ADDENDUM

Section 7

Presence of Uranium and Beryllium at the BFC and Current and Potential

Future Impacts on the Environment

April 2017

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1.0 Introduction

The Missouri Hazardous Waste Management Facility Permit for the Bannister Federal Complex (BFC), which includes the Kansas City Plant, was modified in 2012 to add, in part, the submission of a document entitled *Description of Current Conditions Report* (DCCR). This report was to provide a historical summary of all environmental activities performed at the site. One of the topics to be included in the DCCR was narrative to describe the occurrence of uranium and beryllium at the BFC and the potential impacts that these elements might have on the environment. Section 7 of the DCCR was written to provide this requested information. The DCCR was originally submitted to Missouri Department of Natural Resources (MDNR) and United States Environmental Protection Agency (USEPA) in 2013 (DOE, 2013).

In November of 2014, MDNR provided comments on the previously submitted Section 7. Upon receipt, NNSA prepared a revised narrative and provided a response to comments which were transmitted to MDNR on January 19, 2015. This revised narrative also expanded on and added information describing work that had been conducted since submission of the original DCCR in 2013. This type of dynamic revision, adding narrative regarding work performed since the submission of the original DCCR, was not typical in that the intent of the DCCR was to provide a history of environmental work performed at the BFC up until the time of DCCR submission. However, investigatory work was ongoing regarding potential radiological contamination at the site as it related to releasing the property under DOE Order 458.1 *Radiation Protection of the Public and Environment*. For this reason, this section was further revised through the inclusion of this addendum to provide a synopsis of work performed since the last revision of the Section in 2014.

The BFC in Kansas City, Missouri manufactured non-nuclear components for nuclear weapons for over 60 years. Though designated non-nuclear, in that the site did not manage "Special Nuclear Material" both natural and depleted uranium (DU) were managed at the facility during its history. Significant efforts, both internal and external, have been employed over the last thirty years to address legacy activities related to the use of these materials. The most recent efforts have been provided by the National Institute of Occupational Safety and Health (NIOSH) through numerous file reviews over the last several years as a part of the Energy Employees Occupational Illness Compensation Program (EEOICPA).

Extensive, comprehensive environmental due diligence activities by CenterPoint Properties (CP) was conducted in 2015 and 2016 to, in part, determine the presence of uranium in soil and buildings. Utilization of this data along with NNSA legacy data and more recent data collected by NNSA in 2015 and 2016 is being utilized to document the presence and nature of potential legacy radiologic material in building materials and soils at the BFC.

2.0 Legacy Operations within Buildings

2.1 Work Performed by NNSA (Antech)

Through a detailed records search of on-site legacy files, numerous visits by NIOSH, review of historical records at the Kansas City site as well as records contained within the Department of Energy, a list of legacy activities that managed either natural uranium or depleted uranium were identified. See Appendix A for additional legacy information.

From this review, former Departments 3A, 20, 34C, 49X and areas of Building 96 were identified as warranting radiological surveys (Fig. 1). This was based on historical documents indicated that either natural or depleted uranium were managed in these areas.

In addition, the contractor performing this initial survey and remediation (Antech) was tasked to perform additional radiological surveys of other areas at the Kansas City Plant (KCP). No documentation existed that radiological materials were spilled or released in these additional areas but nevertheless, they were felt to be worthy of consideration. These areas included the following locations as shown in Figure 1:

- Test Cell 11 (TC-11)
- Area of Department 37B (Columns X31/X32 to Y31/Y32)
- Room 70 MESERAN LAB Hood Vent Tubes only
- Room 341 GC Lab Hood Vent Tubes only
- Red-X Lot

Remediation activities were conducted between January, 2015 and August, 2015 at over 1,700 independent locations (Antech 2016). Contractor personnel directly measured and recorded total contamination levels using large area (100 cm^2) dual-phosphor scintillation probes and very large area (609 cm^2) gas-flow proportional floor monitors. This equipment made it possible to detect and quantify alpha and beta particle emissions.

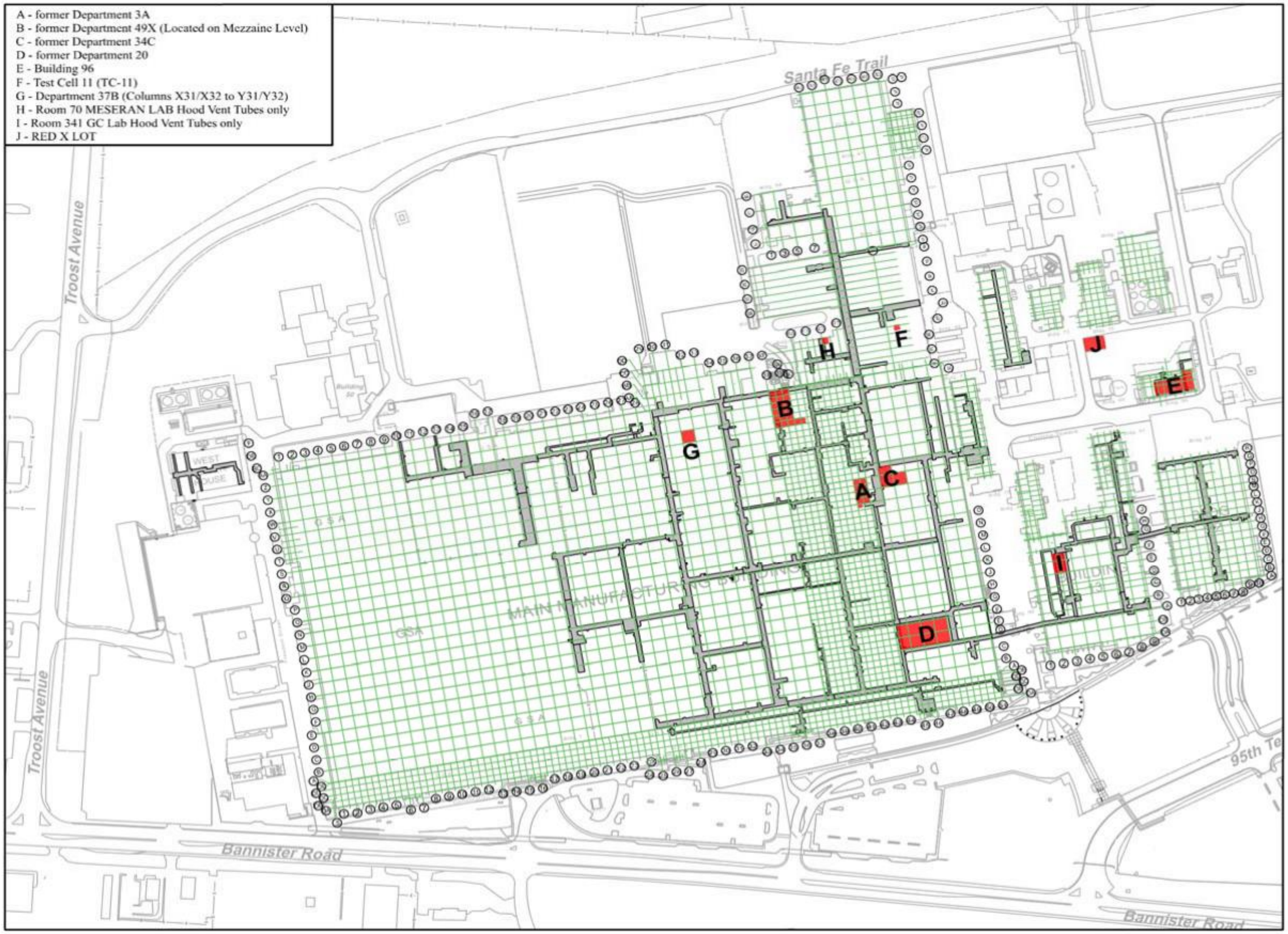

Figure 1: Locations of Building Areas Surveyed at the Kansas City Plant

The surveys were recorded on an Antech Radiological Survey Report (RSR), which is the official document used by the contractor to retain and validate each measurement. Nearly 40 RSRs were completed in that period, documenting characterization of specific areas or items, coverage of jobs involving potentially contaminated areas, or decontamination activities. Each RSR documents from one to several dozen actual measurement points. The RSR's typically have two Direct (or Total) measurement values (one for beta, and one for alpha), as well as two Removable (or Smear) values, again for beta and alpha. All of the RSRs were included in Antech Reports. Surface background ranges based on this survey for cinderblock walls and concrete floors at the facility are shown in Table 1.

Table 1: Representative Background Data

Description	Surface Contamination Level (dpm/100cm^2)	Reference
Cinderblocks	1335-2140	KCP-0001
Floors	945-1690	KCP-0002

(From Radiological Assessment of Former Radiologic Areas at the DOC Kansas City Plant Antech July 13, 2015)

2.2 Type of Work Performed

2.2.1 Removable (Smear) Measurements

Smears were collected by rubbing a piece of filter paper over a potentially contaminated surface using moderate pressure over a 100 cm^2 area. The smears were then transported to a counting station and counted using the Ludlum Model 2929 scaler. Results were converted to a uranium activity concentration. These measurements were made to determine if contamination was removable. The measurements confirmed that all contamination was fixed. This means that the radioactive material cannot by definition be spread but is nevertheless measureable. This differs from removable contamination which can be physically transferred by contact.

2.2.2 Scanning Measurements

The majority of surveys focused on performing scanning measurements. For most surveys, this was conducted no greater than two inches per second at a distance of ¼ inch from the surface. During the scan, the technician listened to the audio output of the instrument or, when in a high noise environment, watched the deflection of the meter. If a discernible difference between the background rate and the measured rate was detected, the technician stopped at that location for at least four seconds. If the count rate appeared to remain elevated, a static measurement was made to quantify the activity under the probe. Often, the highest count rate in a designated area was sought for this quantifying measurement.

2.2.3 Static Measurements

When the health physics technician desired to quantify and record the activity concentration, the probe was held steady at a fixed distance of approximately ¼ inch from the surface. The portable meter was then used in scaler mode and a timed count made. The length of the count could vary with the background to assure the Minimum Detectable Concentration (MDC) could be met, but was typically one minute.

To determine the depth to which contamination had penetrated various surfaces, Antech personnel collected core samples and removed samples from surfaces using a scabbler or needle gun. When taking core samples, the area was prepared by removing the coating material from a small area using a small needle gun similar to the one shown below. The scabbler debris were collected in a HEPA vacuum.

Figure 2: Example of a Needle Gun, HEPA Vacuum and Corer

2.2.4 Core Samples

Core samples were drilled to determine the depth of contaminant penetration.

Specifically coring was performed in the areas where contamination was indicated by survey instruments. The depth of penetration was determined by both core drilling and by scabbling small areas while continuously surveying. The areas which required coring included areas of former Department 49X on floors and walls, former Department 34C on floors, walls and columns, and former Department 20 floors.

Core samples indicated that the contamination by either depleted or natural uranium in the floor was limited to the top layer of cement, approximately 3/8 inch deep. The core samples were sectioned and measured for contamination. In addition, small floor areas and cinder block wall sections were addressed to test the effectiveness of removing thin layers of material on the floor or wall and surveying between each pass. This technique produced similar results in that only the top 1/4 to 3/8 inch of material exhibited contamination above background.

2.2.5 Concrete Removal

Concrete removal involved accessing the shallow contamination in the concrete surface layer and removing it. Where the general floor area was contaminated, a large scabbler such as the Pentek Moose was deployed.

Floor scabbling is a dry operation that removes approximately ¼ inch of material in a single pass while debris are collected with a high velocity HEPA vacuum. A scabbler was used in most of the floor and berm areas (approximately 5000 square feet). Where the large scale floor scabbler could not be used, a smaller hand operated scabbler was used. Testing showed that the contamination on the cinder block walls was removable by removing a small layer from the blocks. It was not necessary to remove any cinderblocks. The collected spoils were packaged in 23 or 55-gallon drums for disposal (Antech, 2016).

2.2.6 Department 20 Air Handler Removal

Several large ducts, plenums, and associated hardware over former Department 20 were found to be contaminated and removed from the facility (Fig. 3). These items were further surveyed, and the smaller components, such as louvers, were removed and dispositioned as radioactive waste while the non-contaminated bulk of the item was managed as non-radioactive waste. Any component with even a trace of activity above the nominal background was considered contaminated. Some large pipes were removed, and did not reveal contamination, but were dispositioned as radioactive waste because their inside surfaces were not accessible. All material was packaged to prevent loss of material and was shipped off-site for disposal at Energy Solutions in Clive, Utah.

Figure 3: Air Handler above Department 20 Prior to Removal

Interior surfaces of the duct work originating within former Department 20 were found to have fixed contamination. This entire system was dismantled and sorted and scanned using a Ludlum model 2360 data logger with a Ludlum 43-93 detector. Those components found to be free of radioactivity were managed as non-radioactive waste with contaminated items managed and disposed of as radioactive waste. A total of eight components called *down-comers* were removed as well. These are the ductwork components that penetrated the roof and connected to the interior heating, ventilation and air conditioning (HVAC) system. These items were sorted and managed in the same manner as the rooftop components. Shortly after removal of downcomers, Antech personnel sealed the roof penetrations. Figure 4 shows a typical downcomer and roof penetration.

Figure 4: View Looking Up at a Downcomer (Left) and The Rooftop Penetration (Right) after Remediation.

2.2.7 Department 20 Floor Drain

During remediation of concrete flooring in former Department 20, Antech personnel were asked to assess a floor drain. The floor-drain was initially found to be back-filled with concrete. When Antech personnel exposed the drain by removing the surrounding concrete, the drain line was found to be filled with sludge consisting of a moist of sand-like material (Fig. 5).

Figure 5: Sludge from Pipe in Former Department 20

Surface measurements showed the presence of radioactivity, and a sample of the material from the pipe was collected. That sample was submitted to a commercial laboratory for isotopic analysis. Results of that analysis indicated that the sample was most consistent with depleted uranium. A summary of results is provided in Table 2. The drain line was then exposed and removed. Approximately 100 feet of drain line was managed by excavating the pipe under the concrete floor and removing pipe (Figures 6 and 7). This drain line ran to a blind collector sump at the west end of the department that was remediated in the 1980's. The tie in location is shown in Figure 7 below at the location noted as "additional drain line found." No other contamination was found. The pipe, contents and affected debris were managed as radioactive waste and placed in an approved low level waste landfill. The trench was back-filled and a concrete cap was placed to ensure personnel safety.

Figure 6: Floor-drain in Former Department 20 during and after Remediation.

Table 2: Measured Isotopic Mass Ratios

Isotope	pCi/g	% Mass
^{238}U	23500	99.68
^{235}U	500	0.32
^{234}U	3610	0.0008

(From Radiological Assessment of Former Radiologic Areas at the DOE Kansas City Plant – Antech March 29, 2016)

2.3 MDNR Independent Verification Sampling

In early March 2015, the MDNR Federal Facilities Program conducted independent verification of radiological survey efforts at the Kansas City Plant (KCP) in areas where radioactive materials and surveys were performed by Antech. Independent scanning was conducted in the same areas and potentially same spots surveyed by Antech for the purpose of verifying the presence or lack of contamination above established background.

Department 49X was noted to be the largest area and involved the largest amount of radioactive materials. The state verification only focused on 49X. Based on the independent verification, the MDNR Federal Facilities program arrived at the following conclusions:

- MDNR personnel did not find elevated readings outside the area marked as elevated by Antech.
- MDNR personnel were able to find areas with elevated readings within the area marked elevated by Antech and elevated readings in depressions on the floor and to confirm that contamination was fixed.

2.4 Work Performed by Auxier

As a part of due diligence activities by CenterPoint Properties, Auxier and Associates (Auxier) were contracted to do an investigation of BFC areas to ascertain the presence of radiologic contamination.

Surveys were performed in the following areas: Former departments 3A, 20, 34C, 37B, 49X Building 96, the Model Shop, Meseran Lab, Test Cell 11, and GC Lab, the Red-X lot, roof areas of Departments 20 and 49 X, and Building 96 (Fig. 1). Six additional areas were addressed (Areas 1-6, Fig. 8) where radioactive materials were handled or stored (see also Appendix A). However, these areas were never considered potential release areas as no physical activity related to these materials was conducted (e.g., machining). Nevertheless these areas were evaluated.

Concrete core samples were also collected in Departments 20 and 34C, and samples were collected from selected sumps.

Surveys indicated the presence of residual radioactive materials above background on floor surfaces in Departments 20 and 49X (Auxier, 2016). The report noted that remedial activities were scheduled in 2016 to address these areas (see Section 2.6) (Auxier, 2016).

2.4.1 Exposure Rate Measurements and Gamma Surveys

The Auxier report noted that all exposure rate measurements fell between 8 and 14 microR/hour, which was within the expected variation of background gamma exposure rates, and very close to the values of the established instrument baseline and daily background checks.

