property, and a new structure was built in 1903. In 1911, the Radium Institute of the Battle Creek Sanitarium was established and provided radium and all accessory appliances for radium therapy, a supply of radium needles for direct contact treatment, and radium loans to physicians. In 1928, a 14-story tower was built, adjacent to the main sanitarium, that housed hotel-like guest rooms. In 1942, the entire facility was purchased by the U.S. Army and became the Percy Jones General Hospital. In 1953, the Percy Jones General Hospital closed and a year later became the Battle Creek Federal Center. In 1997, the Federal Center underwent extensive renovations—fire safety upgrades, new heating and air system, electrical work, removal of asbestos, enhanced telecommunications and power supplies, sprinkler systems, new roofing, and improvements to the mechanical infrastructure. The facility became known as the Hart-Dole-Inouye Federal Center in 2003.

Figure 1 shows an aerial view of the site. The main sanitarium building (Building 2) has a rectangular footprint with three wings radiating out from the main block (Buildings 2A, 2B, and 2C). The 14-story tower is Building 1, and Building 1A was the sanitarium's dining room. The interior of the buildings are mainly composed of drywall-covered walls and carpeted floors in the work areas or tile floors in the bathrooms, lobby, and tunnels. The majority of the space, however, is occupied with cubicles, individual offices, or conference rooms with drywall and carpeting. None of the space is used for residential purposes. The facility interior contains approximately 45,000 square meters in floor space, and the surrounding land area covers approximately 74,000 square meters. The site's exterior has not been altered substantially (ORNL 2015). The land area surrounding the buildings is mainly asphalt, concrete, or stones with areas of grass and mulch. The exterior of the buildings contain multiple types of brick and mortar.

2.2 Initial Site Visit Considerations

The buildings contain approximately 45,000 square meters of floor space, and surveys were limited to non-business hours. Prior to commencing surveys, the general layout of the building was examined for consistency with historical information and to identify impediments to conducting the survey and/or health and safety considerations—none were identified. The buildings have been extensively renovated with little of the original materials still present. Much of the floor space contains cubicles and office equipment, which limited access to surfaces. Some areas of the facility were locked and therefore inaccessible. In the time available for the initial site visit, the inspection team focused on areas that represented the highest probability of containing discrete sources of radiation. The buildings that have the highest potential for elevated levels of radiation due to Ra-226 are the former radium treatment rooms located in Buildings 2, 2A, 2B, and 2C. The use of Ra-226 is unknown in Building 1 and 1A, but is not expected to have occurred often, if at all. Building 1 and 1A were built in 1928, when it was known that uncontrolled use of Ra-226 was hazardous and its use was on the decline. In the basement areas, focus was given to any floor drains or exposed older piping that appeared to be from the period of known Ra-226 use. In the land area outside the building, focus was given to the grassy areas around the building and any drains or low lying areas. Therefore, the approach was to cover as much accessible space as possible within the Building 2 complex, where discrete sources of Ra-226 would most likely be found, but also cover Buildings 1 and 1A, and exterior surfaces, as time allowed.

