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REMOVAL SUPPORT TEAM 3
EPA CONTRACT EP-S2-14-01

May 15, 2017

Mr. Daniel Gaughan, On-Scene Coordinator
U.S. Environmental Protection Agency, Region II
Removal Action Branch
2890 Woodbridge Avenue
Edison, New Jersey 08837

EPA CONTRACT NO: EP-S2-14-01
TDD No: TO-0007-0023
DC No: RST3-03-F-0130
SUBJECT: FINAL PHASE III REMOVAL ASSESSMENT TRIP REPORT – CANADIAN RADIUM AND URANIUM CORP. SITE, MOUNT KISCO, WESTCHESTER COUNTY, NEW YORK

Dear Mr. Gaughan,

Enclosed please find the Final Phase III Removal Assessment Trip Report for the activities conducted at the Canadian Radium and Uranium Corp. Site located in Mount Kisco, Westchester County, New York. This phase of the Removal Assessment was conducted on December 12 through 14, 2016. The U.S. Environmental Protection Agency's comments to the prior version of the report (DC No: RST3-03-D-0206) have been incorporated.

If you have any questions or comments, please contact me at (732) 585-4413.

Sincerely,

WESTON SOLUTIONS, INC.

Bernard Nwosu
RST 3 Site Project Manager

Enclosure
cc: TDD File: TO-0007-0023

FINAL PHASE III REMOVAL ASSESSMENT TRIP REPORT

CANADIAN RADIUM AND URANIUM CORP. SITE
MOUNT KISCO, WESTCHESTER COUNTY, NEW YORK

Prepared for:

U.S. Environmental Protection Agency
Region II – Removal Action Branch
Edison, New Jersey 08837

Prepared by:

Removal Support Team 3
Weston Solutions, Inc.
Edison, New Jersey 08837

DC No.: RST3-03-F-0130
TDD No.: TO-0007-3023
EPA Contract No.: EP-S2-14-01

May 2017

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REMOVAL ASSESSMENT TRIP REPORT

SITE NAME: Canadian Radium and Uranium Corp. Site
DC No.: RST3-03-D-0206
TDD No.: 0007-0023
CERCLIS ID: NYD987001468
EPA ID: A23P
EVENT DATES: December 12 through 14, 2016

1.0 Site Location:

The former Canadian Radium and Uranium (CRU) facility is located to the east of Kisco Avenue and to the west of railroad tracks in the Village of Mount Kisco, Westchester County, New York, in a primarily suburban residential and commercial area. The historic property on the Canadian Radium and Uranium Corp. Site (the Site) is 2.72 acres and is currently occupied by a landscaping business (103 Kisco Avenue) and a stone, masonry, and landscaping business (105 Kisco Avenue). The Site is bounded by Kisco Avenue to the west, southwest, and northwest; railroad tracks to the south, east, and northeast; and a large, privately-owned warehouse to the north and northeast. (Refer to Attachment A, Figure 1: Site Location Map)

2.0 Site History

From 1943 until approximately 1966, the CRU facility operations included the recovery of uranium and other radioactive elements from uranium-bearing sludge, old instrumentation, and watch dials. This work began as part of the federal government's Manhattan Engineering District (Manhattan Project). From 1943 to the 1950s, the primary product was uranium; subsequently, radium became the principal product until the facility's closure. According to a Village of Mount Kisco memorandum, in 1957, CRU pleaded guilty to charges of allowing three employees to be overexposed to radiation. From March 5, 1958, until sometime after May 19, 1961, decontamination procedures and expectations were established for the CRU facility.

In November and December 1966, the facility buildings (a two-story concrete block building and two smaller one-story concrete block buildings) were decontaminated and demolished. Removal of radioactive dirt to a depth of 12 inches was required on the CRU premises. The most contaminated demolition materials were disposed of by Nuclear Diagnostic Laboratories located in Peekskill, New York, while the less contaminated materials were disposed of at Croton Point Sanitary Landfill located in Croton-on-Hudson, New York. After decontamination and demolition, a post-operation survey was conducted by Isotopes, Inc. Two locations on the Haggerty Millwork wall, which originally shared a wall with the former CRU facility that was demolished during the 1966 decontamination and demolition process, were found above specifications. One contaminated location was removed by chiseling out the masonry of a wall. The second was a result of tailings from a leaking waste drum which CRU had stored on the second floor fire escape. Since contamination was low here, the area was sealed with 1 to 2 inches of mortar. Railroad Avenue was constructed where the main CRU building once stood and was put in place by the urban renewal efforts in the area. Between 1964 (pre-decontamination/demolition) and 1971 (post-decontamination/demolition), the building layout of the former CRU facility completely

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changed, and it is believed that none of the original CRU facility buildings remained after the year 1971.

On April 5, 1979, a local newspaper reported the 1957 death of the CRU plant manager due to leukemia from high radioactivity levels found in his body. On April 20, 1979, a survey was performed by the Assistant Commissioner of Health for Environmental Quality, Westchester Department of Health. Based on the surveys, the highest dose rates were found in a small portion of a locked, chain-link fenced area south of the old wood freight station on Railroad Avenue and east of the L. B. Richard's Lumber yard (*i.e.*, an area located adjacent to the railroad). All other elevated dose rates were found in areas covered by soil and vegetative growth. The 1979 investigation reported that the high readings were obtained from an area covering approximately one square yard (sq. yd.) of the property in an area not used by the public. In addition, the report indicated that the dose rates found did not pose a public health hazard to persons passing the fenced area, to persons working in buildings adjacent to the area, or to persons living across the railroad tracks to the east.

In a memorandum dated February 7, 1980, the Westchester County Health Department described investigation findings in more detail. The area in question was approximately 78 feet by 60 feet, enclosed by a chain-link fence located between the railroad tracks and a concrete paved area. The most significant contaminated area was a strip 15 feet by 5 feet, containing two separate "hot spots". A surface reading using an alpha probe survey meter measured 50 disintegrations per minute (dpm). Elevated readings several times above background were reported for an area extending about 50 feet south from the chain-link fence. The memorandum stated that the origin of this contamination was unknown and that it was not discovered in previous surveys.

In September 1993, the Bureau of Environmental Radiation Protection of the New York State Department of Health (NYSDOH) completed a survey of the Site; indoor radon measurements were collected (*i.e.*, office, show room, storage/sale floor) which documented a maximum concentration of 9.8 picocuries per liter (pCi/L), and the average of the different detectors was about 8.1 pCi/L. The NYSDOH also identified two outdoor areas where presence of radioactive materials were indicated at the back of Richard's Lumber, and the road that runs next to the railroad tracks and adjacent to a fence post inside the fenced portion of what appeared to be Richard's Lumber property on the south side of Railroad Avenue.

In 1994, the U.S. Environmental Protection Agency (EPA) conducted an on-site inspection to measure radon levels, collect air and soil samples, and measure radiation exposure rates. The purpose of the investigation was to determine if conditions required immediate action and if the Site was eligible for long-term remediation under the federal Superfund Program. Elevated exposure rate measurements were documented on both the northern (10–700 microroentgens per hour [μR/hr]) and southern (10–240 μR/hr) portions of the Site. Radium-226 (Ra-226) concentrations in soil samples taken from the top 1.5 feet ranged from 3 to 150 picocuries per gram (pCi/g). All of the radon measurements were below EPA's guideline (*i.e.*, 4 pCi/L) and the air samples collected at the Site did not indicate any radioactive contamination.

In July 1998, a complete radiological survey of the Village of Mt. Kisco and Richard's Lumber (former CRU) was conducted by the New York State Department of Environmental Conservation (NYSDEC). The property owned by the Village of Mount Kisco (103 Kisco Avenue) was found

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to have contamination over one large unpaved area [approximately 4,000 to 5,000 square feet (ft^2)] and a few smaller areas. The 1998 report stated that on the Mt. Kisco property, the highest concentrations of radium observed were a few hundred pCi/g and that most of the contamination was in the top 1 foot of soil. The report stated that the distribution suggests that uranium-containing material was placed on the surface and then the area was leveled. A new road (Railroad Avenue) had been built where the CRU facility once stood; soil sampling completed near the road showed elevated concentration of radium a few feet below the surface. The NYSDEC reported that the distribution of radioactive material near the road appeared to be consistent with movement of soil as part of the building demolition and subsequent construction of the road. Sampling beneath the road surface was not performed. There is no documentation of shielding or other control measures implemented on the 103 Kisco Avenue property, though current conditions suggest that the property had been recently paved with asphalt (of an unknown thickness) or other cover materials.