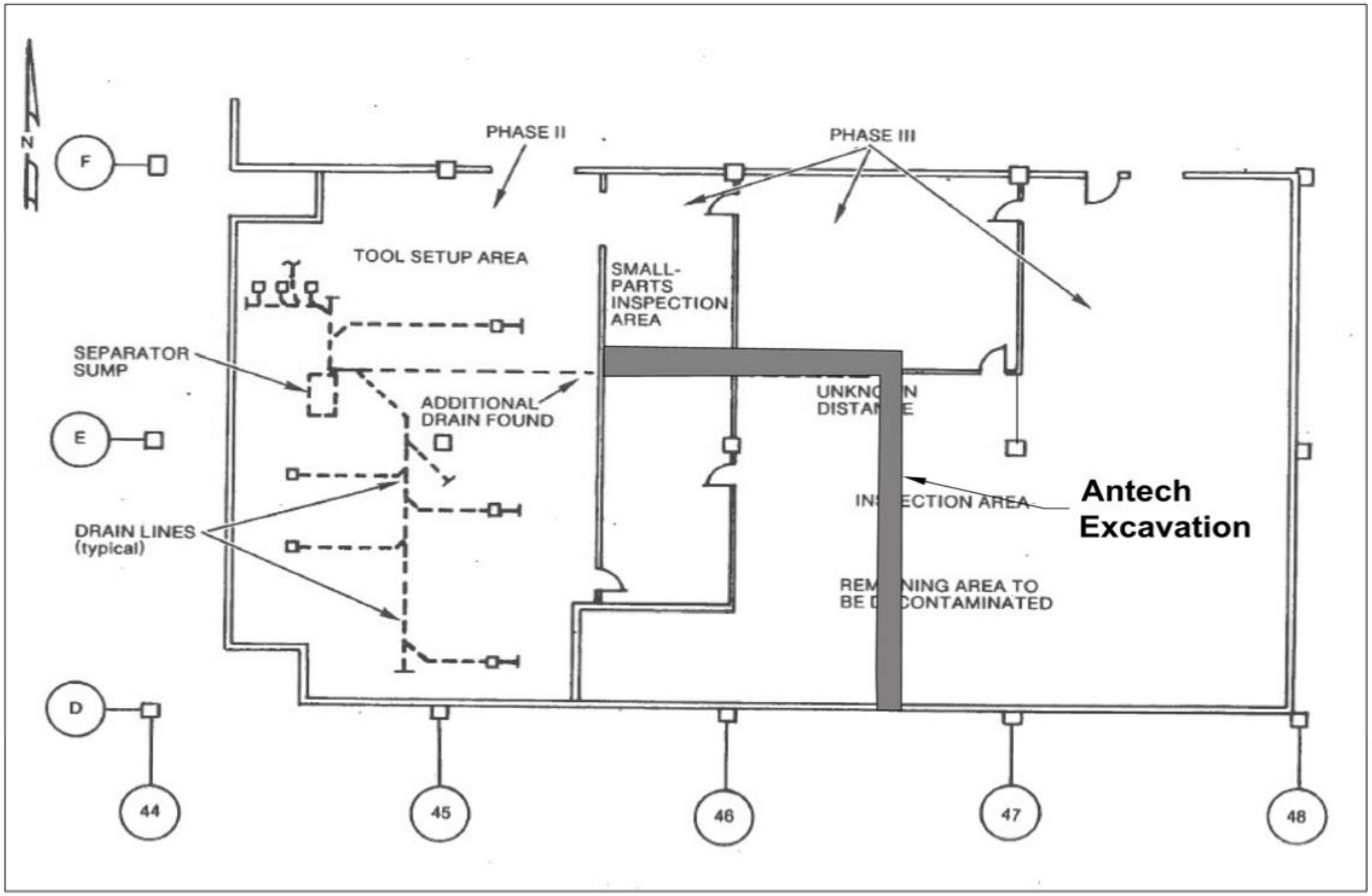

Figure 7: Plant View Map of Department 20 Area Piping

2.4.2 Sump Sample Results

Seven sanitary sewer sumps were identified as being situated along the potential pathway of wastewater from the areas where radioactive materials were handled. These locations included areas near Department 20, 34C, 49X, as well as locations on the southwest and northwest sides of Building 1 (Main Manufacturing Building) where sewage discharges the site. A Ludlum Model 2221 digital rate meter paired with a Ludlum 44-20 3x3 Sodium Iodide (NaI) detector was used to perform gamma scans of sumps. An area surrounding 49X sump demonstrated gamma levels at ~ 2 times background levels. A subsequent investigation did not reveal elevated levels of alpha- and beta- emitting radioactivity.

Sump samples were collected and analyzed by gamma spectroscopy and for isotopic uranium and thorium. Three of these samples were problematic in that they contained very little mass, which increased the error and resulted in inconclusive gamma spectroscopy results.

2.4.3 Concrete Sample Results

Four concrete samples were collected from Department 20 and two from Department 34C. The uranium-238 concentrations in those samples ranged from 0.688 to 3.27 pCi/g. Taking the lowest results as representative of background concrete, the highest net uranium-238 result was 2.58 pCi/g in concrete sample number 2, collected on the east side of Department 20. These results are consistent with typical background values of uranium in soils.

2.4.4 Manholes

Six manholes were identified as access points to potential waste pathways. Select manholes were gamma logged to the extent possible using the Ludlum 44-2 1x1 detector. The results ranged from 1,800-5,000 cpm. At least one static measurement and smear were collected at the location of the highest reading. Static measurements were only slightly greater than the detection limits and were likely due to naturally occurring radiation in the construction material. The gamma readings greater than 2,000 cpm were considered likely due to geometrical considerations and were interpreted as not indicative of unexpected residual radioactivity. The measurements in manholes that were greater than 2,000 cpm were due to changes in the geometry, and not indicative of areas requiring further investigation.

2.4.5 Survey of Exterior Grounds

Auxier surveyed various areas of the facility exterior surrounding the Main Manufacturing Building (MMB), including the Red X lot using a Model 2221/Model 44-180 instrument combinations. The detectors were mounted on a trailer approximately six inches above the ground surface and advanced at a rate of 0.5 meters per second. Separation between the scanned transit lines were approximately 1.5 meter which produced 100% coverage unless influenced by terrain. During wide-area scans, the data from the Ludlum Model 2221 meters were output in cpm units through RS-232 ports to Trimble GeoPositioning Systems which stored each gamma reading and the location of that reading at the rate of once per second. Three areas produced small clusters of results indicative of higher (> 3 sigma above the mean) gamma signatures. Concentrations of radionuclides in surface samples collected from these areas were comparable with those in the sample collected from the reference area (Area 11). It is likely these areas contain subsurface deposits of soil producing anomalous levels of naturally occurring radioactivity.

Table 3: Auxier Measurement above Action Levels

Area	Location	Level
Building 96	Roof	Seven measurements were above the detection limits where the east and west hoods vent onto the roof. Only one measurement was significantly above the detection limit (under the east hood vent).
Dept 49X	Roof	Three measurements were only very slightly above the alpha detection limit. This is likely due to construction materials.
Dept 20 East	Roof	Five measurements were above the beta detection limit, with one measurement in the filter-housing recommended for confirmatory measurements.
Dept 20 West	Roof	Five measurements are slightly above the detection limits, but well below investigation levels.
Sump	Bathroom Trailers	Two measurements only very slightly greater than the alpha detection limit.
Manhole	GSA Bldg 3	One alpha measurement only very slightly greater than the detection limits.
	Roof Elevator	One alpha measurement only very slightly greater than the detection limits.
	2-44	One alpha measurement only very slightly greater than the detection limits.
	T-50	One beta measurement only very slightly greater than the detection limits.
Area 4	Ceiling	One beta measurement only very slightly greater than the detection limits.
49X	Wall 2	Four beta measurements greater than the detection limit, with one above the investigation level.
49X	Wall 4	Two measurements above the investigation level.
49X	Column Z38	Five measurements above the detection level.
34C	Column S46	Three measurements above the detection limit, with one above the investigation level.
Area 2	Wall 3	Three alpha measurements slightly above the detection limit.
Area 2	Wall 5a	Four measurements above the alpha detection limit.
(From Survey Report For Stage 3 Building Materials –Auxier & Associates, Inc January 2016)		

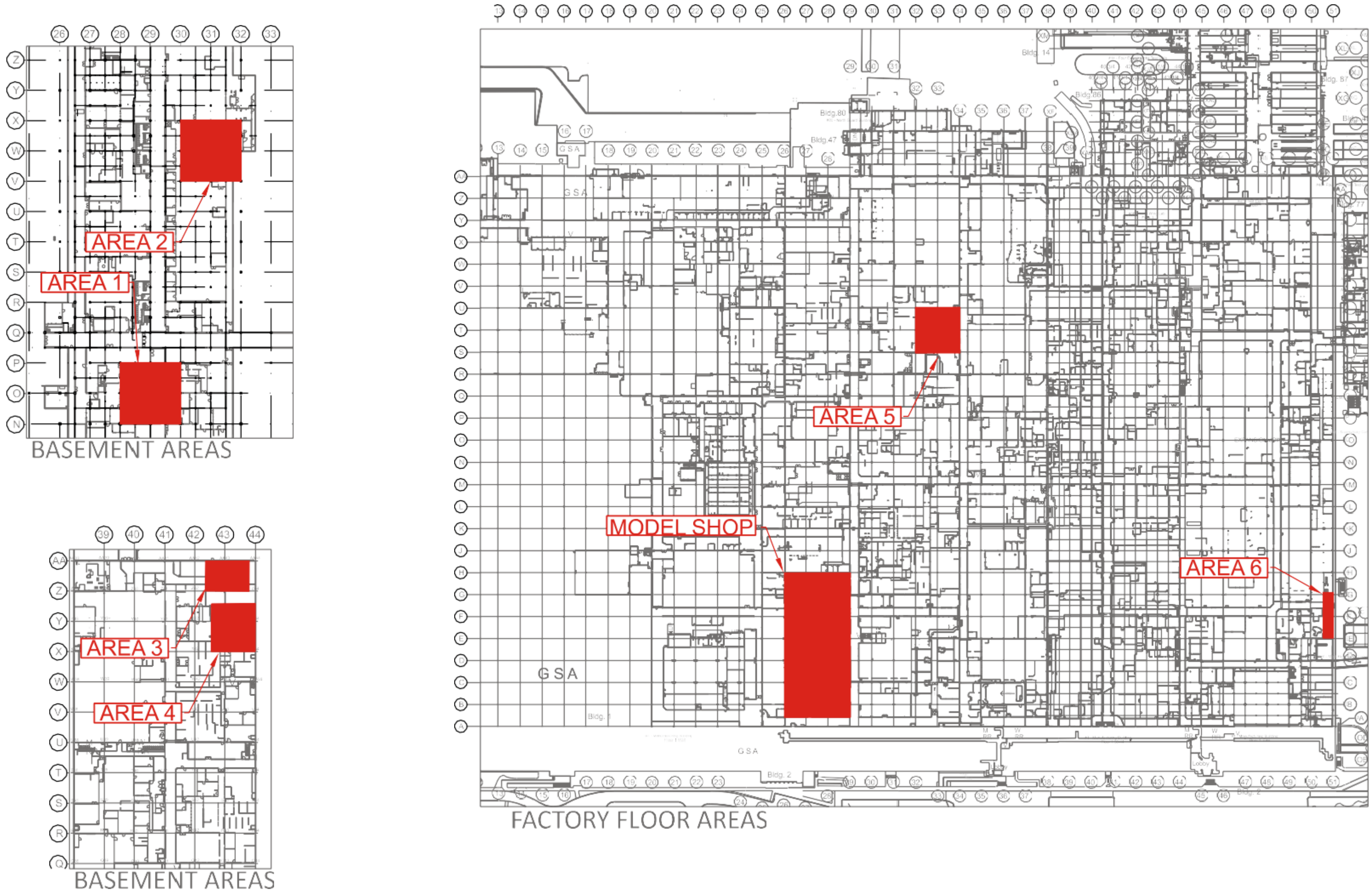

Figure 8: Additional Areas Surveyed by Auxier

2.5 Verification Survey Work Performed by the Oak Ridge Institute for Science and Technology (ORISE) of Work Performed by Antech

In order to turn over the Kansas City Plant property for future use, all of the Department of Energy (DOE) requirements for release and clearance of DOE property, mandated under DOE Order 458.1(k) must be addressed. This work was awarded to Oak Ridge Institute for Science and Education (ORISE). The work done by Antech to remove as much legacy contamination as possible in building materials before ORISE performed their final status survey work was intended to increase the likelihood that Antech addressed areas would meet the DOE Order 458.1 requirements for industrial use release and clearance of DOE property.

Table 4: DOE Order 458.1 Release Criteria Pre-approved Authorized Limits (AL) for Uranium on Building/Structural surfaces

Radionuclides	Units	Average (Total)	Maximum	Removable
Uranium (Natural and Depleted)	dpm/100 cm^2	5,000	15,000	1,000

(From Report For February 2016 Independent Verification Activities at the Bannister Federal Complex at the Kansas City Plant in Kansas City, Missouri – Oak Ridge Institute For Science and Education

ORISE performed on-site investigation activities from December 9-11, 2015 with the main survey effort on December 10, with the objective to ensure that DOE Order 458.1 clearance surface activity requirements were satisfied. A letter report was written documenting the magnitude and location of elevated activity discovered primarily on concrete floor surfaces in the former Department 20 and 49X areas. Surveys of Departments 20, 34C, and 49X (see Figure 1) were performed while on site. These areas were selected because they represented the highest potential for exceeding DOE Order 458.1 criteria.

Results

Figure 9 presents Department 49X area locations measured by ORISE with a gross activity above 1,000 cpm, noting that background for the 43-68 was about 450 cpm. Eleven small hot spots (many 1-2" in diameter) were identified on the floors and lower walls, with a maximum of 11,126 cpm (~25,000 dpm/100 cm^2). It was noted that all identified hot spots were small and did not result in average activity above the 5,000 dpm/100 cm^2 maximum authorized limit (AL) (i.e., over $1m^2$). However, location 9, pictured in Figure 9, was estimated to exceed the AL of 15,000 dpm/100 cm^2. No activity above DOE Order 458.1 limits (5000 dpm/100 cm^2) were identified in former department 34C.

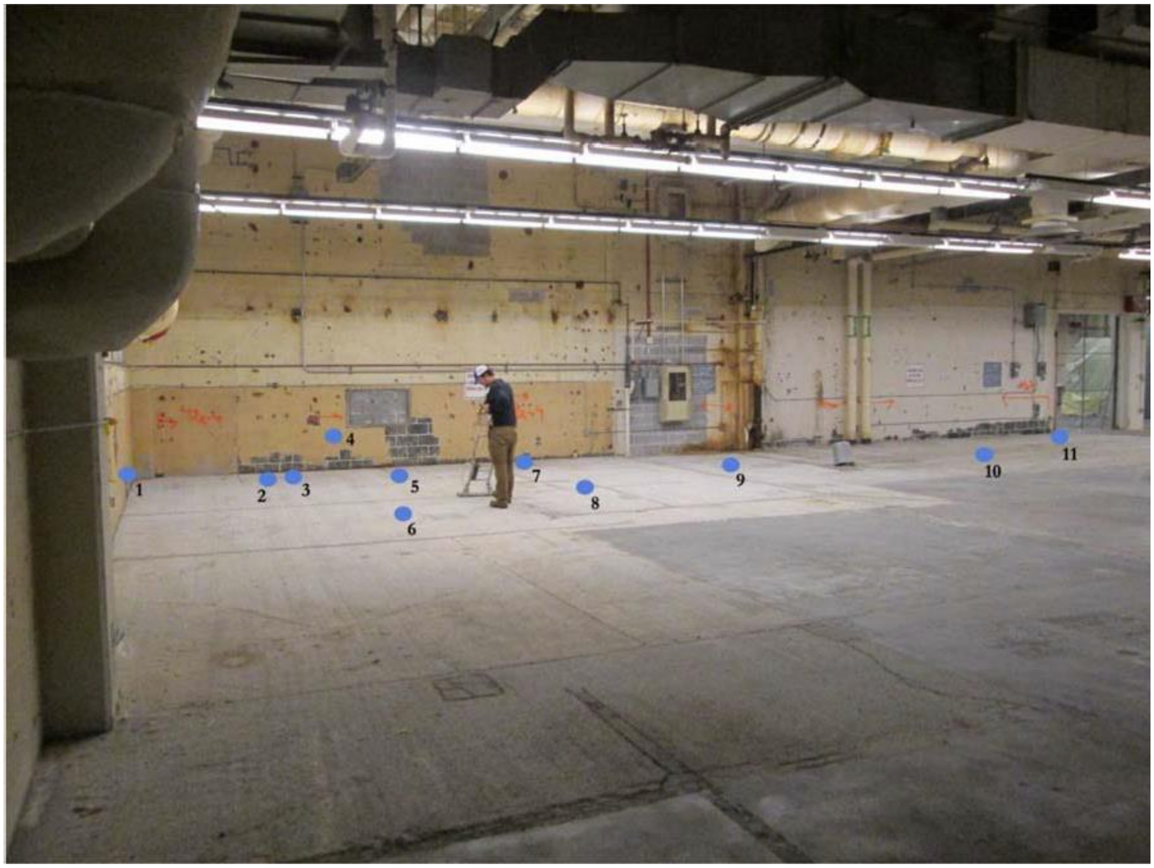

Figure 9: Location and Magnitude of Elevated Gross Alpha-plus-Beta Activity in the 49X Area

Figure 10 presents Department 20 locations with a gross activity above 1,000 cpm. The cpm values associated with each location are presented in Table 5. As with the 49X area, sixteen small hot spots were identified on the floors, with a maximum of 5,512 cpm (~10,000 dpm/100 cm^2). It was estimated that none of the identified hot spots resulted in average activities above the 5,000 dpm/100 cm^2 AL (i.e., over 1m^2), and no value exceeded the maximum AL of 15,000 dpm/100 cm^2.