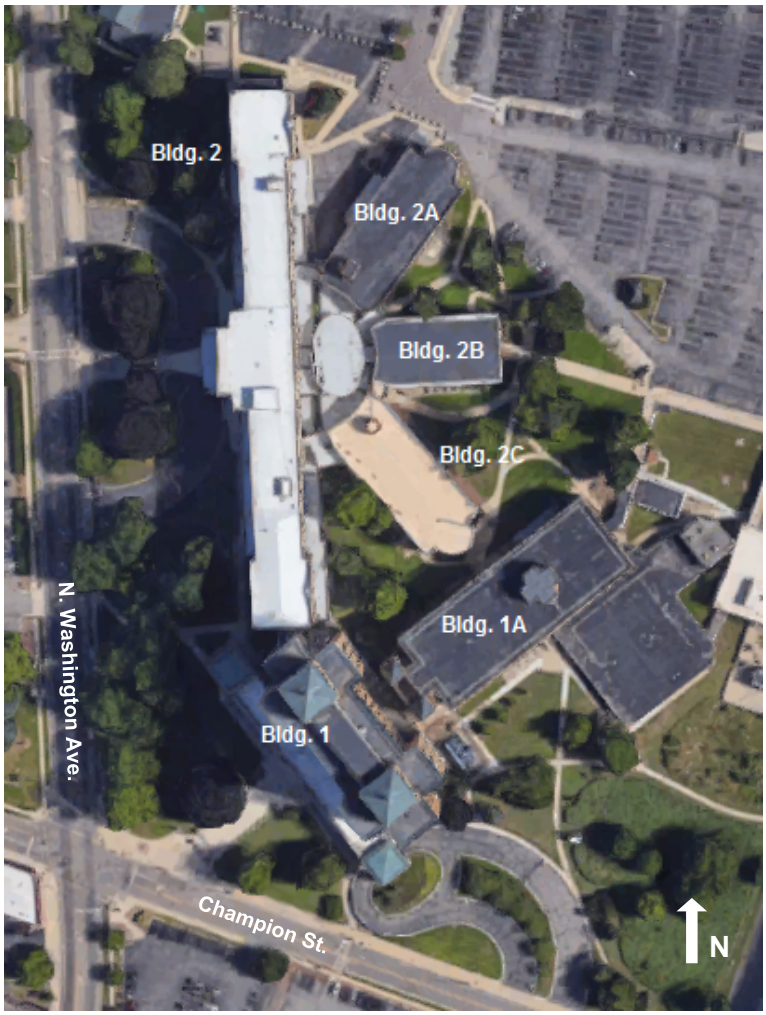


Figure 1. Former Battle Creek Sanitarium Facilities.
Building 1 – Original tower addition with 1A wing
Building 2 – Original Battle Creek Sanitarium with three wings, 2A, 2B, 2C

3.0 SITE OBSERVATIONS AND FINDINGS

3.1 Summary of Activities

The inspection team conducted radiological survey activities during the initial site visit to the N. Washington Avenue property from March 3 through March 5, 2017. A pre-inspection meeting was held with Nick Altic, Teresa Brown, and Kaitlin Engel (ORAU); Matthew Learn, Bill Lin, and Mike Kunowski (NRC); and Rob Potter and Pete Noot (site).

Radiological surveys performed by the inspection team consisted of gamma radiation scans within the facility using a Ludlum model 44-10 2-inch by 2-inch (2x2) 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

NaI-based microRoentgen (μR) ratemeter[1]. Field gamma spectrum measurements were made with a SAM-940 gamma spectrum analyzer. Gamma radiation scans and dose rate measurements were also performed of the surrounding land area. Table 1 presents the specific instruments used during the site visit. Smear samples were also collected at select locations to quantify the removable surface activity levels.

Table 1. Battle Creek Sanitarium Survey Instruments

Radiation Type (units)	Detector Type	Detector (Number)	Ratemeter (Number)
Alpha-plus-beta (cpm)	Plastic Scintillator[a]	44-142 (688) 44-142 (689) 44-142 (690)	2221 (693) 2221 (1036) 2221 (602)
Gross gamma (cpm)	Sodium Iodide	44-10 (663) 44-10 (1151) 44-10 (1152)	2221 (1036) 2221 (693) 2221 (602)
Gross gamma exposure meter (μR/h)	Sodium Iodide	192 (1127) 192 (1128) 192 (1129)	N/A
Gamma Spectrum Analyzer (SAM-940)	Lanthanum Bromide	940 (40272)[b]	N/A

Number = ORAU equipment barcode
N/A = not applicable
cpm = counts per minute
μR/h = microRoentgen per hour
[a]Though traditionally used for beta radiation detection, ORAU has calibrated the detector for quantifying the detector response to both alpha and beta radiation.
[b]Device performs automatic calibration upon startup and is source checked before use.

Summary of Daily Activities – March 3, 2017:

At the completion of the pre-inspection meeting, the inspection team split into three survey teams. Survey activities began in Building 1 around 18:00. Building levels 3, 4, 5, 7, 8, 9, 11, 12, and 13 were surveyed. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters. No discrete areas of elevated radiation were found. The inspection team departed the site around 21:00.