The 1998 report further stated that the survey of the Richard's Lumber (105 Kisco Avenue) property indicated that radioactive materials were present under the parking lot, but no samples were taken beneath the asphalt. The highest concentration of radium at the Site was found just north of Railroad Avenue (approximately 6,000 pCi/g). A large part of the main outside storage area was reported to be contaminated with radium near the surface as well as within some soil profiles to depths of approximately 4 feet. Survey data suggested that the contamination stopped abruptly at the edges of the paved areas. Railroad Avenue showed count rates that were lower than background soils; NYSDEC attributed these results to absorption by the road surface material (*i.e.*, shielding). The July 1998 report indicated that radiation doses to workers or visitors to the Site as it was being used at the time were not significant. The Site location where the dose rate was highest was a small area near Richard's Lumber, just north of Railroad Avenue. Time spent at this location was small; therefore, the accumulated dose was also estimated to be small. The July 1998 report suggested that significant radium contamination was present on both Mt. Kisco and Richard's Lumber properties. The NYSDEC did not consider the Site to be fully characterized at the completion of the survey.

In September 2013, Weston Solutions, Inc., Site Assessment Team (SAT), performed an on-site reconnaissance and gamma radiation screening of the historic CRU property and other suspected areas of contamination. Background readings taken north and northeast of the Site in the right-of-way (ROW) area alongside Kisco Avenue showed background gamma radiation levels of approximately 7,500 counts per minute (cpm). The highest reading of 73,637 cpm was located on the 105 Kisco Avenue property. Most readings were below 2 times (2x) background. There were three areas with readings that exceeded 2x background, ranging from 30,000 cpm to 73,637 cpm. All three areas above 2x background were located in the back portion of the 105 Kisco Avenue property, east of the historic CRU facility. No signs of ground discoloration were observed.

In November 2013, SAT advanced eight boreholes to depths of 10 feet at the Site for gamma screening and soil sample collection. Using a gamma scintillation meter (Ludlum 2221 Scaler Ratemeter), field gamma screening data collected during the sampling event documented the gamma exposure rates at 6-inch depth intervals vertically down each sample location borehole. The soil samples collected represented the highest levels of gamma radiation recorded for each borehole. The soil samples were analyzed for isotopic thorium (thorium-228, thorium-230 and thorium-232), isotopic uranium (uranium-233/234, uranium-235/236 and uranium-238), Ra-226,

and Ra-228. Analytical results from the sampling effort suggested that there was measureable residual contamination remaining at the Site.

SAT reported in its *Final Site Reassessment Summary Letter*, dated June 11, 2014, that the Site overlies unconsolidated fluvial sands and gravels of glacial outwash origin, which comprise a water table aquifer with a saturated zone of unknown thickness and the depth of the water is estimated to be approximately 24 feet below ground surface (bgs). In addition, SAT indicated that a potential for the release of radioactive contamination to groundwater exists at the Site due to the proximity of contaminated soil to the water table. Furthermore, groundwater samples have not been collected at the Site and an observed release is not documented; however, there are 42 active drinking water wells within 4 miles of the Site.

In August 2015, EPA and Weston Solutions, Inc., Removal Support Team 3 (RST 3) conducted ground radiological survey and soil sampling at the Site, including the Metropolitan Transit Authority (MTA), Milepost 136, 103 Kisco Avenue (Property C001), Hickory Homes and Properties, Inc., 103 Kisco Avenue (Property C002), New York Stone and Building Supply, 105 Kisco Avenue (Property C003), and an off-site background location (comprising a strip mall), 145-159 Kisco Avenue (Property C004). Background gamma readings were taken at the off-site background location using Ludlum-2241 equipped with a sodium iodide (NaI) 2x2 scintillator, fluke photoionization chamber (FPIC), and high pressure ion chamber (HPIC). Background gamma readings taken with each instrument were as follows (equipment name and background reading in parenthesis): Ludlum-2241 (7,500 - 9,500 cpm), FPIC (9 - 12 μR/hr at waist height and 11 - 13 μR/hr at contact), and HPIC (8.9 μR/hr). Gamma radiation measurements collected with the Ludlum-2241 were more than 2x background at six of the 11 soil sampling locations selected throughout the Site, with values ranging from 20,000 to 180,000 cpm. At Property C003, above-background gamma readings (12,000 to 15,000 cpm) were observed in the southeast corner of the warehouse located northeast on the property. Gamma measurements collected with the FPIC indicated above-background values ranging from 9 to 15 μR/hr at waist level and 14 to 51 μR/hr at contact in the Electrical Room of the main building and from 14 to 16 μR/hr at waist level and 9 to 15 μR/hr at contact in the southeast corner of the warehouse located northeast on the property. Gamma measurements collected with the HPIC indicated above-background value of 14 μR/hr in the Electrical Room of Property C003 and at six of the 11 soil sampling locations throughout the Site with values ranging from 14.6 to 36 μR/hr. Radon/thoron measurements collected with RAD7 radon/thoron detectors did not indicate any elevated readings in exterior on-site locations.

During the August 2015 event, RST 3 collected a total of 13 soil samples, including two field duplicates, from 11 soil borings advanced to depths 4 feet bgs throughout the Site. Soil samples were collected from the interval exhibiting the highest level of gamma radiation (based on Ludlum-2241 screening data) and/or where a fill layer was observed and/or at the discretion of the EPA On-Scene Coordinator (OSC). The sampling event was conducted in order to verify the presence of residual contamination and potential releases of radiation-containing material in soil associated with the former CRU facility. The soil samples were submitted for laboratory analyses of isotopic thorium, isotopic uranium, and other alpha emitting actinides via alpha spectroscopy Health and Safety Laboratory (HASL)-300 Method A-01-R; Ra-226 (21-day ingrowth), Ra-228, and other gamma emitting radioisotopes via gamma spectroscopy EPA Method GA-01-R; and target analyte (TAL) metals, including mercury. Analytical results indicated that concentrations of Ra-226 exceeded the calculated EPA Site-Specific Action Level (provided by EPA in August 2015) of

4.06 pCi/g in two of the four soil samples collected from Property C002. Exceedance of Ra-226 in Property C002 was highest at 0 to 36 inches bgs with a concentration of 10.4 J (estimated concentration) pCi/g. Ra-226 was also detected above the EPA Site-Specific Action Level in all four soil samples, including one field duplicate, collected from Property C003. Exceedance of Ra-226 was highest at 0 to 24 inches bgs with a concentration of 129 J pCi/g. Lead concentration was above the EPA Removal Management Level (RML) of 400 milligrams per kilogram (mg/kg) in one soil sample with a concentration of 510 mg/kg. Although no Site-Specific Action Level was provided by EPA for the aqueous (rinsate) samples, based on the validated analytical results, radioisotope concentrations were generally, not detected.

In April 2016, RST 3 collected a total of 103 soil samples, including five field duplicates, from 20 soil borings at 6-inch interval up to 4 feet bgs in 15 locations and up to 8 feet bgs in five locations throughout the Site. The sampling event was conducted to identify additional source areas of radiological material at the Site. The soil samples were submitted for laboratory analyses of isotopic thorium, isotopic uranium, and other alpha emitting actinides via alpha spectroscopy HASL-300 Method U-02, radium-226 (21-day ingrowth), radium-228, and other gamma emitting radioisotopes via gamma spectroscopy EPA Method 901.1. Analytical results indicated that concentrations of Ra-226 exceeded the EPA Site-Specific Action Level (updated by EPA in April 2016) of 2.52 pCi/g in eight of the 25 soil samples collected from three locations at Property C002. Exceedance of Ra-226 ranged from 2.57 pCi/g to 89.39 pCi/g at 24 to 36 inches bgs. The concentration of Ra-226 was below the EPA Site-Specific Action Level in soil samples collected 0 to 12 inches bgs at all three soil sample locations. Analytical results indicated exceedance of Ra-226 above the EPA Site-Specific Action Level of 2.52 pCi/g in 32 of the 71 soil samples collected from 16 locations at Property C003. Exceedance of Ra-226 ranged from 2.79 pCi/g at 12 to 24 inches bgs to 926.1 pCi/g at 36 to 48 inches bgs. The concentration of Ra-226 was below the EPA Site-Specific Action Level in soil samples collected 0 to 12 inches bgs in 15 of the 16 soil sample locations.