2.6 Work Performed to Remediate Areas Identified by ORISE

In January of 2016, Antech personnel returned to the site to perform additional surveys and decontamination at locations identified by ORISE. In Department 20, a total of 16 locations surrounding columns E47 and D46 and 47 were further decontaminated.

Antech personnel also performed additional surveys and decontamination at locations specified in Department 49X. A total of 11 cracks and floor anchor locations were decontaminated (Antech, 2016).

2.7 ORISE Final Building Verification

During the initial December 2015, ORISE survey effort, scans were performed with a Ludlum Model 44-10 2-inch by 2-inch (2×2) sodium iodide detector along with a thorough (~100%)

Figure 10: Location and Magnitude of Elevated Gross Alpha-plus-Beta Activity in Department 20

survey of the scabbled and adjacent floors of Department 20, 34C, and 49X using a Ludlum Model 43-37 gas proportional floor monitor, targeted wall scans with a Ludlum Model 43-68 gas proportional detector, and static 1- minute measurements with the 43-68 at judgmental locations, where elevated direct radiation levels were indicated by surface scans. For the return trip, ORISE focused only on those areas that had been re-scabbled by Antech (ORISE 2016b). Specifically those areas identified during the December 2015 ORISE effort, with a gross count above 1,000 cpm. This value roughly equates (using ORISE instrumentation) to about 1,200 dpm/100 cm^2. However, the average AL is assessed over an area of 1 m^2, and maximum and removable ALs are assessed over an area of 100 cm^2; thus the action level would be more than sufficient to meet DOE Order 458.1 requirements. The ORISE verification survey included a targeted scan and static 1-minute measurement at each remediated location. Smear samples were not collected during this effort because there was negligible removable activity identified during the December 2015 effort (i.e., the activity was fixed). All 1-minute measurement results were compared to the following pre- approved ALs. (see Table 4).

Gross detector responses in counts per minute (cpm) were converted to net disintegrations per minute per hundred square centimeters (dpm/100 cm^2) using the 43-68 efficiencies calculated using weighted efficiencies specific to natural uranium (in Department 49X) or depleted uranium (in Department 20), as applicable.

The eleven locations in the Department 49X area (shown in Figure 9) were resurveyed by ORISE in February 2016. The December 2015 and February 2016, cpm values associated with each location are presented in Table 5. Final dpm/100 cm^2 results, using the February 2016 measurement data, are also presented for comparison to the AL in the table. The maximum measured value, over Location 3, is 1,150 cpm or ~1,600 dpm/100 cm^2 and well below the 5,000 dpm/100 cm^2 AL. As noted previously, Figure 10 shows 16 locations in Department 20, identified by ORISE during the December 2015 effort, with a gross activity above 1,000 cpm. Final dpm/100 cm^2 results, using the February 2016 measurement data, are also presented for comparison to the AL. The maximum measured value, over Location 21 is 694 cpm or 545 dpm/100 cm^2 and well below the 5,000 dpm/100 cm^2 AL. Note that Location 25 was resurveyed but the quantitative measurement value was inadvertently omitted from the logbook, though the ORISE staffer recalls innocuous activity levels.

Table 5: Measurement Results for Figures 9 and 10

Measurement	2015 Activity	2016 Activity	2016 dpm/100
49X (see Figure 11)			
1	1,115	671	470
2	5,000	680	490
3	1,544	1,150	1,600
4	1,442	616	340
5	3,108	449	0
6	1,792	482	19
7	4,603	472	0
8	3,631	398	0
9	11,126	457	0
10	4,197	440	0
11	5,206	497	54
Department 20 (see Figure			
12	1,110	630	420
13	1,193	630	420
14	3,099	585	330
15	2,346	522	200
16	1,238	286	0
17	1,504–1,920	450	56
18	1,535–2,074	664	490
19	1,569	426	8
20	1,234	591	340
21	2,372	694	550
22	1,806	647	450
23	3,560	473	100
24	5,512	474	100
25	4,777	Not recorded	Not recorded
26	1,681	522	200
27	4,359	522	200

[a]The 43-68 background response is estimated at 474 cpm for 49X and 422 cpm for Department 20.

All dpm values rounded to two significant digits or nearest whole number.

(From Report For February 2016 Independent Verification Activities at the Bannister Federal Complex at the Kansas City Plant in Kansas City, Missouri – Oak Ridge Institute For Science and Education March 2016)

3.0 Conclusion

ORISE re-surveyed 27 isolated concrete floor locations in the Department 20 and 49X areas that had been rescabbled after elevated activity levels were identified during the December 2015 effort (ORISE 2016). These areas represent the highest probability of exceeding ALs based on process knowledge and historical data. ORISE concludes that by demonstrating that the Department 20, 34C and 49X areas meet pre-approved ALs for surfaces, all BFC facilities that were sampled and tested meet pre-approved authorized limits for surfaces. The new measurements verify that residual activity was adequately remediated, with a maximum single result of 1,600 dpm/100 cm^2, compared to the 5,000 dpm/100 cm^2 pre-approved AL.

4.0 Exterior Analysis and Survey of Soil at the BFC

4.1 Stage I and II soil sampling for Uranium by S.S. Papadopulos & Associates (SSPA)

As a part of a comprehensive investigation to determine and/or verify existing contaminant data at the BFC, SSPA, on behalf of CenterPoint, drilled numerous soil borings at the BFC and performed analysis of soil to assess the presence of contamination. This work was performed in stages. Stage I activities included the installation of 313 soil borings and analysis of 662 samples from these borings (Fig. 11) (S.S. Papadopulos & Associates and Evans Consulting 2015a). Stage II activities included the installation of 171 borings with analysis of 757 samples (S.S. Papadopulos & Associates and Evans Consulting 2015b). Total uranium was detected between 0.24 and 5.63 ppm in Stage I and between 0.342 to 12.4 ppm in Stage II (Fig. 12). The locations of borings from Stage I and II due diligence activities are shown in Figures 11 and 12.

4.2 Stage III Uranium soil sampling by SSSPA

SSPA on behalf of CenterPoint properties collected a total of 179 soil samples (167 individual soil samples, and 12 duplicate samples) at the Bannister Federal Complex as a part of Phase III activities (Fig. 13) (S.S. Papadopulos & Associates 2016a).

In this round of sampling soil, samples were analyzed for the both total uranium as well as uranium isotopes. From this analysis, results were evaluated against two tests as identified in the workplan (SSPA and others 2015); the first test was a comparison to USEPA Preliminary Remediation Goals (PRGs) for radionuclides. The second test compared results from contractor defined "Areas of Concern" (AOCs) to the data population for Reference Areas (RA) to identify what they termed statistical outliers. Highest samples were greater than the Upper Confidence Limit (UCL) for each radiological parameter. In this case, the UCL was calculated as $\bar{x} + 3S$ where $\overline{x}$ is the population mean of the reference area and S is the standard deviation of the reference area.

For the UCLs, the fifteen highest values of this ratio [ratio = Isotopic Result / UCL] (excluding duplicates) were all derived from three borings:

- CP-5004
- CP-5006
- CP-5007

The borings are shown in Figure 13 as borings CP-5004-RAD, CP5006-RAD and CP-5007-RAD.

Location CP-5006 is located on the south edge of the northeast parking lot (IRS lot). It was drilled adjacent to the Stage II soil borings (CP-322 and CP-322R), where maximum total Uranium analyses of 6-10 mg/kg had been reported in the upper 2 feet of soil (Figure 13).

The other two locations (CP-5004 and CP-5007) are located in a grassy area immediately east of Building 59. Total uranium results from these locations (12-73 mg/kg) were elevated relative to the overall data population.

Similarly, using another comparison method, specifically, comparing the isotopic results to the PRGs resulted in 13 of the 15 highest values from these same 3 locations. These areas are further addressed below in Sections 4.4, 4.5 and 4.7

4.3 Concentrations in Soil Allowing Free Release of Property under DOE Order 458.1

As specified in Section 4.k(6) of DOE Order 458.1, authorized limits (ALs) must be established and approved for the clearance of any property with residual radioactive material to provide reasonable assurance that dose constraints are as low as reasonably achievable (ALARA).

Due to the absence of preset AL's for soil in DOE Order 458.1, site specific ALs for soil were derived by ORISE using the RESRAD computer code, Version 7.0 (Yu, et al. 2001). This effort included the use of a conceptual site model adapted from the site baseline risk assessment (URS 2015) and other site documents, and considering ranges of possible industrial/recreational receptors that are consistent with site deed and access restrictions. Because both natural and depleted uranium are known to have been used on the site, ALs were derived for individual isotopes and for total uranium using natural and depleted abundances. Calculations demonstrated that an outdoor excavation/construction worker was the most restrictive receptor producing the following ALs:

Uranium	Authorized Limit (pCi/g)
^{234}U	3,700
^{235}U	150
^{238}U	600
U (Natural)	910
U (Depleted)	810

Table 6 summarizes ALs by receptor (all pathways combined), with each Authorized Limit value associated with a dose limit of 25 mrem/yr. The ALs in Table 6 were calculated by summing across all pathways (inhalation, external gamma, etc.) for each listed combination of isotope and receptor. Table 6 results show the most restrictive ALs are associated with the E/CW, who spends the work-year outdoors actively participating in construction-related activities. Table 7 presents the pathway-specific dose contributions (per unit concentration), the combined (summed) DSRs, and isotope-specific ALs. The external gamma is the primary exposure pathway for all receptors although all isotopes are alpha emitters.

Figure 11: Stage I Soil Boring Locations

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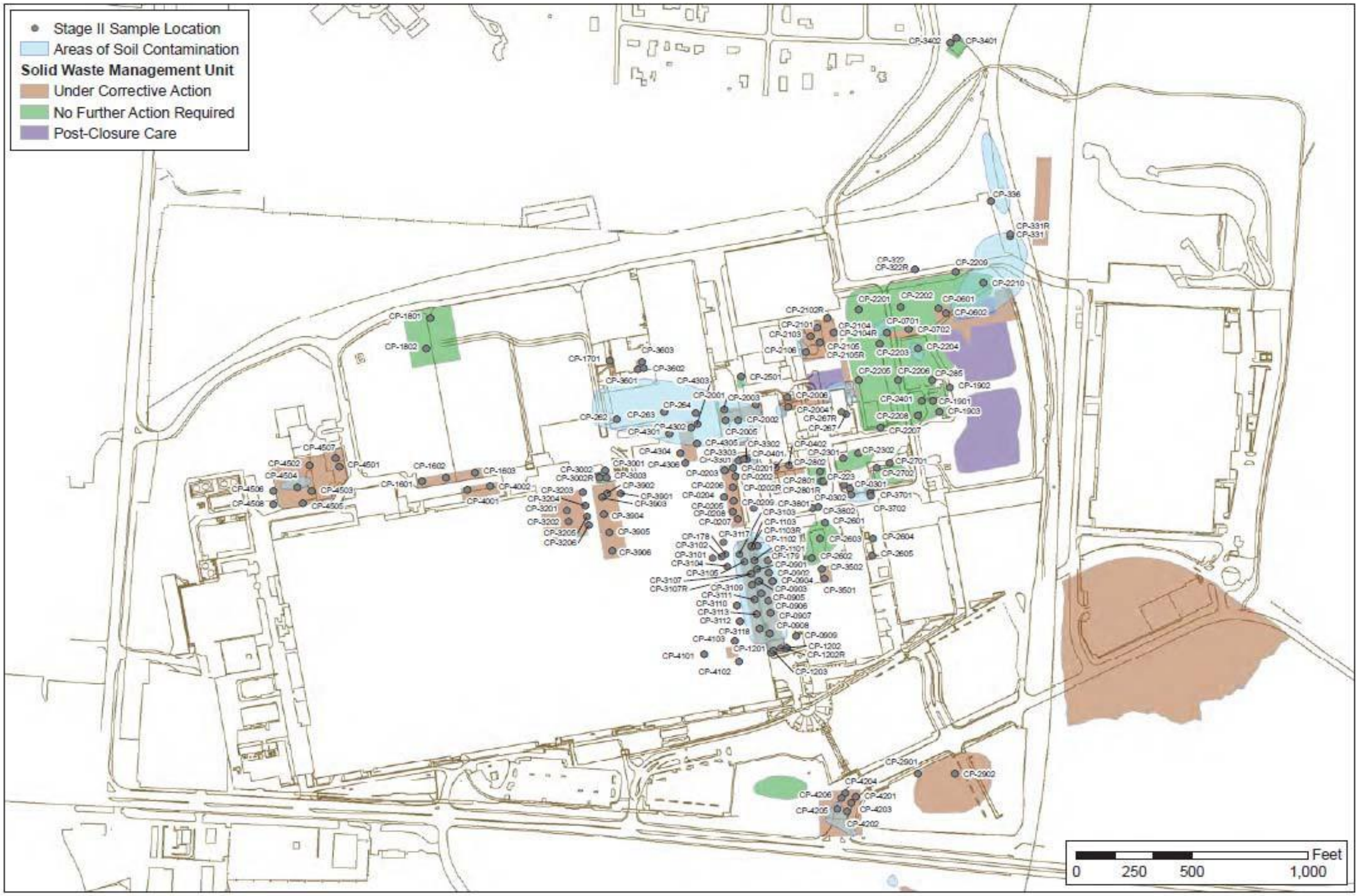

Figure 12: Stage II Soil Boring Locations

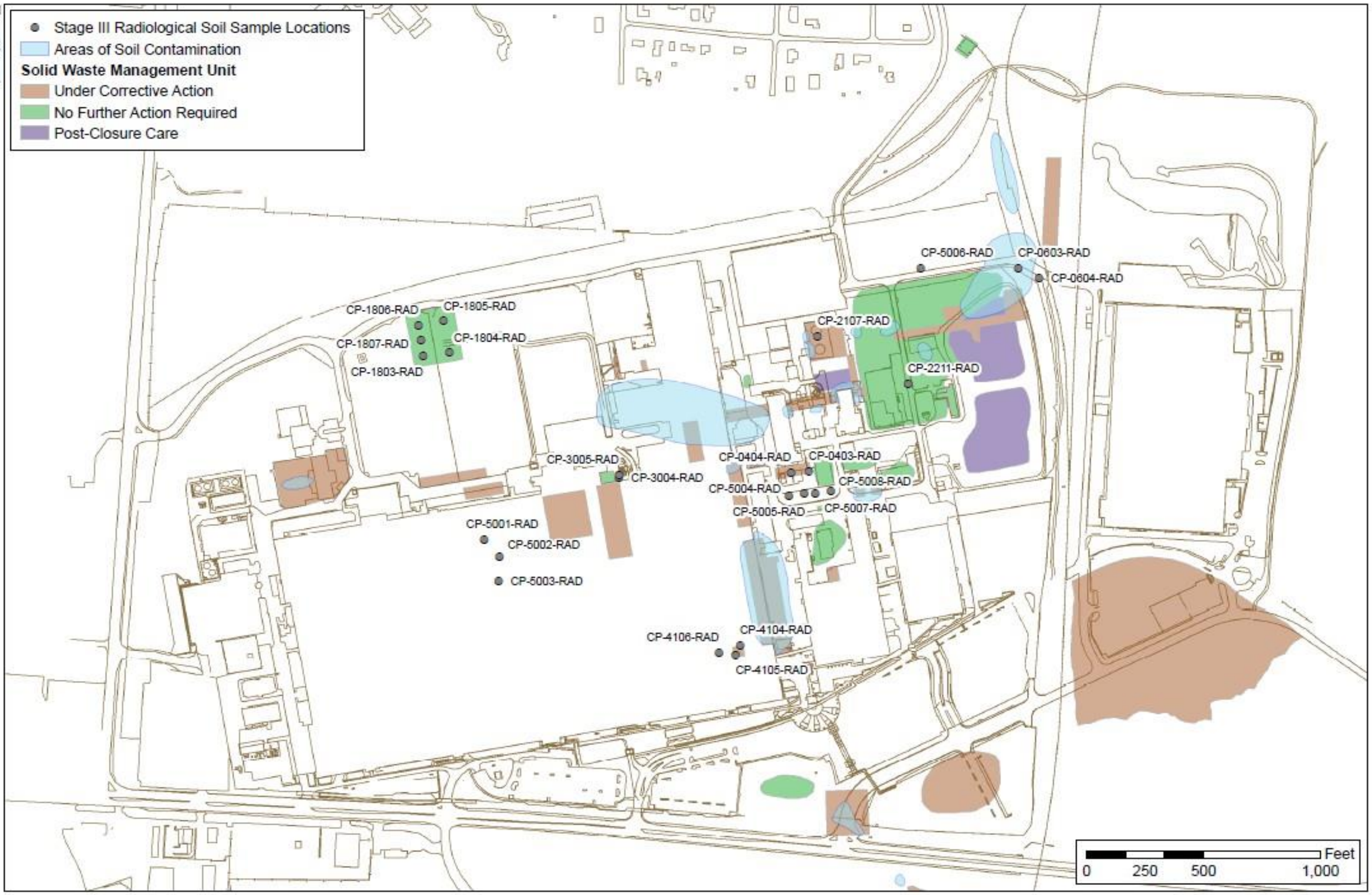

Figure 13: SSPA Stage III Sampling Locations

Table 6: Summary of Authorized Limit Results (pCi/g)