Summary of Daily Activities – March 4, 2017:

The three survey teams began surveys in Building 1 around 09:30 and included levels 6, 10, and 14. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters. No discrete areas of elevated radiation were found. Survey teams proceeded to Building 2 to survey basement level 1 (B1) and levels 1, 2, 3, 4, 5, and 6. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters. One discrete area of elevated radiation was found on the west wall in Room 2-1-6 on level 1 in Building 2. When scanned, the detector reading at the location exceeded 40 μR/h on contact but did not exceed

[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).

the action level (AL) of 40 µR/h at the nearest occupied area. Further, the detector reading was at background levels when measuring 1 meter from the location. A direct measurement, smear sample, and gamma spectrum were collected at the area. Survey teams moved to level 2 of Building 1A and performed gamma radiation scans with the 2x2 sodium iodide detector and exposure meters. No discrete areas of elevated radiation were found on level 2 of Building 1A. The inspection team departed the site around 18:15.

Summary of Daily Activities – March 5, 2017:

One survey team continued survey activities in Building 2, level 1 around 09:30. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters, and no other discrete areas of elevated radiation were found. The other two survey teams performed surveys in Building 1, levels 1 and 2. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters, and no discrete areas of elevated radiation were found. Survey teams proceeded to Building 2C to survey basement level 1 (B1) and levels 1, 2, and 3. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters, and no discrete areas of elevated radiation were found in Building 2C. Survey teams then proceeded to Building 2A to survey levels B1, 1, 2, and 3. All accessible areas were surveyed, and no discrete areas of elevated radiation were identified. All survey teams conducted surveys of the land area surrounding the buildings with focus given to grassy/mulch areas around the buildings and drains. No discrete areas of elevated radiation were identified. Survey teams moved back inside the building to survey Building 1A ground level 1 (G1), B1, and B2 and Building 2B level B1 and the tunnel between Buildings 2B and 2A. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters. One discrete area of elevated radiation was found on the floor of level B2 in Building 2B, but was less than the AL of 40 µR/h on contact. A gamma spectrum was collected of the area, but the activity level was too low to identify specific radionuclides, or to determine whether the elevated radiation is due to naturally occurring radioactive material (NORM), i.e., bricks and tile. No other discrete areas of elevated radiation were identified. Survey teams then proceeded to Building 1 levels G1 and B1 and Building 2B levels 1 and 2. All accessible areas were scanned with the 2x2 sodium iodide detector and exposure meters, and no discrete areas of elevated radiation were identified. The inspection team departed the site around 19:00.

3.2 Summary of Results

The inspection team was granted access to an estimated 75 percent of the total facility footprint. Of that percentage, about half was surveyed during the initial site visit. Much of the accessible space contained tables, chairs, desks, equipment, etc. that precluded direct survey and higher overall coverage percentages. Therefore, a conservative estimate is that the initial site covered approximately 33 percent of the total facility footprint. Areas that were inaccessible included rooms marked “authorized personnel only,” rooms that were undergoing renovation, and locked rooms. Table B-1 presents the building- and floor-specific coverages used to produce these estimates.

The results for each building/area are discussed below. Appendix B presents the tabulated results. Table B-1 presents 2x2 sodium iodide detector gross responses in cpm and gross exposure rate measurements in µR/h that were collected at 1 meter, or approximately waist height. These exposure rate values include background contributions. Table B-2 provides the total and removable alpha-plus-beta surface activity results in units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2). The alpha-plus-beta static measurements 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) = 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:

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

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 alpha and low-energy beta particles, 0.5 for high-energy beta particles) for n^{th} emission

Appendix A provides a photo of the discrete elevated area found in Building 2, level 1, Room 2-1-6.

Building 1. In addition to continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 666 locations in Building 1. Floor-by-floor scan coverage ranged from 20 to 90 percent of accessible floor space (see Appendix B). In Building 1, on average each level had one to two rooms (likely closets) that were inaccessible. The 2x2 sodium iodide detector responses ranged from 5,000 to 18,000 cpm in Building 1, level B1 and levels 1 through 15. The direct gamma radiation counts observed varied based on proximity with materials known to contain NORM. Exposure rates varied similarly depending on proximity to NORM, with a range from 4 to 15 µR/h at 1 meter. These results are expected for NORM in this configuration, and no discrete areas of elevated radiation were encountered in Building 1. Therefore, no locations were selected for direct measurements or smears.