In June 2016, EPA and the Department of Energy (DOE) independently conducted aerial overflights of the Site to determine the possibility of lateral spread of the radiation contamination. The DOE overflight indicated potential lateral spread to the west of the Site along Kisco Avenue. The EPA overflight indicated two other potential areas of interest. One area was located immediately southeast of the Site off North Moger Avenue and the second approximately one half mile southwest of the Site located within the parking lot of Diplomat Towers (a residential condominium complex).

3.0 Removal Assessment Objectives

As part of the Phase III Removal Assessment of the Site, RST 3 was tasked by EPA with providing support to perform a non-intrusive ground radiological survey of two new areas of interest, including the areas within the parking lot of the Diplomat Towers (Property C006) and the parking lot immediately adjacent to the Site on the eastern side of the railroad tracks and fronting on North Moger Avenue (Property C007) and to verify if prior aerial overflight information generated by EPA and DOE were accurate. In addition, RST 3 was tasked with providing a drilling subcontractor to install temporary well points to depths bgs in three locations at Property C003. Groundwater sampling of the temporary well points was performed in order to determine

groundwater flow direction and ascertain if groundwater beneath the Site is being impacted by site-related radioactive materials.

4.0 On-Site Personnel

Name	Affiliation	Duties On-Site
Daniel Gaughan	U.S. EPA, Region II	Lead On-Scene Coordinator
Andrew Fessler	U.S. EPA, Region II	Site Assessment Manager
Bernard Nwosu	RST 3, Region II	Team Lead, Site Health & Safety, Written and Photographic Documentation
Kathryn Donohue	RST 3, Region II	Field Support
Gerry Gilliland	Weston Solutions, SAT	Field Support, Radiological Survey
Tom Wysocki	Environmental Field Services	Geoprobe® Operator
Doug Frar	Environmental Field Services	Geoprobe® operations
Robert S. Johnson, PLS	H. Stanley Johnson & CO.	Temporary Well Point Surveyor

5.0 Summary of Site Activities

Prior to mobilizing to the Site, RST 3 contacted Dig Safely New York to conduct a subsurface utility clearance within the ROW areas of the Site. On December 12, 2016, EPA and RST 3 mobilized to the Site. Upon arrival at the Site, Dig Safely New York had completed utility clearance markings as requested. RST 3 performed a non-intrusive ground radiological survey of Property C006 and Property C007 using a Ludlum-2241 Scaler Ratemeter with a NaI 3x3 scintillator which was setup on a baby buggy for mobility.

On December 13, 2016, RST 3 drilling subcontractor, Environmental Field Services, Inc. (EFS), cleared the proposed on-site temporary well point locations for subsurface utilities and then installed three temporary well points. The temporary wells points were developed by EFS after installation and left overnight to recharge and stabilize.

On December 14, 2016, RST 3 performed groundwater sampling at the Site. All three temporary well points were individually purged of at least three well volumes prior to sample collection. The groundwater samples were shipped to RST 3-procured laboratory for analysis. Refer to Attachment D: Photographic Documentation Log.

6.0 Gamma Survey Methodology

The gamma survey instrument setup comprised of a Ludlum-2241 [Serial Number (No.): 201097] with a NaI 3x3 scintillator [Model: 44-20 (Serial No.: PR269981)] attached. A baby buggy stroller was utilized to provide mobility for the survey instrumentation setup. A Life-line Interoperable Network Communicator (LINC) was attached and connected to the Ludlum-2241 which was placed in the buggy. The Ludlum-2241 was connected via data cable to the NaI 3x3 scintillator which was positioned in a sagging manner approximately 6 inches above the ground surface in the bottom storage compartment of the buggy. A Trimble® Global Positioning System (GPS) unit, laptop computer, and Gateway (internet source) were also placed on the buggy. The LINC, GPS unit, and laptop computer, were connected to the internet via the Gateway. Gamma readings in μR/hr were generated by the Ludlum-2241 setup and transmitted through the LINC via the

Gateway to the VIPER system (a wireless network-based communication system). VIPER provided instantaneous gamma readings through a computer server [Viper Deployment Manager (VDM)]. The GPS unit provided geographical reference of the gamma readings by transmitting the locational data of the Ludlum-2241 setup through the Gateway and VIPER to VDM. The instantaneous gamma readings along with the geographical locations were viewed online on the VDM webpage via the laptop computer screen. With the mobile setup, RST 3 conducted gamma survey throughout both areas of interest, walking along predetermined paths with the buggy as directed by the EPA OSC.

7.0 Temporary Well Point Installation and Groundwater Sampling Methodology

Prior to mobilizing to the Site, RST 3 contacted Dig Safely New York to conduct a subsurface utility clearance within the ROW areas of the Site. In addition, prior to conducting any drilling activities on-site, EFS cleared each proposed temporary well point location for subsurface utilities using a ground penetrating radar (GPR). Based on the analytical results of the April 2016 soil sampling event, prior soil boring locations C003-SB003, C003-SB008, and C003-SB010, were selected by the EPA OSC to correspond with temporary well point locations TW-1, TW-2, and TW-3, respectively. The temporary well points were installed by EFS after utilizing a Geoprobe™ (Model 7822DT) to advance borings to the desired depths. The construction of each temporary well point consisted of a 10 foot 2-inch Schedule 40 polyvinyl chloride (PVC) screen (0.01 slot) plugged at the base with a PVC cap, and a 5 foot 2-inch Schedule 40 PVC casing with at least a 1 foot riser. RST 3 documented the physical characteristics and description of the soils extracted in each core from each boring location. After the temporary well points were installed, they were purged and surged with a Whale pump to facilitate influx of fresh groundwater from the aquifer, and then allowed to stabilize overnight. Prior to groundwater sampling the following day, H. Stanley Johnson & CO, subcontractor to EFS, surveyed all the temporary well points in order to document the top of casing (TOC) elevations and to provide the necessary information required to determine flow direction and hydraulic gradient of groundwater at the Site.

Refer to Attachment A, Figure 2: April 2016 Gamma Survey and Soil Boring Location Map, Figure 3: Soil Analytical Results Map (Radium-226), Figure 4: Temporary Well Point Location Map, Attachment B, Table 1: Temporary Well Construction, Gauging, and Purging Information Summary Table, Attachment D: Photographic Documentation Log, and Attachment E: Temporary Well Construction Log.

Groundwater sampling was conducted by RST 3 in accordance with EPA's Environmental Response Team (ERT)/Scientific, Engineering, Response, and Analytical Services (SERAS) contractor's Standard Operating Procedure (SOP) Numbers (Nos.) 2001: *General Field Sampling* and 2007: *Groundwater Well Sampling*. A Solinst water level meter was utilized by RST 3 to record the water levels and total depths of the temporary well points prior to purging for sampling purposes. Utilizing a non-dedicated submersible Grundfos pump fitted with Teflon™ tubing, RST 3 purged at least three well volumes from each temporary well prior to sample collection. Per the EPA OSC's directive, groundwater quality field parameters were not necessary, and therefore were not recorded. Groundwater samples were collected directly from the dedicated Teflon™ tubing utilized in purging each temporary well.

Decontamination of the non-dedicated submersible pump was performed before and after sampling each temporary well point, and it involved scrubbing the pump exterior with an industrial soap

(Alconox) and water, running the pump in a bucket of Alconox and water for 5 minutes, rinsing the pump exterior with tap water, running the pump in a bucket of tap water, steam cleaning the pump with deionized (DI) water, and air dry. A rinsate blank was collected to verify proper decontamination of non-dedicated sampling equipment (*i.e.,* submersible pump). Per the EPA OSC's directive, once the temporary well points were sampled, the investigation-derived waste (IDW), including well development purge water, sampling purge water, and decontamination fluids, were pumped back into each temporary well point. The boreholes were then backfilled in reverse order with the extracted soil in the cores, tamped down, and sealed with bentonite.

All the groundwater samples were collected for definitive data and quality assurance/quality (QA/QC) objectives. A field duplicate, additional sample volumes for matrix spike/matrix spike duplicate (MS/MSD), and a rinsate blank were collected. All sample information was transcribed into EPA's SCRIBE database, an environmental data management system, from which sample labels and chain of custody (COC) records were generated. All the samples were stored on ice in a cooler and shipped to an RST 3-procured laboratory for analysis.