COC	E/CW	IW	OW	RU
U-234	3,700	20,00	9,900	51,00
U-235	150	220	170	1,500
U-238	600	970	730	6,100
U (Natural)	910	1,600	1,200	9,500
U (Depleted)	810	1,400	1,000	8,400

All ALs are rounded to two significant digits.
All ALs shown are for exposure year 0.0.
E/CW = excavation/construction worker
IW = indoor worker
OW = outdoor worker RU = recreational user
(From Authorized Limits for Soil at the Bannister Federal Complex at the Kansas City Plant in Kansas City, Missouri – Oak Ridge Institute for Science and Education April 2016)

Table 7: Pathway Specific Dose to Source Ratios and Authorized Limit Results

Receptor	COC	Ext. Gamma mrem/yr	Inhalation mrem/yr	Soil Ing. Mrem/yr	DSR mrem-g/pCi-	AL pCi/g
E/CW	U-234	7.93E-05	1.54E-03	5.05E-03	6.67E-03	3,700
	U-235	1.61E-01	1.39E-03	4.81E-03	1.67E-01	150
	U-238	3.52E-02	1.32E-03	4.90E-03	4.14E-02	600
IW	U-234	5.55E-05	4.55E-04	7.68E-04	1.28E-03	20,000
	U-235	1.13E-01	4.10E-04	7.31E-04	1.14E-01	220
	U-238	2.46E-02	3.89E-04	7.45E-04	2.58E-02	970
OW	U-234	7.24E-05	1.04E-03	1.40E-03	2.51E-03	9,900
	U-235	1.47E-01	9.35E-04	1.34E-03	1.49E-01	170
	U-238	3.21E-02	8.88E-04	1.36E-03	3.44E-02	730
RU	U-234	8.28E-06	1.61E-04	3.21E-04	4.90E-04	51,000
	U-235	1.68E-02	1.45E-04	3.05E-04	1.72E-02	1,500
	U-238	3.67E-03	1.38E-04	3.11E-04	4.12E-03	6,100

AL = authorized limits; all values rounded to two significant digits; 25 mrem/yr/DSR
DSR = dose-to-source ratio; all COCs input at 1 pCi/g; sum of pathway-specific doses
COC = contaminant of concern; All values for year = 0

(From Authorized Limits for Soil at the Bannister Federal Complex at the Kansas City Plant in Kansas City, Missouri – Oak Ridge Institute for Science and Education April 2016)

The report concluded that the maximum uranium concentration measured on site is over a magnitude less than the most restrictive industrial ALs, and existing concentrations are ALARA. Elevated concentrations of uranium, when discovered, were isolated to small areas and environmental transport is negligible. Based on these results, further investigation was initiated as discussed below.

4.4 Confirmatory Soil Sampling January 2016.

In January of 2016, Antech personnel collected soil samples drilled by Terracon Consultants from locations immediately adjacent to borings CP-5004, CP-5006 and CP-5007. This was done in an effort to reproduce the results derived from previous sampling by SSPA. Samples were collected at several depths in each bore hole by core-drilling. A sewer sump sample was also collected to check that waste materials from historical operations had not impacted the adjacent sewer. These samples were submitted to the ALS Environmental Laboratory in Fort Collins, Colorado for uranium isotopic analysis. Results are summarized below as Table 8.

Table 8: Core Sample Results

Sample #	Split (g)	Sample Type	Sample Location	Depth (feet)	U-234 pCi/g	U-235 pCi/g	U-238 pCi/g
1	35	Soil	BFC-5004	1 to 2	2.55 +/ -0.47	0.19 +/ -0.073	5.59 +/ -0.97
2	39	Soil		2 to 4	3.04 +/ -0.56	0.16 +/ -0.072	7.9 +/ -1.4
3	42	Soil		5 to 6	3.73 +/ -0.68	0.37 +/ -0.11	11.2 +/ -1.9
4	52	Soil		7 to 10	2.4 +/ -0.46	0.2 +/ -0.082	7 +/ -1.2
5	41	Soil	BFC-5006	3 to 5	3.04 +/ -0.56	0.17 +/ -0.072	3.2 +/ -0.59
6	43	Soil		7 to 9	2.37 +/ -0.44	0.1 +/ -0.051	2.36 +/ -0.43
7	44	Soil		13 to 15	0.93 +/ -0.21	ND	1.07 +/ -0.24
8	45	Soil		18 to 20	1.2 +/ -0.24	0.05 +/ -0.034	1.11 +/ -0.23
9	39	Soil	BFC-5007	1 to 2	1.18 +/ -0.24	0.08 +/ -0.044	1.54 +/ -0.3
10	41	Soil		3 to 5	2.05 +/ -0.38	0.09 +/ -0.044	2.18 +/ -0.4
11	40	Soil		5 to 7	1.17 +/ -0.24	0.07 +/ -0.04	1.43 +/ -0.28
12	43	Soil		8 to 10	1.18 +/ -0.25	0.06 +/ -0.038	1.18 +/ -0.25
13	-	Water	Sump	N/A	0.32 +/ -0.11	0.025 +/ -0.031	0.269 +/ -0.099

(From Radiological Assessment of Former Radiologic Areas at the DOE Kansas City Plant – Antech March 29, 2016)

When compared to previously reported borehole sample results, the data from BFC-5006 and BFC-5007 appear to be consistent with background uranium levels. The results for BFC-5004 are slightly elevated. The sewer sump sample showed uranium levels well below the typical soil concentrations.

4.5 Split Sampling of Soil with ORISE

Antech also shipped 12 split soil samples to ORISE for laboratory analysis. The sampling event (from which the splits were provided) was intended to confirm the presence, magnitude, and isotopic distribution of uranium in the area (S.S. Papadopulos 2016). Table 9 presents analytical results for isotopic uranium, via alpha spectroscopy, for the twelve soil samples that were collected in an attempt to confirm and delineate the maximum historical result of 73 mg/kg uranium metal (~30 pCi/g) at boring CP-5004.

Table 9: Comparison of Split Soil Sample Alpha Spectroscopic Results

Station/Depth	Analyte	Result (pCi/g) ORISE	Result (pCi/g) Antech	Station/Depth	Analyte	Result (pCi/g) ORISE	Result (pCi/g) Antech
BFC 5004 1'-2'	Uranium-233/234	2.45	2.55	BFC 5006 13'-15'	Uranium-233/234	1.21	0.93
	Uranium-235/236	0.196	0.19		Uranium-235/236	0.075	0.04
	Uranium-238	6.17	5.59		Uranium-238	1.11	1.07
	Total U	8.82	8.33		Total U	2.40	2.04
BFC 5004 2'-4'	Uranium-233/234	3.58	3.04	BFC 5006 18'-20'	Uranium-233/234	0.98	1.20
	Uranium-235/236	0.228	0.16		Uranium-235/236	0.036	0.05
	Uranium-238	10.1	7.90		Uranium-238	1.11	1.11
	Total U	13.91	11.10		Total U	2.13	2.36
BFC 5004 5'-6'	Uranium-233/234	3.64	3.83	BFC 5007 1'-2'	Uranium-233/234	1.23	1.18
	Uranium-235/236	0.237	0.37		Uranium-235/236	0.065	0.08
	Uranium-238	10.8	11.20		Uranium-238	1.34	1.54
	Total U	14.68	15.40		Total U	2.64	2.80
BFC 5004 7'-10'	Uranium-233/234	3.55	2.40	BFC 5007 3'-5'	Uranium-233/234	2.06	2.05
	Uranium-235/236	0.216	0.20		Uranium-235/236	0.105	0.09
	Uranium-238	5.59	7.00		Uranium-238	2.24	2.18
	Total U	9.36	9.60		Total U	4.41	4.32
BFC 5006 3'-5'	Uranium-233/234	2.55	3.04	BFC 5007 5'-7'	Uranium-233/234	1.33	1.17
	Uranium-235/236	0.160	0.17		Uranium-235/236	0.076	0.07
	Uranium-238	2.64	3.20		Uranium-238	1.48	1.43
	Total U	5.35	6.41		Total U	2.89	2.67
BFC 5006 7'-9'	Uranium-233/234	1.33	2.37	BFC 5007 8'-10'	Uranium-233/234	1.14	1.18
	Uranium-235/236	0.088	0.10		Uranium-235/236	0.056	0.06
	Uranium-238	1.37	2.36		Uranium-238	1.18	1.18
	Total U	2.79	4.83		Total U	2.38	2.42

(From Report for February 2016 Independent Verification Activities at the Bannister Federal Complex at the Kansas City Plant in Kansas City, Missouri – Oak Ridge Institute for Science and Education March 2016)

Antech and ORISE results are in good agreement. Based on sampling results it was determined that the material was depleted uranium. In all cases, soil concentrations were well below the depleted uranium Authorized Limit of ~810 pCi/g for compliance with DOE Order 458.1 (ORISE 2016).

4.6 Supplemental Fieldwork by SSPA

On June 2, 2016 during SSPA supplemental Stage III drilling, the sampling crew encountered elevated radiation readings at boring CP-5026 (Fig. 14). While using a NaI probe, they determined background was ~18,000 count/minute (cpm). At sample location CP-5026 at a depth of 1.5 feet a reading over 200,000 cpm was noted. SSPA collected a sample and requested a rush analysis for total uranium.

The analysis from boring CP-5026 noted the following results:

0.5 to 1.0 feet depth: 660 mg/kg (~462 pCi/g as natural/~264 pCi/g as depleted)
1.0 to 1.5 feet depth: 716 mg/kg. (~501 pCi/g as natural/~286pCi/g as depleted)

SSPA noted there was no health or exposure concerns at this concentration.

4.6.1 Results – Uranium and Uranium Isotopes

A total of 87 results were reported by Eurofins Lancaster Laboratories for total uranium. The maximum concentrations of 716 mg/kg and 660 mg/kg were reported from boring CP-5026 at depths of 1.0-1.5 feet and 0.5-1.0 feet, respectively.

The maximum concentrations of total Uranium, U-234 and U-238 were found in shallow samples (from 0 to 1.5 feet bgs) at boring CP-5026. These results exceed both the residential and industrial USEPA PRGs, and the site-specific screening Authorized Limits developed by ORISE for uranium-238 (Table 6). During advancement of this borehole, field screening indicated gamma radiation levels about 10 times background at location CP-5026.

Boring CP-5026 Maximum Isotopic Results

- 78.7 pCi/g Uranium-234 (66.8 pCi/g in field duplicate)
- 818 pCi/g Uranium-238 (711 pCi/g in field duplicate)

None of the other soil samples from this grassy area, nor in any of the other targeted locations yielded similar elevated results.

SSPA stated that their data indicated that samples from locations CP-5004 and CP-5026 all have concentrations of U-238 much greater than the U-234 result, indicative of depleted uranium.

4.6.2 Possible Extent of Depleted Uranium Contamination

The Due Diligence Site Investigation Stage III Supplemental Report approved by the MDNR, concluded that the investigation did not find extensive DU in excess of PRGs or authorized limits for either residential or industrial/commercial exposure scenarios. It did, however, confirm the presence of DU at elevated levels at CP-5026.

4.7 Antech Fieldwork to Survey and Remediate Soil Present at Elevated Concentrations

Between June 26, 2016 and July 15, 2016, Antech personnel qualified to perform radiological control (RADCON) work excavated and sorted soil from the area of borings CP-5026, CP5004 as well as CP-5027 in the grassy area near Building 59 (Fig. 15) (Antech 2016b).

A set of risk-based limits under a residential use scenario were utilized in this project to serve to segregate soil from the excavation (Table 10).

Table 10: Uranium Action Levels Calculated by RESRAD (pCi/g)

Uranium	Action Level (pCi/g)
^{234}U	990
^{235}U	39
^{238}U	160
U (Natural)	240
U (Depleted)	220

Antech's goal for this project was to sort soil in real-time during excavation such that a high degree of confidence was established that the activity concentration of soil returned to the excavation was well below the specified risk based limit. To accomplish this, a semi-quantitative relationship between the instrument response (in counts per second) and the approximate activity concentration was established by making measurements of a well-characterized soil standard containing radium. The Antech bulk soil sorting system (BSS) used a pair of 8" x 30" by 1" plastic scintillator detectors with ganged signals totaling more than 3,000 cm^2 of measurement area. Two detector arrays denoted Serial Number 0001 and Serial Number 0002 were purpose- built by Antech. This instrument, and its semi-quantitative calibration are described in detail in Antech document (14)241_SOIL_CAL_16JUN2016, Soil Sorting System Semi-Quantitative Calibration Report.

The expected count rate at the assigned limit of 220 pCi/g for depleted uranium, based on the semi-quantitative calibration was approximately 10,000 counts per second with the detector system. One could therefore conclude that the activity concentration of a bucket load of excavated soil with a net count rate of less than 10,000 counts per second was likely below the risk based limit. Antech took a conservative stance and established this limit at 9,000 counts per second for the BSS.

The instrument was used in two modes; attached to a hoist, allowing the operator to position the array directly onto soil as it was excavated (in the bucket) (see Fig. 17) and on the soil surface, typically for collecting representative background measurements. This instrument was operated by a PC using Antech software. Raw total count rate (in counts per second) were collected and recorded for each measurement.