Building 1A. In addition to continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 57 locations in Building 1A. Floor-by-floor scan coverage ranged from 10 to 30 percent of accessible floor space (see Appendix B). Over half of the basement, B1, was inaccessible with rooms locked and posted to limit entry to authorized personnel only. Half of the second level in Building 1A was open to the dining room below. The 2x2 sodium iodide detector responses ranged from 6,700 to 16,000 cpm in Building 1A on levels B2, B1, G1 and levels 1 through 2. Gamma radiation in these areas also varied based on proximity to NORM-containing brick and tile materials of construction. Exposure rates also varied depending on proximity to NORM and configuration, with a range from 6 to 14 µR/h at 1 meter. No discrete areas of elevated radiation were encountered in Building 1A, and no locations were selected for direct measurements or smears.

Building 2. In addition to continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 331 locations in Building 2. Floor-by-floor scan coverage ranged from 20 to 75 percent of accessible floor space (see Appendix B). In Building 2, nine rooms on level B1, 12 rooms on level 1, four rooms on level 2, two rooms on level 4, one room on level 5, and two rooms on level 6 were inaccessible either due to renovations or locked. The 2x2 sodium iodide detector response ranged from 7,500 to 33,000 cpm in Building 2, B1 and levels 1 through 6 and varied based on proximity to NORM (i.e., red bricks). Exposure rates ranged from 5 to 26 µR/h at 1 meter and varied similarly depending on proximity to NORM. One discrete location of elevated radiation was identified on level 1 with a 2x2 sodium iodide detector response up to 80,000 cpm and a gross exposure rate of 100 µR/h on contact compared to a general area background of 11,000 cpm and 8 µR/h, respectively. The area producing the elevated radiation was less than 100 cm^2 in size. Because this location exceeded 40 µR/h on contact, both a direct measurement and smear were collected. The direct measurement result was 21,000 dpm/100 cm^2, and the smear result was below the minimum detectable concentrations (MDCs) for removable alpha and beta activity. A gamma spectrum was collected at the location, and Ra-226 was identified (see Appendix B). Surveyors slowed the survey pace to increase coverage of the first level after the elevated area was found—no additional anomalous radiation measurements were collected. The finding was discussed with facility personnel.

Building 2A. In addition to continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 181 locations in Building 2A. Floor-by-floor scan coverage ranged from 20 to 40 percent of accessible floor space (see Appendix B). Approximately one third of level B1 in Building 2A was inaccessible with rooms locked and posted to limit entry to authorized personnel only. Other levels had one to two rooms (closets) that were inaccessible. The 2x2 sodium iodide detector response ranged from 4,500 to 13,000 cpm in Building 2A, B1 and levels 1 through 3. Gamma radiation varied based on proximity to NORM (i.e., containing red bricks). Exposure rates varied similarly depending on proximity to and configuration with NORM, with a range from 3 to 12 µR/h at 1 meter. No discrete areas of elevated radiation were encountered in Building 2A, and no locations were selected for direct measurements or smears.

Building 2B. In addition to continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 34 locations in Building 2B. Floor-by-floor scan coverage ranged from 20 to 50 percent of accessible floor space (see Appendix B). In Building 2B, level 2 is a balcony open to level 1 and two rooms in the basement and two rooms on Level 1 were inaccessible (locked) and the site escort did not have access. The 2x2 sodium iodide detector response ranged from 6,000 to 17,000 cpm in Building 2B, level B1 and levels 1 through 2 and also varied based on proximity to NORM (i.e., red bricks). Exposure rates varied similarly depending on proximity to NORM, with a range from 5 to 16 µR/h at 1 meter. One discrete location of elevated radiation was identified on the B1 level with a 2x2 sodium iodide detector response up to 26,000 cpm and an exposure rate of 26 µR/h on contact compared to a general area background of 9,000 cpm and 8 µR/h, respectively. The area was less than 100 cm^2 in size. Since the exposure rate was very small and less than 40 µR/h on contact, a direct measurement and smear were not collected. A gamma spectrum was collected of the area, but the activity level was too low to identify specific radionuclides, or to determine whether the elevated radiation is due to NORM.