8.0 Laboratory Receiving Samples

The following laboratory was utilized during the December 2016 sampling event:

Sample Matrix	Analysis	Laboratory
Aqueous	Isotopic thorium, isotopic uranium, and other alpha emitting actinides via HASL-300 Method U-02; radium-226 (ingrowth) via EPA Method 903.1, radium-228 via EPA Method 904.0, other gamma emitting radioisotopes via gamma spectroscopy EPA Method 901.1, and gross alpha/beta screening via EPA Method 900.0	Pace Analytical Services 1638 Roseytown Road, Suite 2,3,4 Greensburg PA 15601

9.0 Sample Collection and Dispatch Summary

On December 14, 2016, RST 3 collected a total of four groundwater samples, including one field duplicate, and additional sample volumes for MS/MSD, from three temporary well points at Property C003. RST 3 also collected one rinsate blank.

On December 14, 2016, RST 3 shipped a total of four groundwater samples, including one field duplicate and additional sample volumes for MS/MSD and one rinsate blank under COC record No. 2-121416-162810-0009 via Fedex Airbill No.: 8101-1945-2540 to PACE Analytical Services Inc. (PACE) located in Greensburg, Pennsylvania for laboratory analysis. All the samples were submitted for analysis of gross alpha and beta particles via EPA Method 900.0; isotopic thorium, isotopic uranium, and other alpha emitting actinides via HASL-300 Method U-02; radium-226 (ingrowth) via EPA Method 903.1, radium-228 via EPA Method 904.0, and other gamma emitting radioisotopes via gamma spectroscopy EPA Method 901.1. Refer to Attachment C: Chain of Custody Record and FedEx Airbill.

10.0 Radiological Survey Results Summary

A non-intrusive ground radiological survey was conducted at Properties P006 and P007 to verify if the aerial overflight information available to EPA was accurate. Background gamma readings ranged from 17 to 20 kilo counts per minute (kcpm). Based on the results of the ground radiological survey, gamma readings did not exceed 30 kcpm in both areas of interest, which is below 2x background. Refer to Attachment A, Figure 5: December 2016 Gamma Survey Map.

11.0 Groundwater Flow Direction and Analytical Results Summary

Based on groundwater elevation information, groundwater flows north at the Site with a hydraulic gradient of 0.0077 feet per foot (ft/ft). Refer to Attachment A, Figure 6: Groundwater Contour Map.

The validated analytical results of the groundwater samples collected during this sampling event were compared with the calculated EPA Site-Specific Action Level (provided by EPA in April 2017) for target radioisotopes.

Based upon validated analytical results, the concentrations of gross alpha and gross beta particles exceeded the Site-Specific Action Levels of 15 pCi/L and 4 pCi/L, respectively, in all four groundwater samples, including the field duplicate. Exceedance of gross alpha particles ranged from 44.1 pCi/L in TW-2-01 to 109 pCi/L in TW-3-01, and exceedance of gross beta particles ranged from 29.6 pCi/L in TW-2-01 to 202 pCi/L in TW-3-01.

Based upon validated analytical results, the concentration of Ra-226 exceeded the Site-Specific Action Level of 5 pCi/L in two groundwater samples, (sample number and concentration in parenthesis) TW-1-01 (7.18 pCi/L) and TW-3-01 (45.8 pCi/L), and the field duplicate TW-3-02 (315 pCi/L) of TW-3-01.

Based upon validated analytical results, the concentration of Ra-228 exceeded the Site-Specific Action Level of 0.702 pCi/L in all four groundwater samples, including the field duplicate. Exceedance of Ra-228 ranged from 1.14 pCi/L in TW-2-01 to 46.7 pCi/L in TW-3-02 (duplicate of TW-3-01).

Based upon validated analytical results, the concentrations of at least two or more of the following radionuclides, including bismuth-212, bismuth-214, lead-212, lead-214, Ra-224, and thallium-208, exceeded the respective EPA Site-Specific Action levels in all four groundwater samples, including the field duplicate.

Refer to Attachment A, Figure 7: Groundwater Analytical Results Map, Attachment B, Table 1: Temporary Well Construction, Gauging, and Purging Information Summary Table, Table 2: Validated Groundwater Analytical Results Summary Table - Radioisotopes, and Attachment F: Data Validation Report.

Report prepared by: _____ 5/15/2017
Bernard Nwosu — Date
RST 3 Site Project Manager

Report reviewed by: _____ 5/15/2017
Timothy Benton — Date
RST 3 Operations Leader

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ATTACHMENT A

Figure 1: Site Location Map
Figure 2: April 2016 Gamma Survey and Soil Boring Location Map
Figure 3: Soil Analytical Results Map (Radium-226)
Figure 4: Temporary Well Point Location Map
Figure 5: December 2016 Gamma Survey Map
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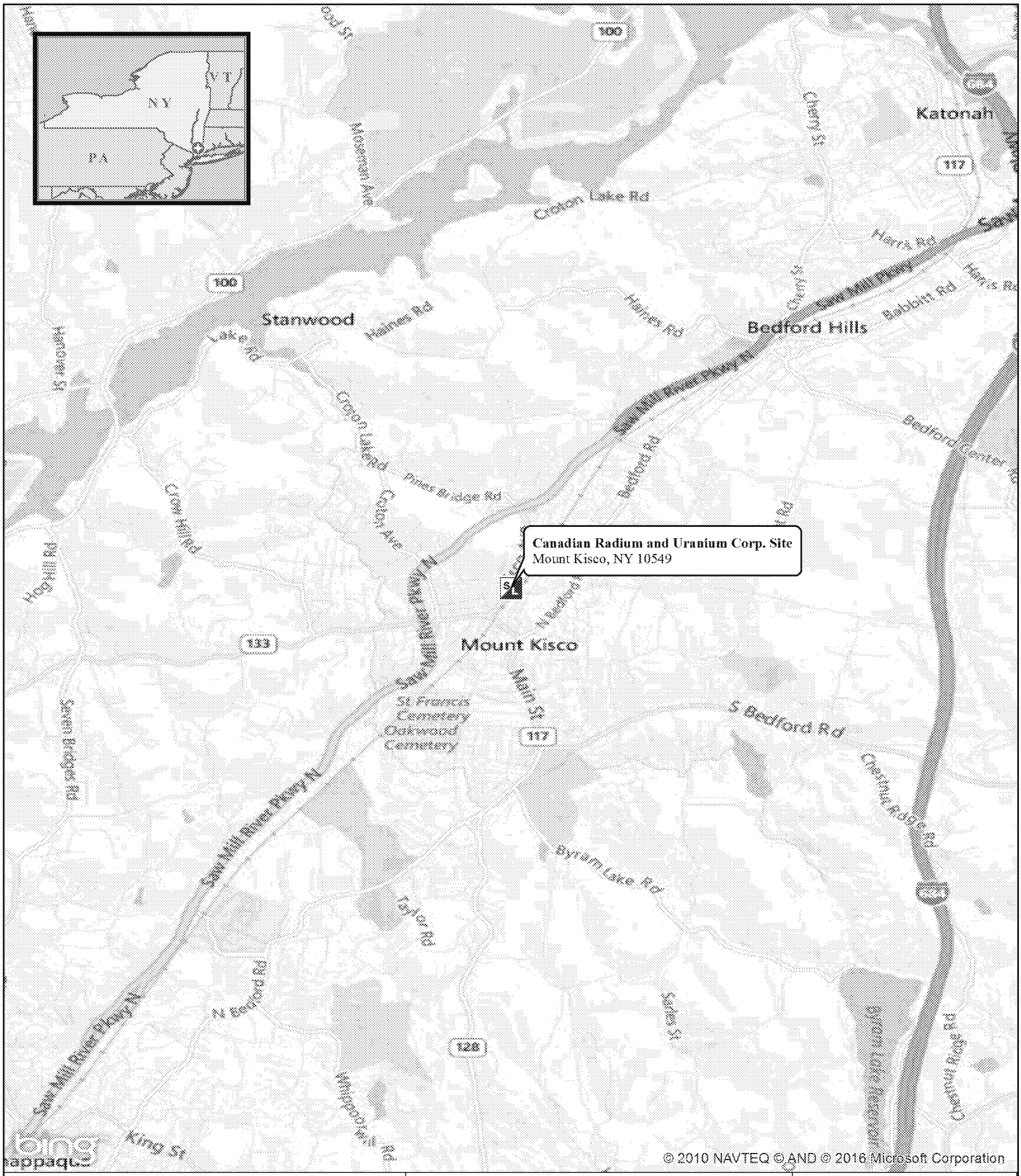
Figure 7: Groundwater Analytical Results Map