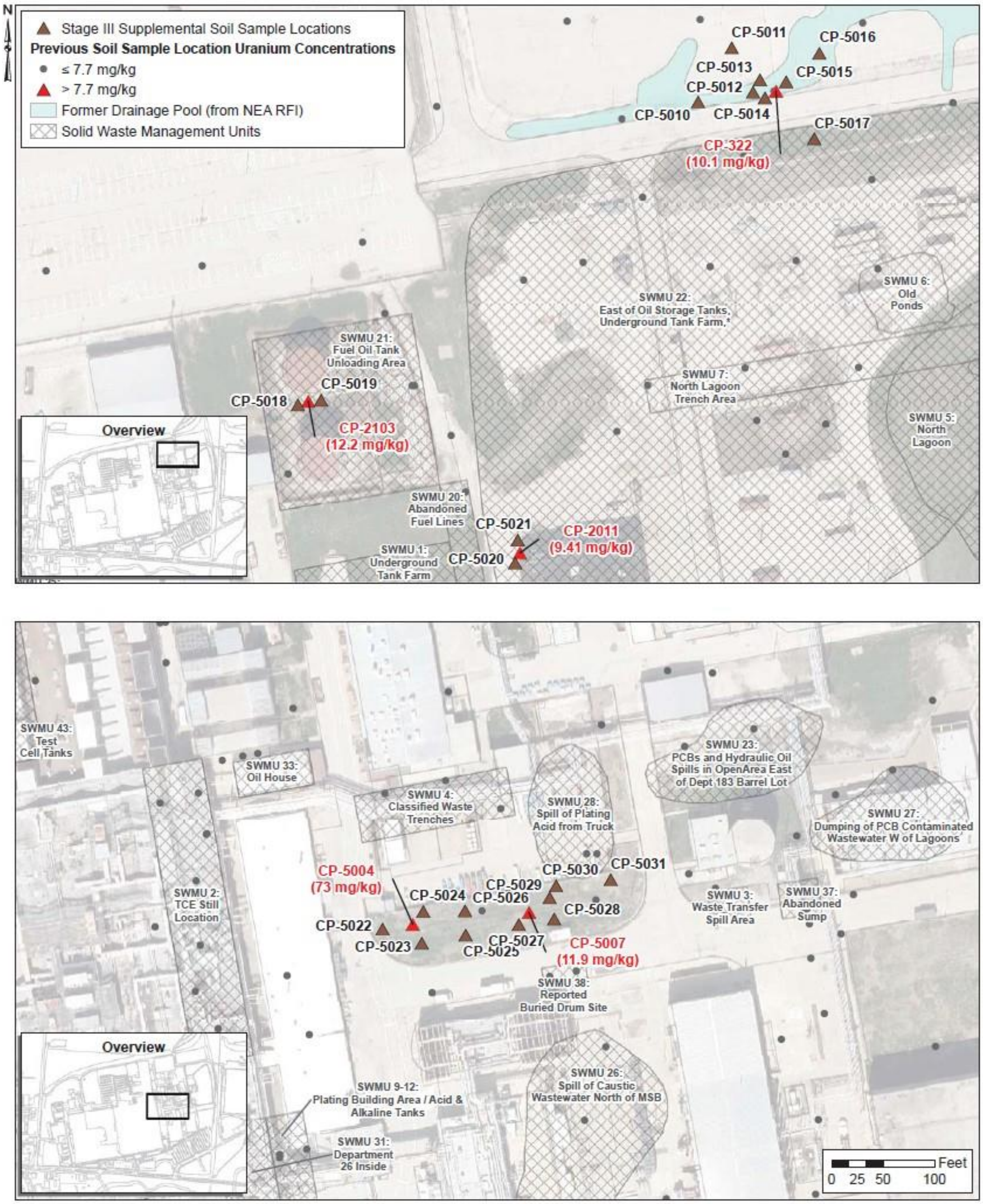

Figure 14: Location of Stage III Supplemental Borings

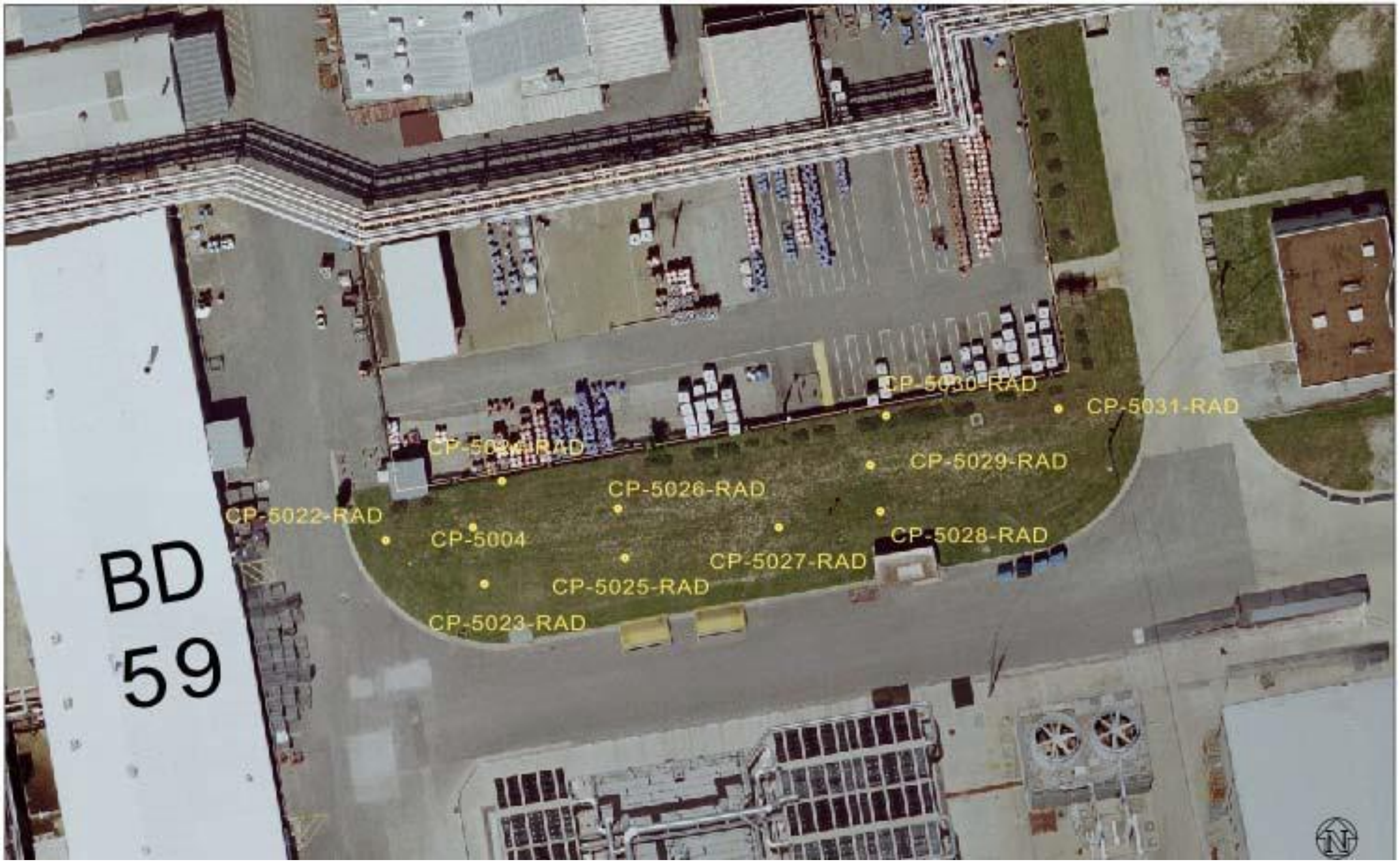

Figure 15: Map of Boring Locations for Stage III Supplemental Sampling

The Antech software used by the BSS has a feature that notifies the operator in the event the background subtracted net count rate exceeds a measurement limit that was set to the cut limit of 9,000 counts per second. So, in practice, field personnel considered any measurement by the BSS above the cut limit as suspect. During all of the excavation activities, there were no measurements where the BSS yielded results greater than the cut limit. However, field analysis of soil by a portable sodium iodide (NaI) survey instrument (Gamma scanner) did reveal isolated count rates over 9000 cps which prompted additional activity as discussed below.

4.7.1 Site Control and Preparation

Due to the low potential for contamination, no engineered controls were necessary other than to restrict access by use of a chain-link fence.

4.7.2 Excavation

A Caterpillar Model 324E hydraulic excavator was used for the excavation using a 36" bucket with a 48" bucket used when filling in the excavations. A hydraulic breaker excavator attachment was available to break up thick cement slabs if encountered, but was not used.

The objective was to separate soil into contaminated or clean-fill. As each bucket-load of soil was removed from the excavation, it was measured and sorted. Bucket-loads of soil measured with the BSS with activity less than the cut limit were placed in a clean-fill pile. Although a Supersack was in place for collection of contaminated soil, there were no bucket-loads with measured activity exceeding the cut limit, and the Supersack was not used.

Field personnel also visually inspected bucket-loads of interest. Additionally, each bucket-load of interest was scanned with the Gamma Scanner.

Excavation included areas surrounding three boreholes, CP-5026, CP-5027, and CP-5004.

CP-5026

Bore hole CP-5026 (Figure 18) was excavated due to the elevated count rate observed at this bore hole. The background observed using the Gamma Scanner was roughly 8,000 cps. At a depth of 16-18" in borehole CP-5026, Gamma Scanner readings were 180,000 cps. Prior to excavation, there was an observable layer of top soil followed by 8-10" of gravel starting at 6-8" below ground surface. The bore hole had been filled in with clumps of dirt below this level. The gravel was observed around the entire circumference of the bore hole. A yellow rock like material about the size of a plum and yellow staining was also noted within the gravel layer on the southeast side of the bore hole about 16-18" below ground surface. This was the same level where the Gamma Scanner was reporting 180,000 cps.

Color Codes			
	CP5026 bore hole		Cement storm sewer
	Safety area while excavating CP5026 bore hole		PVC water and 240 V electric
	CP5027 bore hole		Fire protection line
	Safety area while excavating CP5027 bore hole		1300 kV electric
	CP5004 bore hole		Cast iron water line (broken)
	Safety area while excavating CP5004 bore hole		
	Cement footings		
	Cement slab		
	Excavation boundary		
	Wood fence		
	Safety fence		

Figure 16: Excavation Site Description (not to scale)

Figure 17: Excavator Bucket with Bulk Soil Sorting System

Figure 18: Borehole CP-5026 Excavation

Bore hole CP-5026 was excavated roughly 25’ square around the bore hole. Excavation began by removing the top soil. The location of bore hole CP-5026 was maintained. The excavator penetrated the ground in all directions in an attempt to determine the extent of what looked to be a gravel layer observed down bore hole CP-5026. The edges of the gravel layer were not discovered within the 25’ foot excavated area. The Gamma Scanner was used to locate any additional hot spots in this gravel layer. The only hot spot that was measured was immediately around the CP-5026 bore hole. The excavator operator was instructed to remove a single bucket-load of dirt approximately 24” deep centered on bore hole CP-5026. The Gamma Scanner was then used to scan the borehole area again, after which the hot spot observed around CP-5026 bore hole was no longer found.

The Gamma Scanner was then used inside the bucket on the dirt from the bore hole and a hot spot was found in the bucket. The bucket of dirt was incrementally laid out on plastic sheeting; a quarter of a bucket at a time. The Gamma Scanner was used along with visual identification to locate a plum sized yellow rock like material and 10-12 pencil eraser sized pieces of yellow rock like material that showed elevated count rates. All of the yellow rock like material was found mixed with dirt in the same general vicinity to one another. The yellow rock like material was removed to a suitable container.

Two additional bucket-loads of gravel and dirt were also removed and laid out on plastic sheeting. One bucket was roughly 5’ to the east and another bucket 5’ to the west of the CP-5026 bore hole. No additional yellow rock like material was found in these two bucket-loads.

The rest of the gravel layer approximately 15’ around bore hole CP-5026, was excavated and measured by the BSS, scanned with the Gamma Scanner, and visually inspected. No further yellow rock like material was found in the exposed gravel layer. Bore hole CP-5026 was then excavated to a depth of 40-48” in a trench 5 ½’ wide. Two shelves were created. The southern shelf had the top soil removed to expose the gravel layer underneath which remained mostly in-tact except for a small semi-circular area that was pushed off directly south of the bore hole and measured. This was done due to the PVC water line and 240 V electric line below the shelf. The northern shelf was excavated roughly 24” deep to completely remove the top soil, gravel layer, and 3-4” of clay and dirt below the gravel layer. The entire area that was exposed was 20’ north south by 22’ east west.

CP-5027

After CP-5026, bore hole CP-5027 (Figure 19) to the south east of CP-5026 was excavated. CP-5027 measured count rates around 14,000 cps using the Gamma Scanner (background in air equaled 8,000 cps). A below ground background with the Gamma Scanner was performed outside the safety fence resulting in a value of approximately 11,000 cps.

Excavation began by removing the bore hole and scanning with the Gamma Scanner. No dirt was found by the BSS to be above the cut limit. The gravel layer noted at borehole 5026 was absent at 5027. An elevated count rate was observed in the southeast corner of the excavated area. Further excavation in this direction continued with elevated count rates to the southeast.

Figure 19: Borehole CP-5027 excavation

Utility location services performed during bore hole drilling were repainted for this project and used during excavation. During excavation, two abandoned utilities were exposed that were not marked by the prior utility location services. A large cement storm line was 2’ 3” deep running north south and a cast iron water line was 1’ 7” deep running east west. The CP-5027 bore hole was drilled directly on top of the storm line as indicated by the white paint circle in Figure 19. The storm line was uncovered without incident, but the cast iron water line was damaged along a 2’ run. Several large limestone pieces were removed and left on the surface. A small wooden 2 X 4 and a piece of wood laminate board were also encountered during excavation of CP-5027.

The excavated area was 16’ east/west by 4’ north/south. The area had two pits, one to the east of the storm line and one to the west. The east pit was excavated to 5’ and the west pit was excavated to 40”.

In the southeast corner of the east pit, a small blue-gray clay layer (Figure 20) was observed below the cast iron water line. The Gamma Scanner returned elevated count rates at the clay layer and the count rate diminished above and below the clay layer. Samples of the clay layer were taken from the excavation along with other soil samples before the hole was filled. The location is noted as South Shelf floor (CP-5026-16 and CP-5026-17) in the table below. Surveys were also taken in and around the damaged cast iron water line with no radioactive contamination found. The damaged water line was not repaired and pieces of the water line were placed on the surface above the break.

Figure 20: Clay layer and damaged cast iron water line

CP-5004

Bore hole CP-5004 (Figure 21) to the west of CP-5026 was the last to be excavated. A Gamma Scanner reading down the bore hole could not be performed due to the fact that CP-5004 was filled with grout.

Excavation began by removing the borehole and scanning with the Gamma Scanner. No soil above the cut limit was found by the BSS. The Gamma Scanner did measure a count rate around 12,000 counts per second in the excavation and the soil removed from the excavation.

The entire excavation was 6' north south by 7' east west and was 3' deep with the bore hole in the middle of the excavation. Each bucket-load of dirt was measured with the BSS and no soil above the cut limit was found. A gravel layer was observed 6-8" down similar to CP-5026. Another cement footing was also uncovered in a similar fashion as found in CP-5026. Several soil samples were taken from the excavation prior to being filled. Results are shown on table below for CP-5026 (Figure 22).

Figure 21: Borehole 5004 excavation

<u>Results</u>
Aside from a small amount of yellow rock like material collected from boring 5026, all of the excavated soil was found to have activity consistent with the naturally occurring background activity in the area of the site (Antech 2016c).

All samples were submitted to a certified analytical laboratory for isotopic uranium and gamma spectroscopy analysis. ALS Environmental Labs was selected by Antech to analyze the 51 split grab samples. With the exception of one sample, the yellow rock like material from CP-5026-02; all samples came in well below the AL.

Sample locations and analytical results from the excavation are shown in Figures 22-24 below.

Sample ID	Depth (inches)	Narrative	Lab Results in Picocuries per gram		
			U-234	U-235	U-238
CP-5026-1	12	Sandy gravel Layer.	2.37 +/- 0.46	0.156 +/- 0.073	4.24 +/- 0.77
CP-5026-2	24	Gravel layer/clay.	1.13 +/- 0.25	No Detection	1.32 +/- 0.28
CP-5026-3	12	Gravel layer.	1.3 +/- 0.26	0.095 +/- 0.047	1.99 +/- 0.37
CP-5026-4	12	Gravel.	1.58 +/- 0.31	0.075 +/- 0.044	3.19 +/- 0.58
CP-5026-5	12	Floor. Gravel/crushed gravel.	1.53 +/- 0.3	0.08 +/- 0.045	2.14 +/- 0.4
CP-5026-6	12	Floor. Gravel/sand.	1.43 +/- 0.29	0.09 +/- 0.05	1.92 +/- 0.37
CP-5026-7	12	Gravel layer.	1.69 +/- 0.33	0.107 +/- 0.055	2.67 +/- 0.49
CP-5026-8	24	East face trench.	1.52 +/- 0.3	0.089 +/- 0.049	2.14 +/- 0.4
CP-5026-9	24	North face trench.	1.24 +/- 0.25	0.094 +/- 0.049	2.01 +/- 0.38
CP-5026-10	24	North face trench.	1.18 +/- 0.24	0.063 +/- 0.039	1.57 +/- 0.31
CP-5026-11	24	West face trench.	2.43 +/- 0.45	0.188 +/- 0.072	6 +/- 1
CP-5026-12	24	South face trench.	1.16 +/- 0.24	0.052 +/- 0.034	1.26 +/- 0.25
CP-5026-13	24	South face trench.	3.62 +/- 0.64	0.231 +/- 0.08	6.5 +/- 1.1
CP-5026-14	~~36~~	Trench floor.	1.53 +/- 0.3	0.109 +/- 0.053	2.57 +/- 0.47
CP-5026-15	36	Trench floor.	2.36 +/- 0.44	0.162 +/- 0.069	3.46 +/- 0.63
CP-5026-16	6	South shelf floor	1.17 +/- 0.24	0.061 +/- 0.041	1.44 +/- 0.29
CP-5026-17	6	South shelf floor	1.16 +/- 0.24	0.075 +/- 0.044	1.5 +/- 0.29
CP-5026-18	N/A	Excavated dirt pile sample.	2.67 +/- 0.49	0.188 +/- 0.075	7.4 +/- 1.3
CP-5026-19	N/A	Excavated dirt pile sample.	1.44 +/- 0.29	0.061 +/- 0.04	2.45 +/- 0.46
CP-5026-20	N/A	Excavated dirt pile sample.	1.92 +/- 0.38	0.126 +/- 0.061	3.52 +/- 0.64
CP-5026-21	N/A	Excavated dirt pile sample.	1.82 +/- 0.35	0.126 +/- 0.057	5.16 +/- 0.9
CP-5026-22	N/A	Excavated dirt pile sample.	2.62 +/- 0.5	0.213 +/- 0.084	4.74 +/- 0.85
CP-5026-23	N/A	Excavated dirt pile sample.	2.03 +/- 0.39	0.115 +/- 0.056	3.98 +/- 0.71
CP-5026-02	12	Gravel layer near bore hole .	24000 +/- 4000	4610 +/- 950	217000 +/- 35000