Building 2C. In addition to the continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 139 locations in Building 2C. Floor-by-floor scan coverage ranged from 20 to 40 percent of accessible floor area (see Appendix B). In Building

2C, half of level B1 and two to four rooms on levels 2 and 3 each were locked. The 2x2 sodium iodide detector response ranged from 4,500 to 15,000 cpm in Building 2C, level B1 and levels 1 through 3, varying based on proximity to NORM (i.e., red bricks). Exposure rates varied similarly depending on proximity and configuration to NORM, with a range from 3 to 15 µR/h at 1 meter. No discrete areas of elevated radiation were encountered in Building 2C, and no locations were selected for direct measurements or smears.

Land Area. In addition to continuous scanning, discrete 2x2 sodium iodide detector and exposure measurements were collected at 38 outdoor locations across the land area. Scan coverage ranged from 10 to 20 percent of accessible grassy areas surrounding the buildings (see Appendix B). The 2x2 sodium iodide detector response ranged from 6,000 to 20,000 cpm in the land area, varying based on proximity to NORM (i.e., building exterior wall bricks and landscaping rocks). Exposure rates ranged from 5 to 16 µR/h at 1 meter, also varying with proximity to NORM and in direct proportion to 2x2 sodium iodide detector measurements. No discrete areas of elevated radiation were encountered in the land area, and no soil samples were collected for analysis.

Facility Summary. It is estimated that about 75 percent of the facility was generally accessible and about 33 percent of the total floor space was surveyed during the initial site visit. Based on this estimate, the inspection team collected radiation measurement data over approximately 15,000 m^2, including almost 1,450 discrete measurement locations across the facility in addition to observations made during continuous scanning. This extensive effort identified one small isolated location in Building 2 level 1 that exhibited characteristics consistent with a discrete source of Ra-226. A second area of elevated activity in Building 2B, level B1 produced significantly lower radiation levels than that from Building 2 and is not considered further.

3.3 Summary of Dose Assessment Results

To date, a site-specific dose assessment has not been performed for the Battle Creek Sanitarium site. However, contamination identified in Building 2 during the initial site visit must be considered to assess potential doses to current and potential future occupants. Temporary Instruction 2800/043 presents an AL that correlates to 100 mrem/yr for a worker (1-meter measurement of 40 µR/h above background). This AL accounts for gamma exposure alone and may be used to quickly identify radiation levels that could conservatively produce a dose above the public limit in Title 10 of the *Code of Federal Regulations* (10 CFR) Section 20.1301. Contamination was identified on the first floor in Building 2, which is configured for industrial use, thus the 40 µR/h AL applies. While no individual works within one meter of the location, it is conceivable that workspace reconfiguration could result in routine exposures within a 1-m radius.

Background exposure rate levels vary based on the proximity to NORM-containing materials such as brick and ceramic tile. Results generally fell in the 4-16 µR/h range, and although up to 26 µR/h was observed near brick walls, an average of 10 µR/h is assumed for the site as a whole. Therefore, a gross 1-meter measurement of 50 µR/h is required to exceed the industrial AL. The maximum 1-meter measurement found on the property was 26 µR/h (does not exceed the AL). Therefore, external exposure measurements suggest that potential doses would not, based on external gamma radiation alone, exceed NRC's 100 mrem/yr public dose limit specified in 10 CFR 20.1301. Moreover, the external exposure rates in the area of elevated measurement identified in Building 2, as indicated in Table B-2, fall to 10 µR/h at one meter, consistent with average background for the facility. The observed external exposure rate in the area of elevated measurement, like the maximum observed exposure rate, suggests that

potential doses would not, based on external gamma radiation alone, exceed NRC's public dose limit.