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Site Location

N

0 0.3 0.6 1.2 1.8 2.4 Miles

Weston Solutions, Inc.
Federal East Division

In Association With
Scientific and Environmental Associates, Inc.,
Environmental Compliance Consultants, Inc.,
Avatar Environmental, LLC, On-Site Environmental,
Inc.and Sovereign Consulting, Inc

Figure 1:
Site Location Map

Canadian Radium and Uranium Corp. Site
Mount Kisco, New York

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

DATE MODIFIED: 9/21/2016

GIS ANALYST:	T. Benton
EPA OSC:	D. Gaughan
RST SPM:	B. Nwosu
FILENAME:	160921_CRU_SITELOCATIONMAP.MXD

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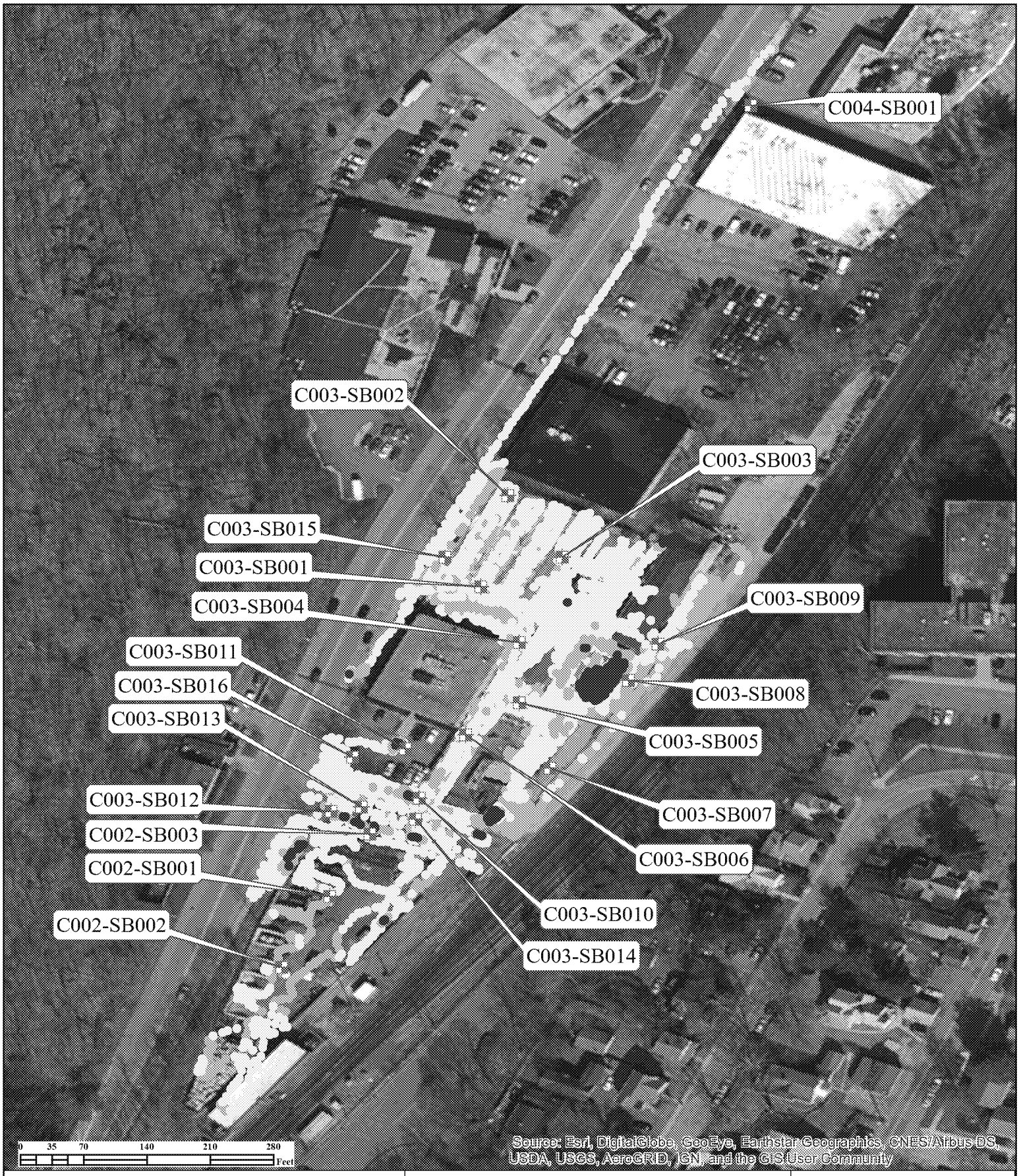

Legend

Gamma Survey (µR/hr)

- 0 - 9
- 9 - 16 (2X)
- 16 - 24 (3X)
- > 24
- Soil Boring Location

Notes:

***Gamma survey conducted using a Ludlum-2241 scaler ratemeter with a sodium iodide 3x3 scintillator.**
***Gamma measurements presented in microroentgens per hour (µR/hr).**
***Background gamma reading = 9 µR/hr.**

N

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Environmental Compliance Consultants, Inc.,
Avatar Environmental, LLC, On-Site Environmental,
Inc.and Sovereign Consulting, Inc

Figure 2: April 2016 Gamma Survey and Soil Boring Location Map

Canadian Radium & Uranium Corp Site
Mount Kisco, New York

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

DATE MODIFIED: 5/2/2017

GIS ANALYST:	P. Buster
EPA OSC:	D. Gaughan
RST SPM:	B. Nwosu
FILENAME:	170501_Figure_2_Gamma_SB_Map.mxd

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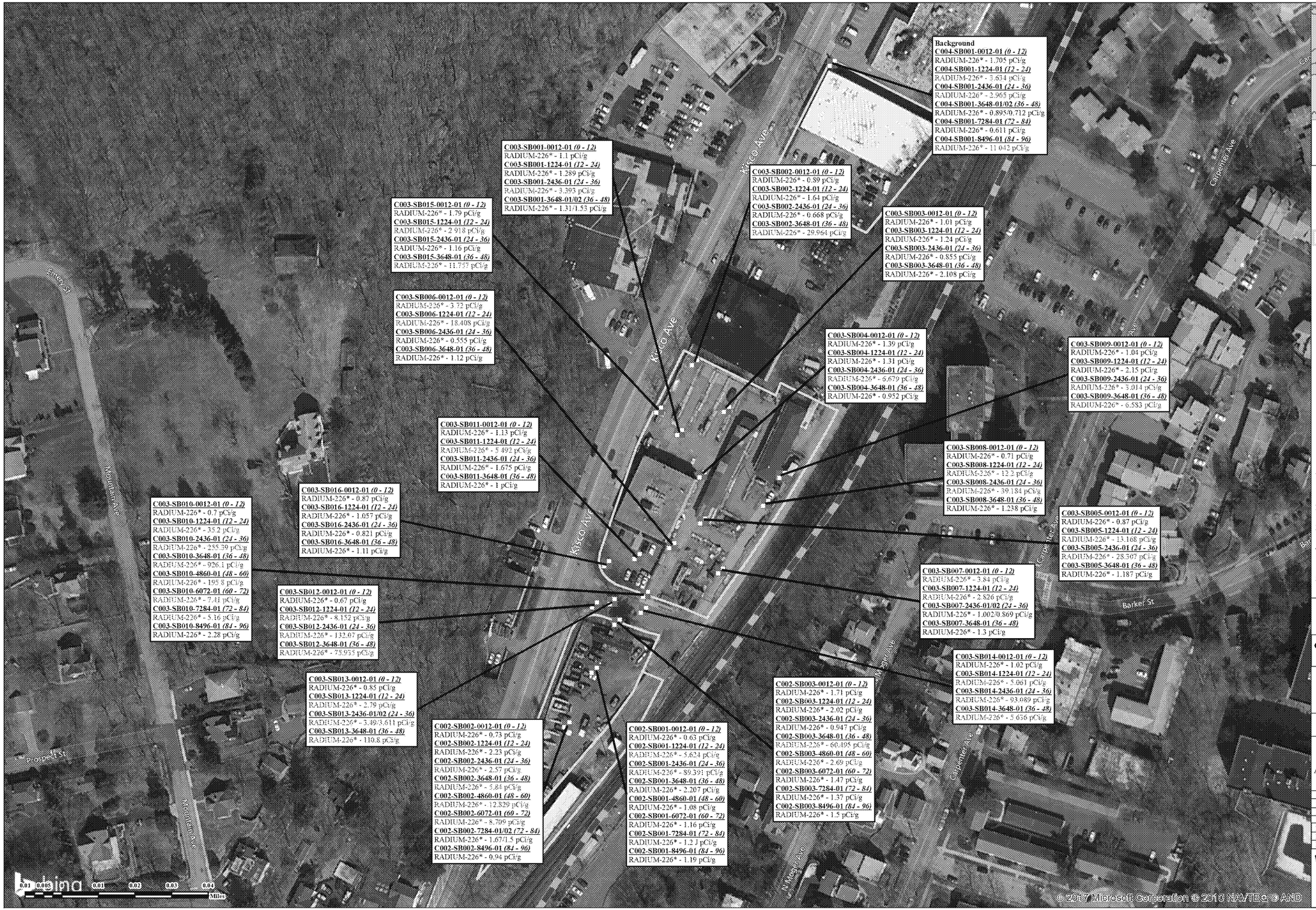