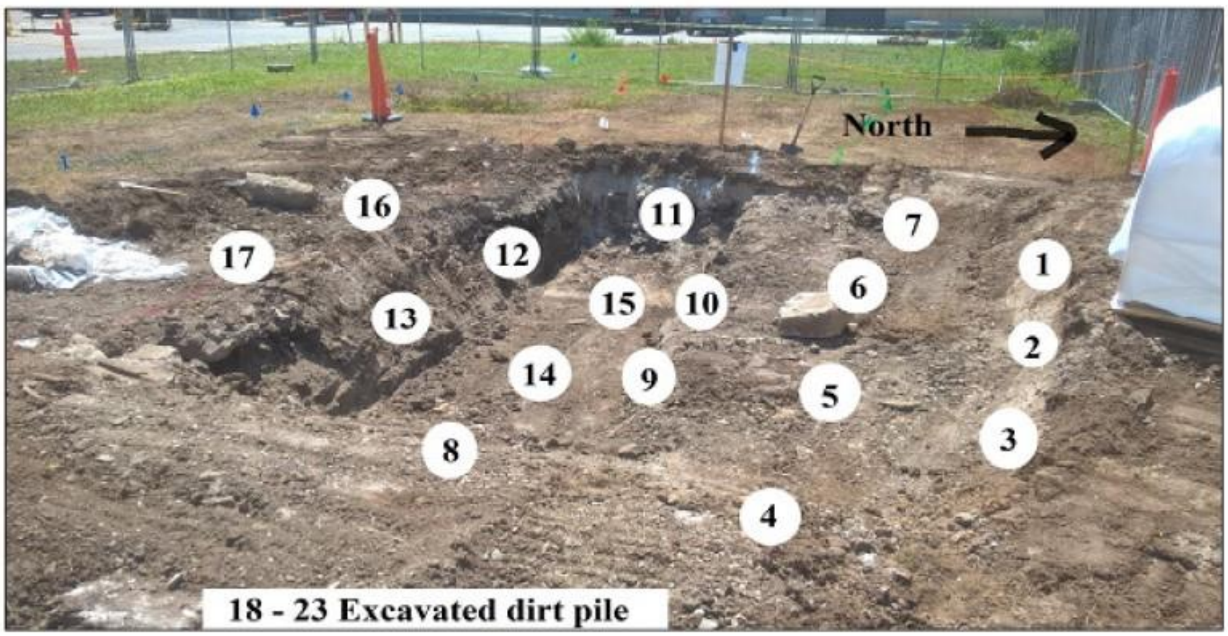

Figure 22: Sample Locations and Results near Boring CP-5026

Sample ID	Depth (inches)	Narrative	Lab Results in Picocuries per gram		
			U-234	U-235	U-238
CP5027-1	24	Clay/gravel layer.	1.28 +/- 0.26	0.081 +/- 0.047	1.29 +/- 0.26
CP5027-2	36	Clay layer. **	2.53 +/- 0.46	0.166 +/- 0.067	2.69 +/- 0.49
CP5027-3	12	Gravel layer.	1.24 +/- 0.25	0.05 +/- 0.037	1.4 +/- 0.28
CP5027-4	30	Clay/sand.	0.89 +/- 0.2	0.072 +/- 0.043	0.94 +/- 0.21
CP5027-5	18	Clay/gravel.	1.43 +/- 0.28	0.074 +/- 0.044	1.6 +/- 0.31
CP5027-6	36	Gravel/stone/dark dirt.	2.12 +/- 0.4	0.132 +/- 0.058	2.42 +/- 0.45
CP5027-7	18	Gravel layer.	1.48 +/- 0.3	0.081 +/- 0.046	1.45 +/- 0.29
CP5027-8	30	Gravel/clay layer.	1.39 +/- 0.29	0.082 +/- 0.049	1.63 +/- 0.33
CP5027-9	18	Gravel/clay.	1.29 +/- 0.26	0.092 +/- 0.048	1.49 +/- 0.29
CP5027-10	36	Trench floor. Rock/clay/dark dirt mixture.	1.26 +/- 0.26	0.075 +/- 0.046	1.36 +/- 0.27
CP5027-11	36	Trench floor.	1.49 +/- 0.29	0.076 +/- 0.044	1.59 +/- 0.31
CP5027-12	N/A	Excavated dirt pile sample.	2.03 +/- 0.38	0.073 +/- 0.041	2.04 +/- 0.38
CP5027-13	N/A	Excavated dirt pile sample.	2.03 +/- 0.38	0.12 +/- 0.056	2.18 +/- 0.41
CP5027-14	N/A	Excavated dirt pile sample.	1.3 +/- 0.27	0.072 +/- 0.045	1.41 +/- 0.29
CP5027-15	N/A	Excavated dirt pile sample.	1.15 +/- 0.23	0.066 +/- 0.04	1.25 +/- 0.25
Offsite-T1	N/A	Clay from offsite church site. **	1.21 +/- 0.25	0.095 +/- 0.049	1.79 +/- 0.34

** - The two results should be used to determine if the clay layer off site possesses similar counts as the on-site sample.

Figure 23: Sample locations and Results near Boring CP-5027

Sample ID	Depth (inches)	Narrative	Lab Results in Picocuries per gram		
			U-234	U-235	U-238
CP5004-1	18	Hard clay.	4.02 +/- 0.72	0.207 +/- 0.083	8.4 +/- 1.4
CP5004-2	12	Gravel/upper clay layer.	0.97 +/- 0.21	No Detection	1.25 +/- 0.26
CP5004-3	18	Clay layer.	2.48 +/- 0.5	0.21 +/- 0.091	7.7 +/- 1.4
CP5004-4	12	Gravel layer.	2.05 +/- 0.38	0.143 +/- 0.061	6 +/- 1
CP5004-5	18	Clay layer.	9 +/- 1.5	0.91 +/- 0.22	40.6 +/- 6.7
CP5004-6	12	Gravel/loose sand.	1.88 +/- 0.36	0.128 +/- 0.06	5.39 +/- 0.94
CP5004-7	12	Gravel/rock/clay bottom.	4.24 +/- 0.76	0.36 +/- 0.11	9.9 +/- 1.7
CP5004-8	18	Clay layer.	10.8 +/- 1.8	0.73 +/- 0.18	28.9 +/- 4.8
CP5004-9	36	Floor/gravel/dark dirt.	2.9 +/- 0.53	0.243 +/- 0.088	9.9 +/- 1.7
CP5004-10	36	Floor/gravel/stone/dark dirt.	4.14 +/- 0.73	0.261 +/- 0.089	13.2 +/- 2.2
CP5004-11	N/A	Excavated dirt pile sample.	2.53 +/- 0.47	0.149 +/- 0.065	7.2 +/- 1.2
CP5004-12	N/A	Excavated dirt pile sample.	2.89 +/- 0.52	0.142 +/- 0.061	7.5 +/- 1.3

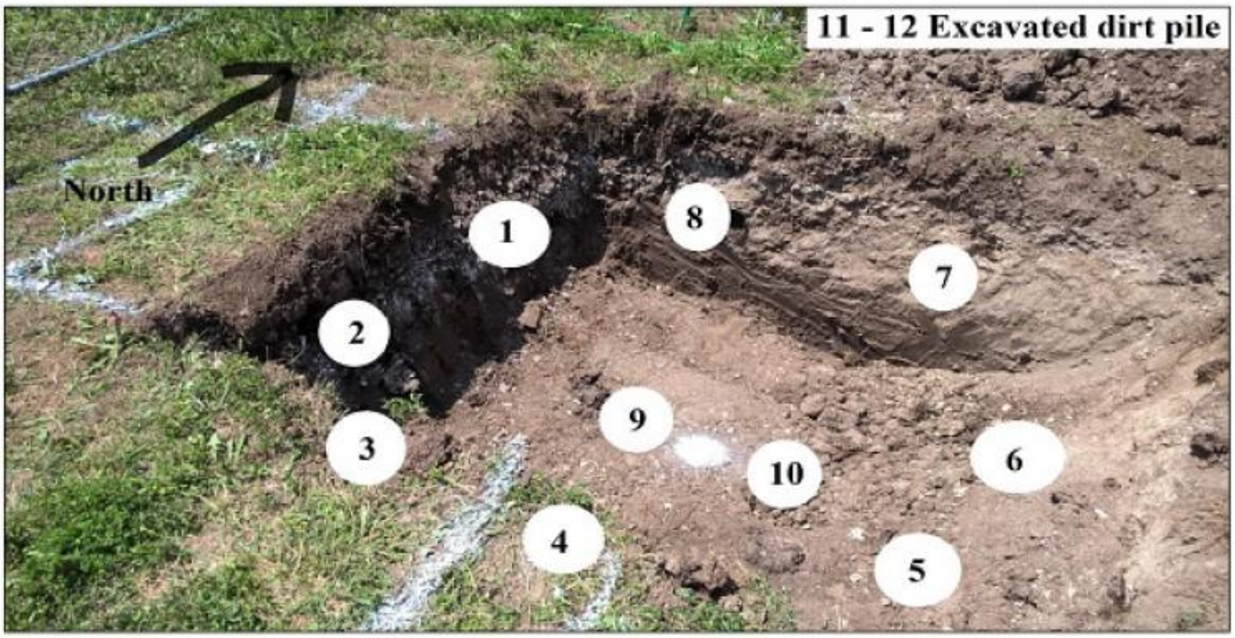

Figure 24: Sample Locations and Results near Boring CP-5004

4.8 Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM) Study

The sampling efforts described in this addendum were not explicitly conducted under the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) framework. Though not a requirement, the prospective buyer of the BFC property requested that the data collected be converted to the MARSSIM format. MARSSIM provides a nationally consistent consensus approach to conducting radiation surveys and investigations at potentially contaminated sites. Radiologic data was consolidated, organized and resubmitted in accordance with MARSSIM protocol.

This conversion project ultimately concluded that the quantity and quality of all data collected as a part of survey, characterization and as necessary, remediation of building material and soil satisfied the requirements of MARSSIM. However, prior to this, a review of the complete dataset for the site indicated that only certain peripheral areas had not had at least a cursory survey completed. "Walk-over" surveys of these areas were completed. Findings and results of these efforts are discussed below.

5.0 Walkover Surveys and Related Field Activities

A number of areas at the Bannister Federal Complex (BFC) have had ground surveys performed as a part of efforts to determine whether residual legacy radiological contamination may exist at the site. In order to provide consistency on the nature and breadth of these surveys, MARSSIM was utilized to guide the activities performed.

The provisions of MARSSIM prescribe recommendations on the aerial coverage surveys must cover based upon the likelihood of finding contamination, the known contaminant history of the area and previous remediation that may have occurred.

Impacted areas may be determined to be Class 1, 2 or 3 areas based, in general, upon the amount of information known about the area and the likelihood of finding new or additional contamination.

Three walkover surveys were performed and are described below along with resulting activities that may have occurred as a result of performing these surveys. The initial survey described as the "Antech Initial Survey" below was not utilized in the calculation of aerial coverage to address MARSSIM requirements due to a malfunction of GPS equipment in the field. However, it is nevertheless discussed here because this survey noted two areas where survey readings were above background.

Walkover surveys were performed on the dates listed below:

1. Antech Initial Survey - September 2016
2. Tidewater, October 10 – 14, 2016
3. Antech, November 4 – 9, 2016

5.1 Initial Antech Walkover Survey

The shaded area in Figure 25 was identified as a Class 3 area upon initial surveying as it was not expected to contain any residual radioactivity, or was not expected to contain levels of residual radioactivity based on site operating history or previous surveys. If contamination was found from this survey, reevaluation of the classification of contamination potential would be performed and locations that exceeded the investigation level would be flagged for further investigation.

The survey was conducted in September 2016 as survey KCP-072. This survey noted two areas that were found to be above background, the locations of which are shown in Figure 26. The first area identified as Location 1 was in a location of landscape rocks. Location 2 was initially identified as a small, (~1' x 1') localized spot shown just east of Building 96. As stated previously, results of this survey were not used nor included in calculating overall aerial walkover survey coverage.

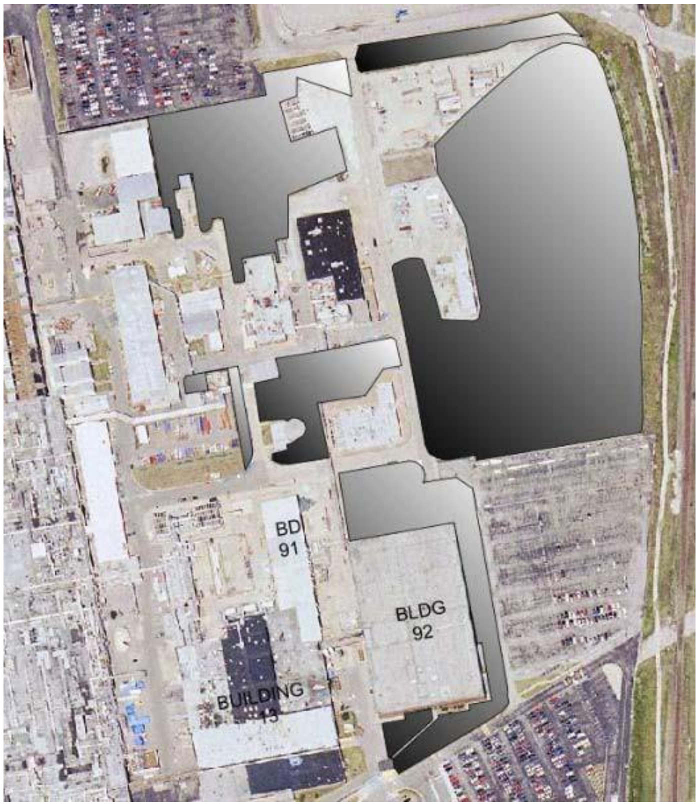

Figure 25: Grassy Areas Surveyed by Antech During the September 2016 Walkover Survey

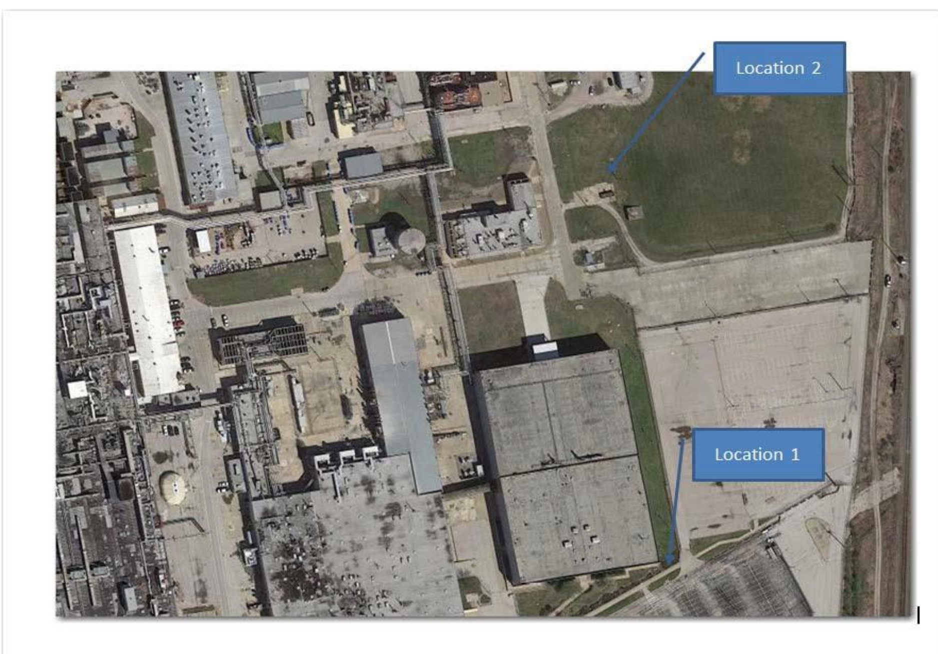

Figure 26: Locations Identified above Background from the September 2016 Walkover Survey

5.2 Tidewater Walkover Survey

Locations 1 and 2 identified in the initial Antech survey were surveyed again in October 2016 by Tidewater as a part of a larger ground survey performed in other areas of the BFC (Antech 2016e). This survey also confirmed the two locations shown in Figure 26 which corroborated the results of the initial Antech survey.

During this survey, Antech personnel who were on site with Tidewater investigated the material at Location 1 and the source was determined to be emanating from the high-density landscape rock adjacent to the building. Elevated readings (approximately twice background) were inherent to that material. Soil samples were collected by Antech from this area during this survey and upon analysis were found to be at background levels (Antech 2016d).

Samples were also collected from Location 2 by Antech during this survey with a shovel and noted a palm sized piece of blue colored material shown in Figure 27 and upon analysis were found to exhibit a thorium signature. As discussed in Section 5.4, a decision was made to further excavate the area around where this sample was collected to assure that the extent of this material was determined and removed.

Figure 27: Material Found at Location 2

Tidewater used two 3" x 3" NaI(Tl) detectors coupled with a Trimble GeoPro Global Position System (GPS) data logger to walkover the shaded areas identified in Figure 28.

These areas were originally identified as Class 3 areas as defined by MARSSIM.

The gamma walkover surveys were performed from October 10, 2016 to October 14, 2016 with the collection of 42,230 data points. The field of view of the detector when held 6" above the ground was assumed to be a 1.5 foot radius. The area seen by the detector was 7.1 square feet. With the 42,230 data points this gives 299,833 ft^2 covered by the survey.