Consideration of external exposure pathways alone is appropriate at this site because other exposure pathways are not expected to be significant contributors. Smear data from the area of elevated measurement shows a lack of removable surface contamination (see Table B-2), suggesting secondary ingestion and inhalation pathways are not expected to be significant contributors to dose. Smear data indicate that the existing removable contamination (<<1 percent removable) is much less than the percentage assumed in typical screening analyses for an industrial building occupant screening scenario (i.e., 10 percent). Thus, the elevated alpha-plus-beta measurement of 21,000 dpm/100 cm^2, which is highly localized ($\leq$ 100 cm^2) and, based on smear data, is fixed and is unlikely to produce an unacceptable dose under current-use conditions. The lack of removable activity suggests that modeled values, such as those derived using DandD (NRC 2001), will be limited to the external gamma pathway and actual measurements are preferred over modeled data.

In addition, the condition of the room, as depicted in Figure A-1, suggests that the location with the elevated radiation levels may have recently been renovated, or at least recently painted, and it is possible that the material producing elevated gamma radiation is behind the wall, which would be consistent with the observed lack of removable activity.

Due to the lack of removable activity, these data are also suitable to assess whether future occupants may receive a dose in excess of the 25 mrem/yr limit for unrestricted use in 10 CFR 20.1402. Because the area of elevated exposure rate is highly localized ($\leq$ 100 cm^2) rather than uniformly distributed over a large portion of the surface, it is not likely that average members of the critical group for a worker occupant scenario would spend a significant portion of their occupancy within 1 meter of the localized contamination. Exposure rates are lower throughout the rest of the building, indicating that measured radiation levels throughout accessible portions of the building would not produce a dose above the 25 mrem/yr unrestricted dose limit.

4.0 OBSERVATIONS AND RECOMMENDATIONS

Based on the data collected, the former Battle Creek Sanitarium property contains one discrete source of Ra-226, but not at concentrations that would result in a dose in excess of regulatory requirements. It is uncertain, however, whether the entire property satisfies dose limits given about 25 percent of the facility was not accessible during the site visit, and the inaccessible portions included large contiguous blocks of floor space. This and other observations are summarized as follows:

- Elevated direct gamma radiation due to Ra-226 was identified at one location on the first level of Building 2, Office 2-1-6, which is the Building with the highest potential for containing discrete sources of Ra-226.
    - The exposure rate value at this location is significantly above background on contact, but does not exceed the 40 µR/h at 1 meter from the surface AL specified in the TI. Facility personnel were informed of this finding.
    - Elevated total alpha-plus-beta activity levels were also present at the Building 2, Office 2-1-6 location, but there was a lack of removable contamination.

- This location represents 1 of over 330 discrete measurement locations within Building 2 (the building with the highest potential for Ra-226 contamination), or 1 of almost 1,450 discrete measurement locations across the entire facility. However, several blocks of Building 2 and Building 2C were inaccessible during the initial site visit.

- Historical data are not available for the Battle Creek Sanitarium, therefore these findings are presumed representative of overall site conditions. Particularly given the redevelopment history of the site.

- The doses to current or possible future receptors, from the small area of elevated activity on the wall of Building 2, level 1 is unlikely to exceed either the 100 mrem/yr or the 25 mrem/yr limits for industrial scenarios.

- The level of coverage achieved, and number of measurements collected, during the initial site visit are arguably at or in excess of that which would be achieved during a scoping survey. Therefore, a follow-up scoping survey in those covered during the initial site visit would likely add little new information to the record presented herein.

Based on these observations, it is recommended that the NRC not perform a follow-up scoping survey at the former Battle Creek Sanitarium. The rationale is that the initial site visit already generated a robust dataset that meets the scoping survey purpose: to identify the general level and extent of contamination.