SCALE

1:1,580

LEGEND

April 2016 Soil Sample Location

Site Boundary

Notes:
1.) All results presented in picocuries per gram (pCi/g).
2.) Depth of sample collection is presented in parenthesis next to sample number.
3.) * Represents a Radium-226 value that was analyzed via the 21-day ingrowth method.
4.) Values highlighted red indicate an exceedance of the EPA Site-Specific Action Level for the specific radionuclide.
5.) EPA Site-Specific Action Levels: Ra-226 = 2.52 pCi/g.

Figure 3: Soil Analytical Results Map (Radium-226)

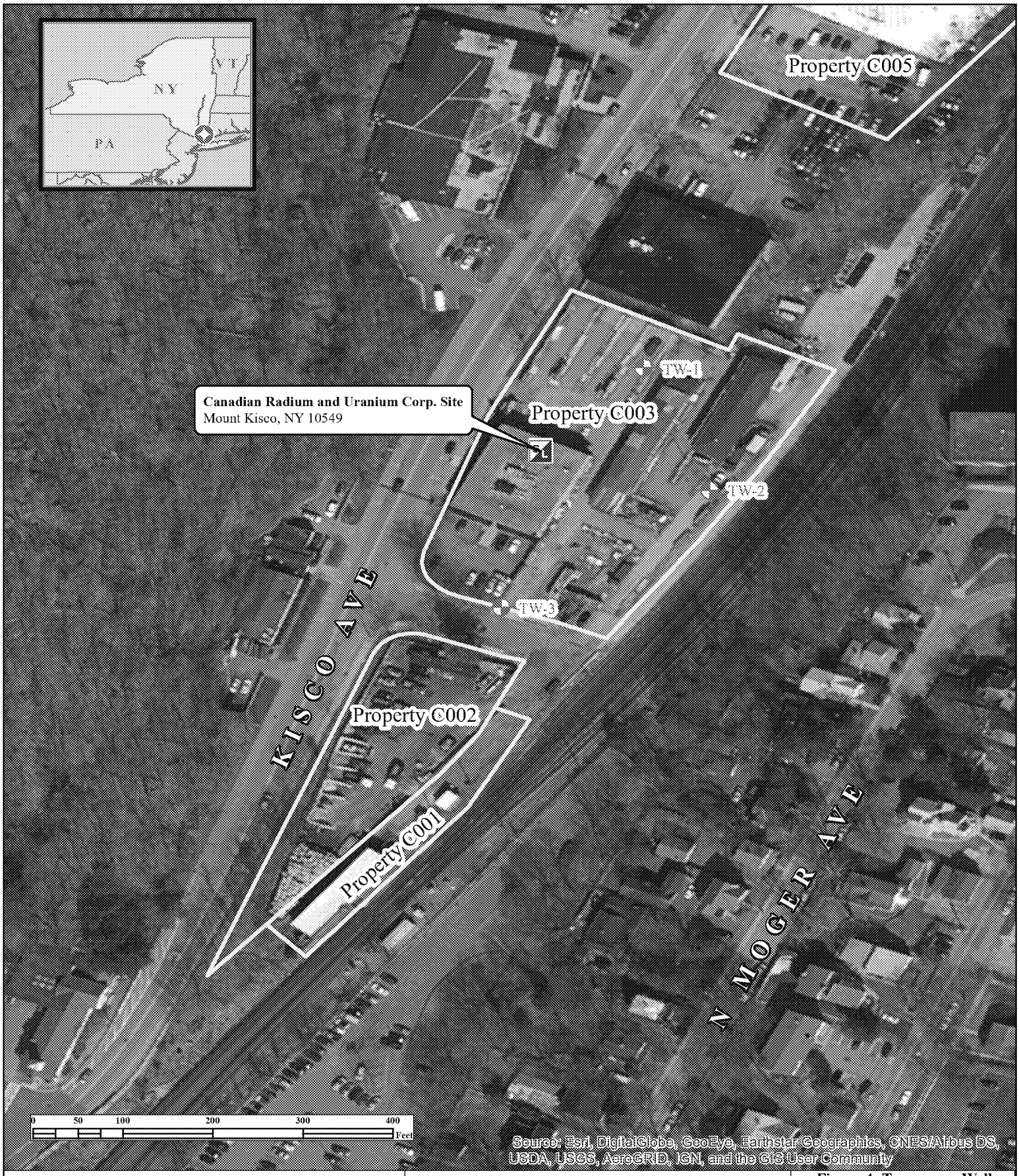
Canadian Radium and Uranium Corp. Site
Mount Kisco, New York

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

Weston Solutions, Inc.

In Association With
Scientific and Environmental Associates, Inc., Environmental Compliance Consultants, Inc., Avatar Environmental, LLC, On-Site Environmental, Inc., and Sovereign Consulting, Inc.

GIS ANALYST:	T. BENTON
EPA OSC:	D. GAUGHAN
RST 3 SPM:	B. NWOSU
FILENAME:	150929_SampleLocationMap.mxd
FIGURE	5
REVISION	2
DATE MODIFIED	11/9/2016



Legend

- Temporary Well Point Location
- Site Boundary
- Site Location

Weston Solutions, Inc.
Federal East Division

In Association With
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Environmental Compliance Consultants, Inc.,
Avatar Environmental, LLC, On-Site Environmental,
Inc.and Sovereign Consulting, Inc