The percentage area surveyed can be calculated as:

$$\frac{\text{Surveyed Area, } 299{,}833\ ft^2}{\text{Grassy Area size } 1{,}753{,}083\ ft^2} = 17.1\%$$

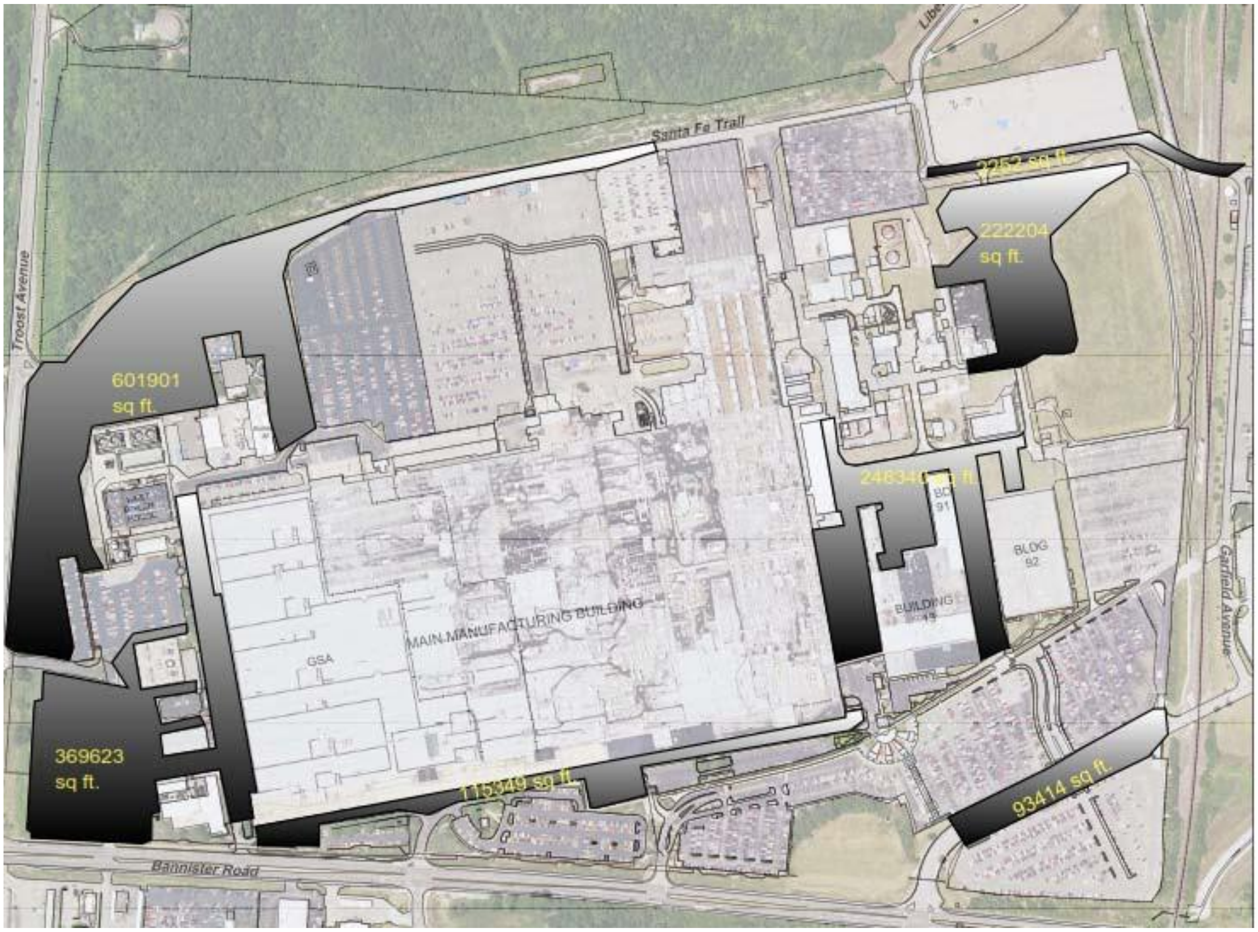

Figure 28: Areas surveyed by Tidewater in October 2016

5.2.1 Discussion

The entire survey shown in Figure 28 found no areas having indication of radioactivity above what would be considered normal background fluctuations within a normal statistical distribution.

The amount of gamma walkover surveys performed was sufficient to meet those necessary for a Class 3 survey area and actually exceed the amount needed for a Class 3 area. The consistency of the results being close to natural background fluctuations throughout the areas surveyed support the conclusion that no abnormal radioactivity is present. No further surveys were required in these areas.

5.3 Antech Second Ground Survey

In early November, Antech repeated their initial survey. The coverage area of the second survey (the same as that of the initial survey) was arbitrarily broken into sub areas (1-5) with the total area of each subarea provided below in square feet and shown pictorially in Figure 29.

The areas of these areas are given below in square feet:

The total area is surveyed as a part of this effort was 587,936 ft^2. The gamma walkover surveys were performed from November 4, 2016 to November 9, 2016 with the collection of 26,051 data points. The field of view of the detector when held 6” above the ground was assumed to be 1.5 foot radius. The area seen by the detector was 7.1 square feet. With the 26,051 data points this gave 184,144 ft^2 covered by the survey.

With a total survey area of 587,936 ft^2 the percentage surveyed was calculated as:

$$\frac{\text{Surveyed area, 184,144 ft}^2}{\text{Grassy area size 587,936 ft}^2} = 31.3\%$$

The 31.3% exceeds the typical recommended land survey guidance of greater than 10% for a Class 3 land area in MARSSIM.

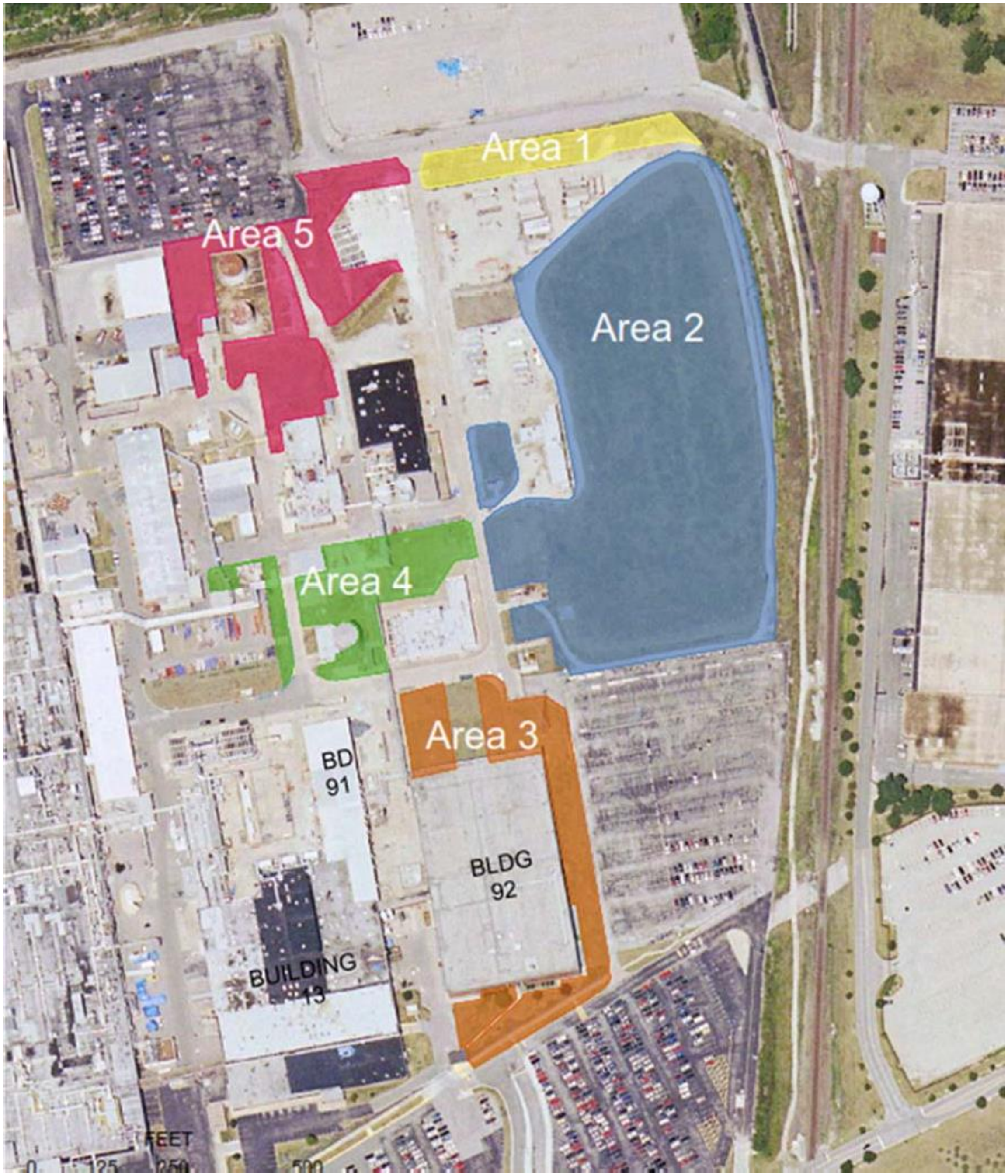

Figure 29: Antech Areas Surveyed

5.4 Excavation and Removal of Blue Material

Upon discovery of Location 2 during the initial Antech survey, Antech personnel returned to the site during the Tidewater survey to excavate Location 1 and Location 2 using a shovel. Location 2 was found to contain a single palm sized mass exhibiting a blue color and a crystalline structure, described as resembling snow melt material (Figure 27). Upon analysis of this material it was found to exhibit a radium and thorium signature with uranium at background concentrations (Tables 11-13 below).

In November 2016, the area at and surrounding Location 2, was excavated with a small backhoe (see hole 1, Figure 30). No other material with elevated readings was found at this location. The area around the initial spot was surveyed after the sample and a small amount of additional soil surrounding the sample was removed and disposed of in an approved low level waste landfill. The results of a post removal survey indicated the area was at background levels (Antech 2016d). The area surrounding Hole 1 at Location 2 was surveyed through the excavation and sampling of soil from 3 additional adjacent locations but within the general work area of 30 x 30 feet (holes 2-4, Figure 30). Upon field screening, these were found to be not impacted (Antech, 2016d). Soil samples from all excavation areas were collected to confirm the thorium concentration of remaining soil. Ten samples (#1 through 10) were submitted for analysis. These results document that the activity concentrations in the back-filled excavations were consistent with Naturally Occurring Radioactive Material (NORM) background (Antech 2016d).

The blue material itself was subsequently further analyzed for constituents consistent with fertilizer and snow melt as the sample resembled this type of material based on its crystalline structure and bluish color (Figure 27). These results were provided in Antech 2016c. Upon review of this data, it was tentatively concluded that the lack of sodium and limited chloride in the sample precluded the material being ice melt. Limited nitrate in the sample also suggested that it was likely not derived from a fertilizer. Analysis for metals indicative of a hazardous waste under RCRA was also inconclusive.

An outside consultant was tasked to review the data collected on the blue material and to perform additional analysis, if necessary. Additional analysis was subsequently performed on the material using analysis methods including but not limited to, Inductively Coupled Plasma (ICP) – Mass Spectrometry (MS), ICP Optical Emission Spectrometry (OES) and X-ray fluorescence (XRF).

A review of the analysis results performed on the material was provided in a letter report (Korte, 2017). The report concluded that the data suggested that there was a high probability that the material was copper sulfate though the nature of the sample precluded a precise determination of origin of the material including a precise cause for the elevated thorium.

5.4.1 MARSSIM Class Designation of Location 2

Upon review Location 2, Hole 1 was reclassified as a Class 1 area (Figure 31). This area was 100% surveyed for RADCON support. The work area surrounding this Class 1 area was reclassified as a Class 2 area. Specifically, the general ~30' x 30' area surrounding the Hole 1 excavation location where prior scanning was conducted by both Tidewater and Antech and additional excavations were made and soil samples collected and analyzed for the presence of contamination (Antech, 2016d). The remaining grassy areas addressed in this discussion remained Class 3 areas.

The amount of gamma walkover surveys performed in the follow up Antech survey addressed in this narrative exceeds that required for Class 3 areas. The location where a small piece of material was found and removed was reclassified as a Class 1 area with the surrounding work area reclassified as a Class 2 area. The consistency of the results being close to natural background fluctuations throughout the areas surveyed support the conclusion that no abnormal radioactivity is now present.

5.4.2 Thorium Background

Subsequent to the removal of the blue material from the site, it was concluded that removal alone did not eliminate the need for a more thorough review of the site dataset. As a result, the Oak Ridge Institute for Science and Education (ORISE) was tasked to determine if residual Th-232 concentrations in surface (top 2 ft.) or subsurface (below 2 feet below ground surface) were inconsistent with background and, therefore, would require additional study as a potential radiological contaminant. Specific objectives were to determine if Th-232 was present in elevated concentrations and to determine whether there was a discernable relationship between elevated Th-232 concentrations and elevated uranium concentrations. These objectives were completed by first compiling all Th-232 data collected across the BFC, including data in the area where elevated gamma signatures were noted and thorium containing (blue) material was found and removed. Summary statistics were generated and analytical results plotted for visual inspection. In addition, results for uranium and Th-232 were directly compared to determine if elevated uranium suggested the presence of elevated Th-232.

The data review and statistics associated with the Th-232 data, including over 230 individual analytical results, concluded that these data were consistent with background concentrations. Median and mean concentrations were almost identical with maximum results between 2 and 3 standard deviations from the average. Visual inspection identified no discernable outliers, and surface and subsurface concentrations results were found to overlap. The review concluded that Th-232 is not a site contaminant and, and additional data analysis or sample collection was unnecessary (ORISE 2017).

Figure 30: Location of excavations during remediation of Location 2

Table 11 – Location 2 Radium Data

	Depth (in)	**Ra-226 (pCi/g)**	**Ra-226 UNC (pCi/g)**	**Ra-228 (pCi/g)**	**Ra-228 UNC (pCi/g)**
L2S1D6	6	1.12	0.29	5.86	0.89
L2S1D12	12	1.31	0.28	12.90	1.60
L2S3D24	24	0.97	0.30	12.10	1.60

Table 12 – Location 2 Thorium Data

Sample	Depth (in)	**Th-228 (pCi/g)**	**Th-228 UNC (pCi/g)**	**Th-230 (pCi/g)**	**Th-230 UNC (pCi/g)**	**Th-232 (pCi/g)**	**Th-232 UNC (pCi/g)**
L2S1D6	6	5.15	0.82	1.33	0.23	4.69	0.75
L2S1D12	12	20.60	3.20	3.13	0.51	21.40	3.30
L2S3D24	24	21.00	3.30	2.78	0.45	19.70	3.10

Table 13– Location 11 Uranium Data

Sample	Depth (in)	**U-234 (pCi/g)**	**U-234 UNC (pCi/g)**	**U-235 (pCi/g)**	**U-235 UNC (pCi/g)**	**U-238 (pCi/g)**	**U-238 UNC (pCi/g)**
L2S1D6	6	0.80	0.18	0.046	0.035	0.94	0.21
L2S1D12	12	1.06	0.23	0.045	0.037	1.22	0.26
L2S3D24	24	0.79	0.18	ND	0.029	0.84	0.19

Figure 31: Class 1, Class 2 and Class 3 Areas

5.5 Summary

Walkover Surveys were performed in the fall of 2016 at the Bannister Federal Complex in support of data collection efforts to assure data quantity and quality consistent with MARSSIM requirements.

An initial ground survey performed by Antech, as well as, a follow-up walkover survey by Tidewater identified the same two locations over site background that warranted follow-up activities. The first location (Location 1) was determined to be comprised of landscaping rock. Soil samples were collected and confirmed background concentrations (Antech, 2016d).

Location 2 revealed a small amount of bluish crystalline material through excavation by shovel that exhibited a thorium signature. This material was determined to be composed of copper sulfate though a cause could not be found for the elevated thorium in the hand sized quantity of material found. Subsequent excavation with a small backhoe removed a small amount of soil immediately surrounding Location 2. Soil samples were collected from this excavation which documented that the remaining soil was at background levels. Three adjacent excavations were dug to corroborate background levels at depth. Sampling results from these excavations were consistent with that from the original excavation (Antech 2016d).

Tidewater performed a walkover survey of additional Class 3 areas of the BFC unrelated to the Antech survey. Over 17% of approximately 1.7 million square feet was surveyed with no aberrations noted.

Antech performed walkover surveys of areas within the perimeter security fence covering over 31% of an approximate 588,000 square foot area with results within expectations of normally distributed data. The majority of this surveyed area was classified as Class 3. However, reclassification of the excavation area that contained the small piece of bluish material as a Class 1 area was made with the ~30’ x 30’ area surrounding this location reclassified as Class 2 area.

Sufficient surveys have been performed to address MARSSIM recommendations based on the information known at the site and the intense comprehensive soil sampling that has occurred as part of due diligence activities. A reclassification of a small area where a piece of thorium containing material was found and removed was made with the immediately surrounding area reclassified as a Class 2 area.

5.6 Unrestricted Use/Unlimited Exposure

A significant amount of data has been collected for total radiological parameters at the BFC. By far, the most prevalent is that of soil data analyzed for uranium from a significant number of soil borings installed on site as part of due diligence investigations. DOE examined whether this comprehensive data set could be utilized to show that soil values for uranium met risk levels for residential use. Though not required, “meeting” these levels would aid redevelopment in that no potential controls for uranium in the way of land use restrictions would be required for the property.

DOE compared soil sampling data to CERCLA risk-based preliminary remediation goals (PRGs) to determine if residual concentrations were within the target risk range of 10^{-4} to 10^{-6}. The USEPA has defined the upper bound for the CERCLA risk range for radionuclides as 3×10^{-4} (EPA 2014). If residual concentrations were at or below the CERCLA target risk range for a conservative residential receptor (even though the property is zoned for industrial use), DOE could conclude that the property met the designation for Unlimited Use/Unlimited Exposure (UU/UE).

The steps that lead to the UU/UE determination for uranium at the BFC included an estimate of background uranium concentrations, an estimate of residual uranium concentrations in potentially impacted soil, and an assessment of risk from net residual concentrations.

Table 14 presents a summary of surface soil and subsurface soil background data in units of mg/kg, and the same data converted to natural uranium in units pCi/g. The first/upper half of Table 14 presents summary statistics of soil data collected in the GSA portion of the Kansas City Plant. The GSA portion shown in Figure 32 serves as a background location in that no documented industrial activities were known to have been performed in this area. This uranium data was copied into ProUCL software (EPA 2013) and summary statistics generated. .

The second/bottom half of Table 14 presents the same data converted from mg/kg to pCi/g using the conversion factor of 0.7, derived using the Health Physics Manual of Good Practices for Uranium Facilities (INEL 1988) rule of thumb for natural uranium. Once again, this data was copied into ProUCL to generate the summary statistics generated.