5.0 REFERENCES

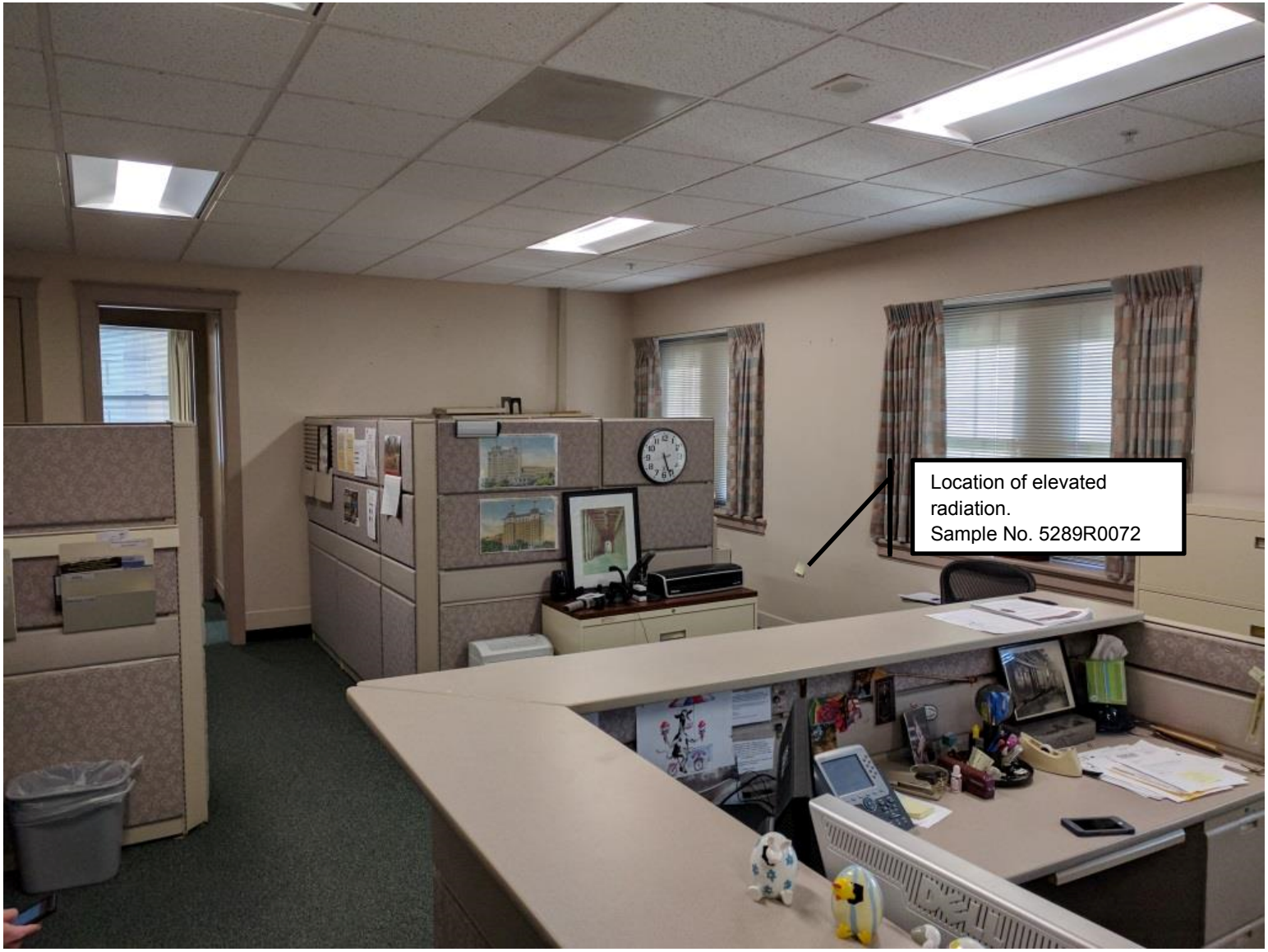
NRC 2001. *Residual Radioactive Contamination from Decommissioning – User's Manual DandD*. Version 2.1. NUREG/CR-5512, Vol. 2, U.S. Nuclear Regulatory Commission, April.

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

ORNL 2015. *Historical Non-Military Radium Sites Research Effort Addendum*, "Battle Creek Sanitarium: Site Summary," Pgs. 15-23, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 24. (ADAMS Accession No. ML16291A488).