Figure 4: Temporary Well Point Location Map

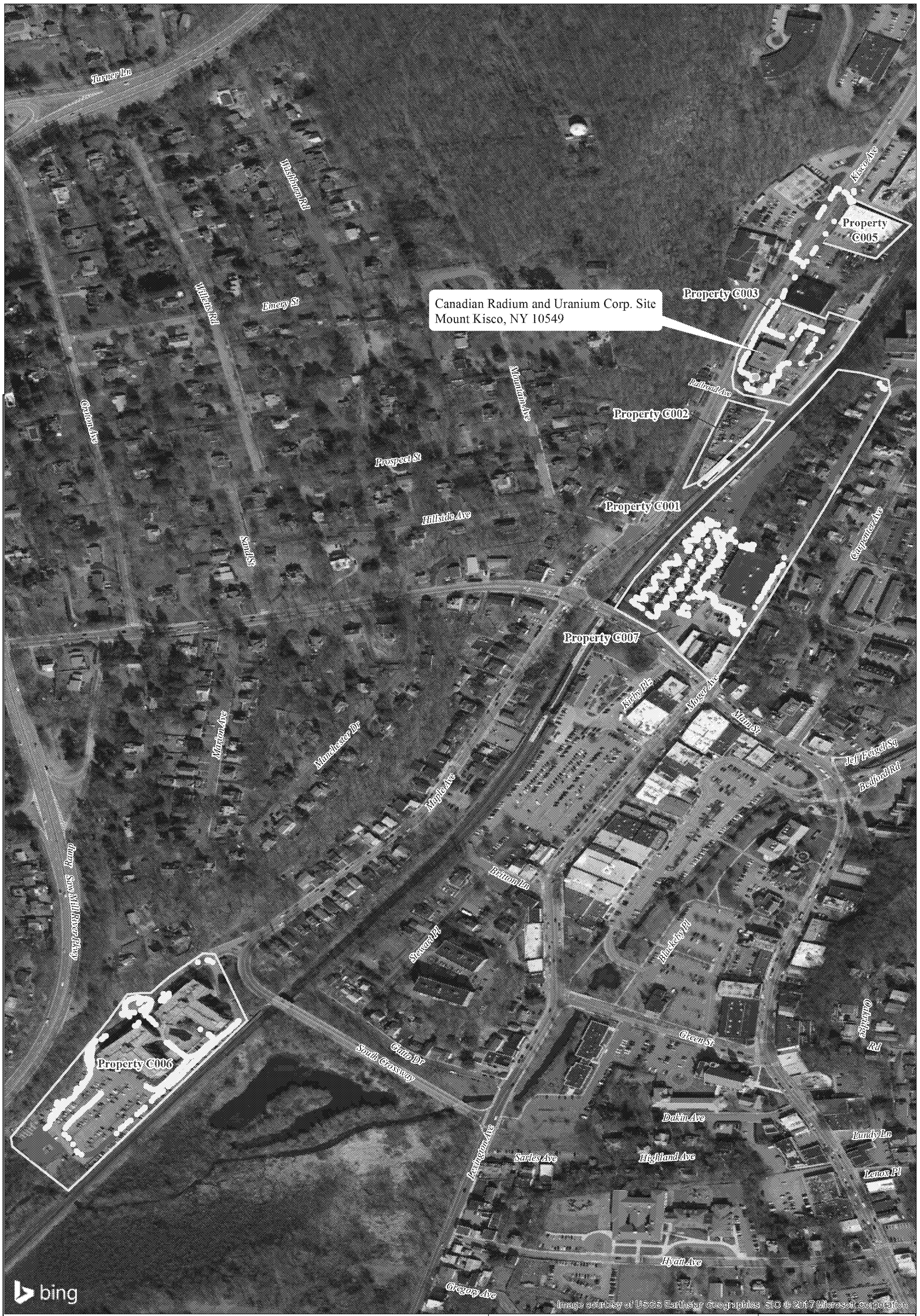
Canadian Radium and Uranium Corp. Site
Mount Kisco, New York

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

DATE MODIFIED: 5/10/2017

GIS ANALYST:	T. BENTON
EPA OSC:	D. GAUGHAN
RST SPM:	B. NWOSU
PROJECT #:	30400.031.007.3023

\\FSED2DATA1\GISDATA\RST_3\00070023\MXD\161121_CRU_PROPOSEDWELLPOINTLOCATIONMAP.MXD



Legend

Gamma Survey (kcpm)

- 0 - 20
- 20 - 40 (2X)
- 40 - 60 (3X)
- 60 - 80 (4X)
- > 80

Areas of Concern

0 50 100 200 300 400 500 Feet

Notes:
*Gamma survey conducted using a Ludlum-2241 scaler ratemeter with a sodium iodide 3x3 scintillator.
*Gamma measurements presented in kilo counts per minute (kcpm).
*Background gamma reading = 20 kcpm.
*Maximum gamma reading = 128 kcpm.

N

WESTON SOLUTIONS **Weston Solutions, Inc.**

In association with
Scientific and Environmental Associates, Inc.,
Avatar Environmental, LLC, Environmental Compliance Consultants,
On-Site Environmental, Inc., and Sovereign Consulting, Inc.

Figure 5: December 2016 Gamma Survey Map

CANADIAN RADIUM AND URANIUM CORP. SITE
MOUNT KISCO, NEW YORK

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

GIS ANALYST:	P. BUSTER
EPA OSC:	D. GAUGHAN
RST SPM:	B. NWOSU
FILENAME:	170425_Figure 3_Gamma_Survey_Map.mxd

DATE MODIFIED: 5/1/2017

Legend

- Site Boundary
- Temporary Well Point Location
- Groundwater Contour
- Groundwater Flow Direction

Notes:

1.) Groundwater contours developed based on data collected as part of the professional groundwater elevation survey completed at the Site on December 15, 2016.

2.) Groundwater elevations presented in feet.

3) Groundwater flows north with a hydraulic gradient of 0.0077ft/ft

Weston Solutions, Inc.
Federal East Division

In Association With
Scientific and Environmental Associates, Inc.,
Environmental Compliance Consultants, Inc.,
Avatar Environmental, LLC, On-Site Environmental, Inc.and Sovereign Consulting, Inc

Figure 6:
Groundwater Contour Map

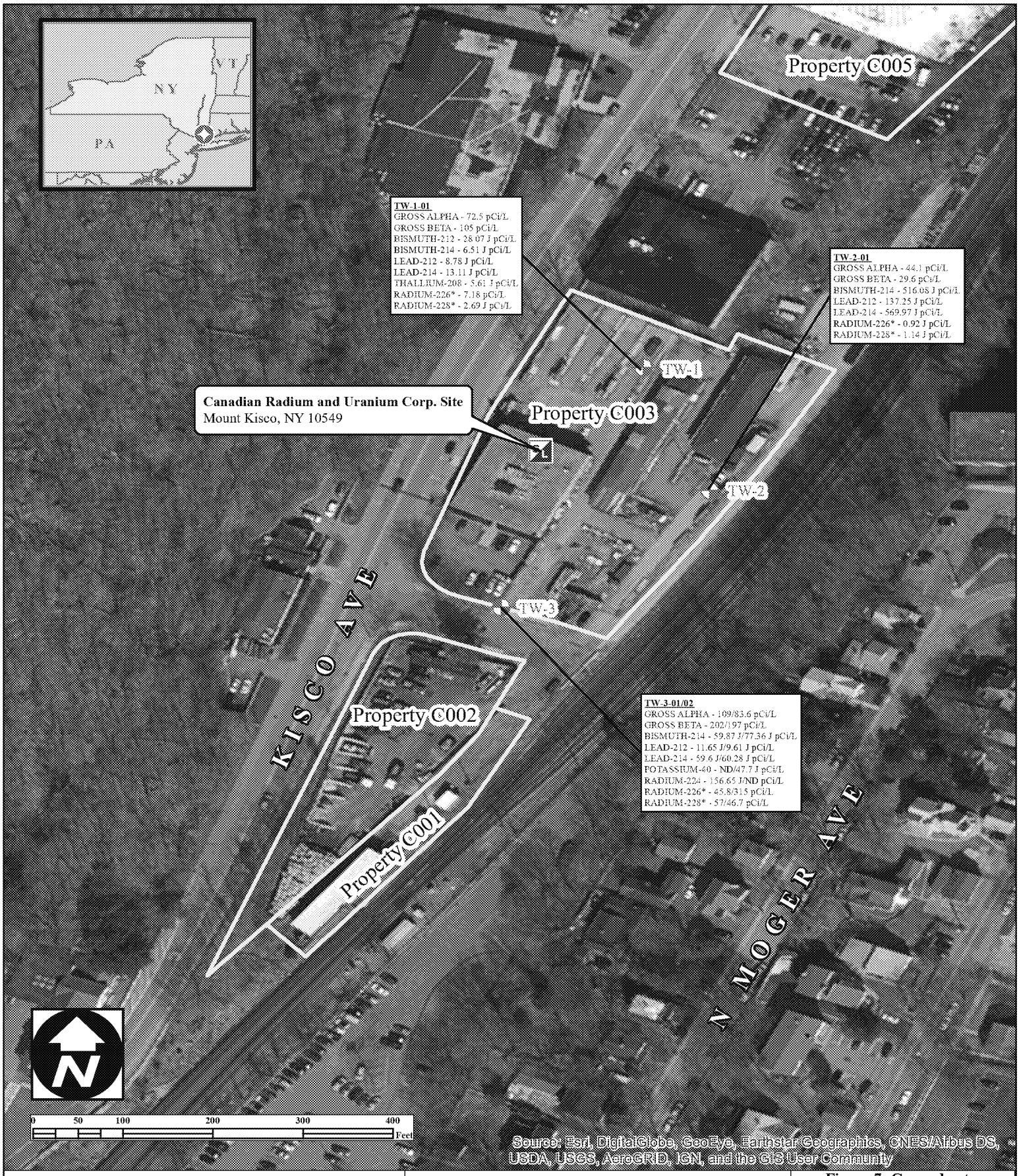
Canadian Radium and Uranium Corp. Site
Mount Kisco, New York