Table 14 Summary of Surface and Subsurface Background Soil Data

Uranium Data from the GSA Property (mg/kg)			
Parameter	**Units**	**Surface Soil[a]**	**Subsurface Soil[b]**
Observations	Unitless	103	177
Minimum	mg/kg	0.96	0.55
Maximum	mg/kg	4.3	3.3
Standard Deviation	mg/kg	0.48	0.41
Mean	mg/kg	1.7	1.3
Median	mg/kg	1.7	1.3
UCL95	mg/kg	1.8	1.4
Uranium Data from the GSA Property (pCi/g)			
Parameter	**Units**	**Surface Soil[a]**	**Subsurface Soil[b]**
Observations	Unitless	103	177
Minimum	pCi/g	0.7	0.39
Maximum	pCi/g	3.0	2.3
Standard Deviation	pCi/g	0.3	2.3
Mean	pCi/g	1.2	0.9
Median	pCi/g	1.2	0.9
UCL95	pCi/g	1.3	1.0

Of all the uranium samples that have been collected across the BFC results from a ~1,500 ft^2 area just to the east of Building 59 exhibited low level isolated concentrations of uranium above the background values listed in Table 14 (Figure 32). Residual uranium concentrations in this area represent the highest site-wide potential for producing a human health risk above the CERCLA target risk range and are, therefore, the focus of this discussion. Available data from the Building 59 area includes a combination of results reported in mg/kg or pCi/g. As with the background dataset, mg/kg results were converted to pCi/g. Based upon review of the data, a conversion factor of .49 for depleted uranium was used.

As with the background data, the Building 59 area samples were divided in surface and subsurface intervals using the aforementioned rules.

Risk from Residual Uranium

Risk estimates were calculated in excess of that generated by background concentrations (i.e., calculations excluded the risk from background concentrations). Because risk and concentration are directly proportional, risk from residual concentrations can be estimated as follows:

Residual Risk = ($UCL95_C$ - $UCL95_B$)×(Risk Level)/PRG)

Where:

- $UCL95_C$ is the depth-interval-specific value for the Building 59 area (pCi/g),
- $UCL95_B$ is the depth-interval-specific value for the background area (pCi/g),
- Risk Level is the selected risk from Table 3 (unitless), and
- PRG is Table 15 value that corresponds to the associated Risk Level (pCi/g).

Table 15 presents the human health risk estimate by depth interval. The results show a net surface soil concentration of 2.2 pCi/g corresponds to a lifetime risk of $4x10^{-5}$, and a net subsurface soil concentration of 6.0 pCi/g corresponds to a lifetime risk of $1x10^{-4}$. Both risk levels are within the CERCLA target risk range of 10^{-4} to 10^{-6}.

Table 15: Surface and Subsurface Background Risk Estimates Uranium Data from the GSA Property (mg/kg)

Parameter	Units	Surface Soil	Subsurface Soil
$UCL95_C$ (Gross Concentration)	pCi/g	4.3	8.0
$UCL95_B$ (Background)	pCi/g	1.3	1.0
Net Concentration	pCi/g	3.5	7.0
Risk Estimate	$Lifetime^{-1}$	$7x10^{-05}$	$1x10^{-04}$

The ORISE document concluded that the concentrations of uranium in soils at the BFC are below levels that would be of concern for human health and the environment. As a result, institutional controls were deemed not to be required for uranium in soil even when conservatively considering hypothetical residential future-use scenarios. Based on the evaluations conducted, the levels support a UU/UE determination for uranium.

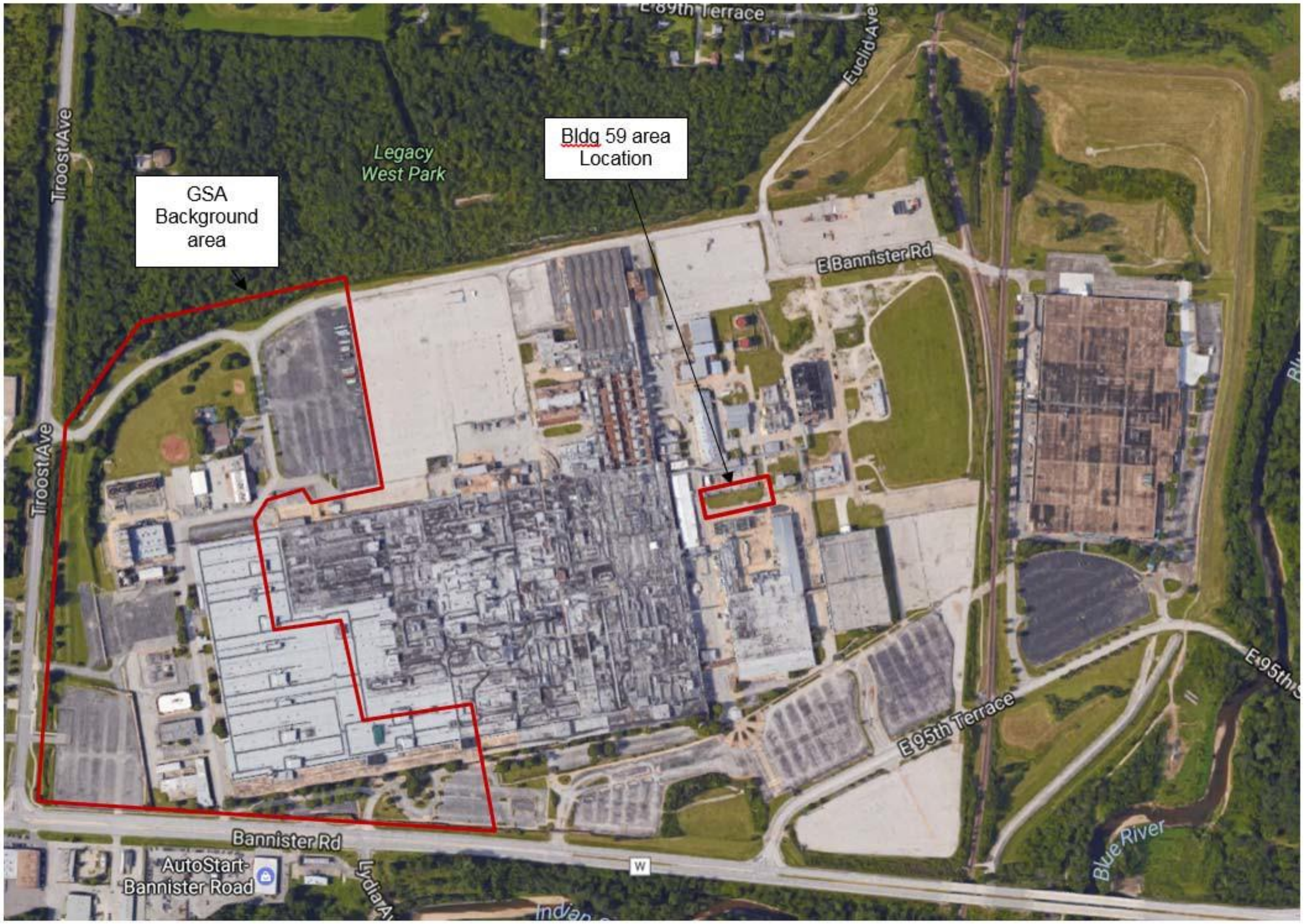

Figure 32: Background and Building 59 Area Boundaries at the Bannister Federal Complex

6.0 Conclusion

This addendum to Section 7 of the DCCR was written to document activities related to radiological investigation of buildings and soils at the BFC since the last update of this Section in 2014.

Areas which formerly managed either depleted or natural uranium within the DOE Kansas City Plant were identified, surveyed and remediated as necessary. Independent verification of remedial activities completed as a final status survey was performed by the Oak Ridge Institute for Science and Education (ORISE) to allow release of the DOE property under DOE Order 458.1. All building areas were remediated to pre-approved alternative limits for surfaces outlined in the Order allowing release and clearance of the DOE property.

Soil analytical data, including uranium analysis from over 1800 samples derived from over 500 soil borings drilled at the BFC as a part of due diligence activity by a prospective buyer of the property were evaluated. From this comprehensive effort, one soil boring was found to exhibit concentrations of uranium over authorized limits developed by ORISE for uranium 238. The area in question was then investigated to determine the extent of elevated uranium concentration. Soil in the area was excavated and screened to a conservative risk based value. From this investigation a single small piece of rock like material with associated fragments were found at a shallow depth immediately adjacent to the single boring that exhibited elevated activity. This material was removed from the site and analyzed and found to consist of depleted uranium. Additional excavation was conducted in adjacent areas surrounding the single boring as well soil surrounding to two other borings in the area with no results exceeding the conservative project specific screening value.

The location of the single small piece of depleted uranium in a grout matrix corresponds to an area of the facility historically used of manage waste. It is possible that the material found was spilled during the mixing of liquid depleted uranium containing waste with grout to solidify the material for offsite transport and disposal. The plausibility of this scenario is based on the location as well as the very shallow depth at which the material was found.

After sampling and remediation were completed, a decision was then made to apply MARSSIM protocol to data collected to date. This effort concluded that MARSSIM requirements were satisfied. In effect, all data collected at the site was sufficient in quality and quantity to satisfy MARSSIM requirements.

A review of the complete dataset for the site indicated that the only areas that had not had at least a cursory survey to be conducted to be consistent with MARSSIM were located in selected grassy areas. Those areas were addressed by “walk-over” surveys of approximately 17% and 31% respectively of these remaining Class 3 areas. From these surveys one small area was noted where subsequent investigations confirmed the presence of a palm sized piece of crystalline material similar to ice melt in the shallow subsurface that exhibited a thorium signature. This material was excavated and removed. Results from follow up sampling of remaining soil was consistent with background concentrations. The actual blue colored material was sampled and is believed to be primarily composed of copper sulfate.

A thorium background value was calculated for the BFC. This document concluded that thorium results for the site were consistent with this background concentration and that Thorium 232 was not a site contaminant.

Finally, existing radiologic data for the BFC was evaluated against residential risk values that would serve to assure that institutional controls for radiologic materials would not be required.

7.0 References

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Appendix A
Synopsis of Historical Phrases and Terms

As an additional effort to define legacy practices regarding radiological materials, a review of certain terms or departmental names was conducted and narrative provided for additional explanation in order for readers to gain a better understanding of these terms and departmental areas. The names, some raised by MDNR, were noted during review of historic legacy documents. These terms or departmental areas are discussed below:

1. **Cobalt-60** (Co-60): Half-life 5.3 years. No release of this material occurred. No radioactive material or contamination concerns.

Co-60 use at the KCP was primarily limited to sealed sources for calibration. Other known uses of Co-60 were in: sealed gap tubes of the MC-3 "Albert" radar in amounts less than 1.0 microcurie between 1952 and 1958 and an 18 millicurie source was used in D/60 (T-290 Testing Crib) from January 1957 through June 1958. When not in use, the T-290 source was always stored in a lead pig in D/213 (Industrial X-Ray). Narrative provided for informational purposes only.

2. **Cesium-137** (Cs-137) Pellets: Half-life - 30.2 years. No release of this material occurred. No radioactive material or contamination were noted.

Production use of Cs-137 occurred between 1957 and 1958 on the MC-633 Project by placing two pellets (40-50 microcuries each) within a 'capsule', which was then potted. Radiation measurements at the surface of the MC-633 was 8-10mR/hr. Part #601756-1 contained 50-70 microcuries of Cs-137 each. Six additional Cs-137 Pellets (Part #1421057-1) similar to the MC-633 parts were documented to exist. Contamination potential for these 'pellets' was minimal since these parts were encapsulated. Other production use of Cs-137 is referenced in Classified Document SC1509 SP for MC-74.

The MC-74 Production and Disassembly Areas assembled and scrapped brass gap tubes (M-26-3) containing Cs-137 from 1950 through 1956. NIOSH found no evidence that gap tubes (containing Cs-137) were manufactured at KCP; however, there are reports that Bendix Aviation Co. did manufacture gap tubes in New Jersey (Schiltz, Jun1962; Grant, 1962). Narrative provided for informational purposes only.

3. **Magnesium/Thorium Machining**

From May 1, 1957 to April 5, 1979 - Classified items with a Mg-Th alloy were machined and fabricated in two areas of the Main Manufacturing Building (Department 20 and the Model Shop). It was originally thought that this machining began in May of 1957 but NIOSH later

determined that machining of Mg-Th was conducted off-site from 1957-1961. Department 20 was investigated in 1985 and remediated (Rockwell, 1985). No evidence of thorium contamination was noted upon investigation in either D/20 or the Model Shop. Contamination by uranium was confirmed in D/20 and addressed in 1985 and again in 2015 as discussed in this document.

4. **Metal Tritides:** half-life of tritium (H^3) - 12.3 years.

Metal Tritides are metals organically bound with tritium within an instrument. Thought to be used in controlatrons which are still used today to create the neutron pulses in Telemetry. There is no evidence of any release from this activity.

5. **Department 96** (disassembled triggers).

There is no indication of 'triggers' being disassembled in a Building 96 (Department 96) or what materials 'triggers' may be composed of. Building 96 is discussed in Section 2.1 of this document.

6. **Erbium tritide**: half-life of tritium (H^3) - 12.3 years

There was spillage within a data analyzer instrument in September of 1989 (Nasca personal communication with G. Wolf March, 2016). On August 12, 1987, a Data Analyzer that contained erbium tritide was received from Sandia National Laboratory. On September 30, 1987, a KCP worker removed the analyzer's protective cover. The analyzers were known to be exposed to tritium during operational testing at Sandia; however, they were normally decontaminated prior to returning them to KCP for follow-up testing. The outside cover had a visibly clean appearance, but when the worker removed the cover it was apparent that the interior was not cleaned as was required. The cover was immediately replaced and the Health and Safety group was contacted. The next day, swipe samples were taken inside and outside of the cover of the assembly and taken from nearby work surfaces. Contamination was only detected on the inside of the cover at 986 dpm/100 cm^2. The Data Analyzer was returned to Sandia National Laboratory for decontamination. Urinalysis was performed for the worker who opened and closed the case and the results indicated that there was no detectable activity for tritium as erbium tritide (solubility class M from *International Commission on Radiological Protection (ICRP) Publication 71*). As a result of this incident, procedures were upgraded at Sandia National Laboratory and the KCP to ensure that similar incidents would not occur in the future (Tritium Incident, 1987). KCP Health Physics personnel were asked about this incident in August 2013, and they informed NIOSH that this incident was unique and did not reoccur (Personal Communication, 2013t).

7. **Thorium Oxide Powder Operations**

NIOSH located a KCP reference that was included as part of a chronological list of radioactive material at KCP, and the reference reads, "July 23, 1958 to July 1959 – Thorium oxide ThO_2 powder was handled in the plant" (KCP, 1950-1963, pdf p. 12). Inventories of radiological sources were also found and the inventories show that the KCP used some ThO_2 sources and that the KCP made a thorium nitrate solution at a rate of 20 grams per year (Rad Inventory, 1989). With the information that NIOSH currently has available, including personal communication with KCP site experts (Personal Communication, 2013), it appears that KCP ThO_2 operations were limited to laboratory analysis and solution preparations used in analytical procedures. No release of this material occurred. Narrative provided for informational purposes only.

8. **Site 14:**

This is believed to be a reference to 'Crib 14' (old D/20A and D/33) that performed DU operations and is referenced in 7.2.2 - Depleted Uranium (DU) Operations. There is no indication that a Site 14 exists.

9. **Promethium-147 Incident, February 10, 1989**

Pm-147 is a relatively low-energy, 100% beta-emitting nuclide (e.g., maximum energy of 224.7 keV, average energy of 62 keV) with a half-life of 2.6 years. The primary concern with this type of nuclide ould be direct skin contamination and intake.

Pm-147 sources were used to measure film thickness at KCP. Failure of the integrity of one of these sources resulted in some minor skin contamination and was the subject of an official investigation; however, there were no personal internal exposures.

On Friday, February 10, 1989, loose radioactive contamination was discovered on top of an X-ray fluorescent unit in Department 456, Non-Destructive Test (NDT) Laboratory. This discovery was made during a routine radiological survey of an X-ray fluorescent unit by two industrial hygiene personnel.

Subsequent investigation identified loose radioactive contamination on a nearby laboratory stool and on the hand of a member of the survey team. Further checks revealed contamination in the following areas: the NDT Laboratory; the D/456 office area directly above the NDT Laboratory; the stairway connecting the NDT Laboratory area and the D/456 office area; D/33, Precision Pattern Assembly Area (Room E) containing beta backscatter equipment; and one employee's residence.

Decontamination activities conducted by the DOE-Albuquerque Complex and Rockwell International health physics teams revealed that loose radioactive contamination in the previously mentioned areas was extensive and widespread. Rockwell International, by using gamma spectral analysis, positively identified samples of the KCP contamination as Pm-147. This contamination was caused by fragile and unsealed Pm-147 sources, fabricated by Oak Ridge National Laboratory, which had been treated as sealed by the KCP. Inadequate monitoring and control failed to reveal that these Pm-147 sources were unsealed prior to this investigation.

According to an extensive investigation report, DOE, EPA, and Missouri Department of Health, Radiological Health Division representatives were notified at the time of this incident. A DOE team of investigators arrived at KCP on February 14, 1989, to assume technical management of the situation. The analytical laboratory that evaluated 97 urine samples from KCP personnel had initially reported 4 of those samples as having activity. A few days later the laboratory determined that they had made an error and there was actually no activity present in any of the samples (AlliedSignal, 1989). The homes of [redacted] KCP workers were inspected and some contamination was found in one home. That home was decontaminated, the cause and extent of the contamination was determined, and corrective actions were put in place to prevent reoccurrences. No contamination remains from this event.

Appendix B

Bibliography of Historical Documents Related to Radiological Activities

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