APPENDIX A

PHOTO FROM THE BATTLE CREEK SANITARIUM SITE VISIT



A-1. Office 2-1-6 on the First Floor of Building 2 (looking approximately southwest)

APPENDIX B

SURVEY RESULTS FROM THE BATTLE CREEK SANITARIUM SITE VISIT

Table B-1. Battle Creek Measurements Summary					
Building No.	Floor No.	Gamma Ranges		Scan Coverage (%)	Number of Measurement Locations
		cpm at contact[a]	µR/hr at 1 meter[b]		
1	B1	7,000 - 18,000	6 - 15	30-40	44
1	G1	6,500 - 13,000	5 - 11	30-40	66
1	1	6,500 - 14,000	5 - 13	30-40	41
1	2	6,000 - 11,000	5 - 11	30-40	56
1	3	5,500 - 12,000	4 - 10	20-30	7
1	4	6,500 - 10,000	5 - 14	20-30	5
1	5	7,600 - 13,000	5 - 12	20-30	5
1	6	6,200 - 9,500	5 - 8	20-40	16
1	7	5,700 - 13,000	5 - 12	35-40	79
1	8	6,000 - 13,000	5 - 12	30-40	95
1	9	6,400 - 17,000	5 - 11	30-40	73
1	10	6,000 - 13,000	5 - 11	30-40	97
1	11	5,000 - 12,000	4 - 11	40	26
1	12	6,000 - 14,000	4 - 10	40	27
1	13	7,000 - 14,000	5 - 12	40	23
1	13 1/2	7,000 - 11,000	7 - 10	10-20	NA
1	14	8,000 - 18,000	5 - 15	90	6
1	15	7,000 - 12,000	4 - 12	90	NA
1A	B2	6,900 - 15,000	6 - 14	10	6
1A	B1	7,200 - 8,900	8 - 8	10	3
1A	G1	6,700 - 11,000	6 - 11	20-30	12
1A	1	9,700 - 15,000	7 - 10	30	12
1A	2	9,000 - 16,000	7 - 14	10-30	24
2	B1	8,000 - 23,000	5 - 23	40-75	27
2	1	8,000 - 80,000[c]	8 - 26	50	37
2	2	7,600 - 14,000	6 - 15	20-30	26
2	3	7,500 - 14,000	6 - 14	20-40	102
2	4	9,000 - 22,000	6 - 15	30	38
2	5	9,200 - 18,000	8 - 16	20-40	54
2	6	7,700 - 14,000	6 - 11	20-40	47
2A	B1	6,000 - 9,000	5 - 8	20-30	9
2A	1	5,500 - 11,000	5 - 10	30-40	48
2A	2	5,500 - 13,000	4 - 12	30-40	63
2A	3	4,500 - 12,000	3 - 12	30-40	61
2B	B1	6,000 - 26,000	5 - 12	30-40	13
2B	1	7,600 - 17,000	7 - 16	20	12
2B	2	8,700 - 17,000	8 - 16	50	9
2C	B1	7,100 - 12,000	6 - 11	20-30	8
2C	1	6,000 - 13,000	4 - 12	20-30	19
2C	2	5,000 - 15,000	4 - 15	30-40	55
2C	3	4,500 - 15,000	3 - 15	30-40	57
Exterior Land	n/a	6,000 - 20,000	5 - 16	10-20	38

[a] Ludlum Model 44-10 2x2 NaI
[b] Ludlum Model 192 Micro R Meter
[c] Area further investigated

Table B-2. Battle Creek Elevated Areas Investigated												
Bldg./ Floor No.	Smear No.	Removable [a]		Alpha-plus-Beta [b]		Gamma [c]			Comments	SAM 940 In Field Analysis		
		Alpha	Beta	Gross	Total	Contact		1m		Report No.	Nuclide Identified	Confidence Level
		dpm/100 cm²		cpm	dpm/100 cm²	cpm	µR/h	µR/h				
2 / 1	5289R0072	1.92	-3.38	31,381	21,000	80,000	100	10	West wall of office 2-1-6	929	Ra-226	93%

[a] As reported by the Radiochemistry and Environmental Analytical Laboratory in Oak Ridge, Tennessee.
[b] Ludlum 44-142 plastic scintillator with Ludlum 2221 rate meter
[c] Ludlum 44-10 NaI with Ludlum 2221 rate meter; Ludlum 192 NaI