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

DATE MODIFIED: 5/1/2017

GIS ANALYST:	T. BENTON
EPA OSC:	D. GAUGHAN
RST SPM:	B. NWOSU
PROJECT #:	30400.031.007.3023

<ACP>\\fsed2data1\gisdata\RST_3\00070023\MXD\170213_CRU_GWContour&DirectionMap.mxd</ACP>



Legend

- Temporary Well Point Location
- Site Boundary
- Site Location

Notes:
1.) All results presented in picocuries per liter (pCi/L).
2.) J = Estimated value; ND = Non-Detect
3.) Only detected results are depicted on this map.
4.) * Represents a Radium-226 value that was analyzed via EPA Method 903.1 and a Radium-228 value that was analyzed via EPA Method 904.0.
5.) Values highlighted red indicate an exceedance of the EPA Site-Specific Action Level for the specific radionuclide.

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Federal East Division

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Scientific and Environmental Associates, Inc.,
Environmental Compliance Consultants, Inc.,
Avatar Environmental, LLC, On-Site Environmental, Inc.and Sovereign Consulting, Inc

Figure 7: Groundwater Analytical Results Map

Canadian Radium and Uranium Corp. Site
Mount Kisco, New York

U.S. ENVIRONMENTAL PROTECTION AGENCY
REMOVAL SUPPORT TEAM 3
CONTRACT # EP-S2-14-01

DATE MODIFIED: 5/10/2017

GIS ANALYST:	T. BENTON
EPA OSC:	D. GAUGHAN
RST SPM:	B. NWOSU
PROJECT #:	30400.031.007.3023

\\FSED2DATA1\GISDATA\RST_3\00070023\MXD\170508_CRU_GROUNDWATERRESULTS_REVISED.MXD

ATTACHMENT B

Table 1: Temporary Well Construction, Gauging, and Purging Information Summary Table
Table 2: Validated Groundwater Analytical Results Summary Table - Radioisotopes

Table 1: Temporary Well Construction, Gauging, and Purging Information Summary Table
Canadian Radium and Uranium Corp. Site
Mount Kisco, Westchester County, New York
December 13 and 14, 2016

Well Number	**TW-1**	**TW-2**	**TW-3**
Associated Soil Boring	C003-SB003	C003-SB008	C003-SB010
Well Construction Information			
Well location (Latitude)	41°12'44.84939"	41°12'43.52507"	41°12'42.22776"
Well location (Longitude)	73°43'37.49893"	73°43'36.75453"	73°43'39.03325"
Well permit	NA	NA	NA
Well diameter (inches)	2	2	2
Well construction (flush/stickup)	stickup	stickup	stickup
Depth to bottom from TOC (ft)	**15.10**	**16.12**	**16.73**
Depth from TOC to TOS (ft)	5.10	6.12	6.73
Top of casing elevation (NAVD 88) (ft)	290.85	291.25	293.80
Ground elevation (NAVD 88) (ft)	289.50	289.77	292.06
Top of screen elevation (NAVD 88) (ft)	285.75	285.13	287.07
Ground water elevation (NAVD 88) (ft)	285.49	286.08	287.85
Well Gauging Information			
Time gauged	8:22	8:27	8:30
Depth to water from TOC (ft)	**5.36**	**5.17**	**5.95**
Odor (Yes/No)	No	Yes	No
Gamma reading (kcpm)	18 - 20	14 - 18	15 - 18
Well Purge Information			
Linear feet of water in well (estimate) (ft)	9.74	10.95	10.78
Water volume in well (estimate) (gal)	1.66	1.86	1.83
3 well volumes	4.97	5.58	5.50
Purge start time	9:05	10:00	10:45
Purge end time	9:18	10:09	11:47
Purge duration (minutes)	13	9	62
Total volume purged (gal)	5.0	5.6	5.0
Purge rate (gal/min)	0.38	0.62	0.08
Purge method (bailer/pump)	pump	pump	pump
Time sampled	9:19	10:10	11:48

Notes:
NA - Not Applicable, TOC - Top of Casing, TOS - Top of Screen.
Well Volume Correction Factors (gallons per foot) for 2 inch well = 0.17.
NAVD 88 - North American Vertical Datum of 1988.
kcpm - kilo counts per minute, ft - feet, gal - gallon, min - minute.
Gamma readings collected with Ludlum-2241+sodium iodide (NaI) 2x2 scintillator.

Table 2
Validated Groundwater Analytical Results Summary Table - Radioisotopes
Canadian Radium and Uranium Corp. Site
Mount Kisco, New York
December 2016

	Location Number		C003-SB003			C003-SB008			C003-SB010						Rinsate		
	RST 3 Sample Number		**TW-1-01**			**TW-2-01**			**TW-3-01**			**TW-3-02**			**RB-121416**		
	Sample Matrix		Groundwater			Groundwater			Groundwater			Groundwater			DI Water		
	Sample Date		12/14/2016			12/14/2016			12/14/2016			12/14/2016					
	Sample Result		Value (pCi/L)	Qualifier	Total Uncertainty	Value (pCi/L)	Qualifier	Total Uncertainty	Value (pCi/L)	Qualifier	Total Uncertainty	Value (pCi/L)	Qualifier	Total Uncertainty	Value (pCi/L)	Qualifier	Total Uncertainty
Radioisotope	**Analysis Method**	**[1]EPA SSAL**															
Gross Alpha	EPA 900.0	15	**72.5**		27.5	**44.1**		10.8	**109**		31.2	**83.6**		28.6	0.53	J	0.34
Gross Beta	EPA 900.0	4	**105**		24.3	**29.6**		5.91	**202**		40	**197**		40.7	-0.08	U	0.35
Actinium-228	EPA 901.1	9.18	0	UJ	12.7	0	UJ	15.15	0	UJ	24.06	1.68	UJ	18.9	0	UJ	15.36
Bismuth-212	EPA 901.1	15	**28.07**	J	48.56	0	UJ	37.34	6.11	UJ	117.29	0	UJ	19.83	0	UJ	16.24
Bismuth-214	EPA 901.1	15	6.51	J	11.18	**516.08**	J	61	**59.87**	J	19.58	**77.36**	J	15.56	0	UJ	13.37
Cesium-137	EPA 901.1	12.3	-1.88	UJ	5.4	-1.19	UJ	6.83	0.93	UJ	8.22	1.73	UJ	4.59	0	UJ	1.15
Lead-210	EPA 901.1	15	157.39	UJ	1,984.5	0	UJ	2,431.7	0	UJ	289.13	0	UJ	1,301.6	36.99	UJ	391.48
Lead-212	EPA 901.1	15	8.78	J	16.7	**137.25**	J	49.85	11.65	J	10.97	9.61	J	6.3	0	UJ	9.39
Lead-214	EPA 901.1	15	13.11	J	12.83	**569.97**	J	67.5	**59.6**	J	19.15	**68.28**	J	11.95	12.34	J	16.72
Potassium-40	EPA 901.1	29.7	11.29	UJ	53.78	22.57	UJ	77.23	0	UJ	48.01	**47.7**	J	51.01	0	UJ	48.01
Radium-224	EPA 901.1	15	0	UJ	42.49	90.78	UJ	150.19	**156.65**	J	115.85	0	UJ	29.44	-41.38	UJ	184.26
Radium-226	EPA 901.1	5	0	R	70.61	55	R	168.77	120.95	R	167.94	172.59	R	114.02	47.62	R	158.97
Radium-228	EPA 901.1	0.702	0	UJ	12.7	0	UJ	15.152	0	UJ	24.06	1.68	UJ	18.9	0	UJ	15.36
Thallium-208	EPA 901.1	4	**5.61**	J	4.21	0.69	UJ	7.46	0	UJ	2.65	1.37	UJ	4.94	2.62	UJ	6.26
Thorium-228	EPA 901.1	15	126.89	R	171.54	456.74	R	561.52	42.76	R	613.3	0	R	714.29	194.78	R	598.36
Thorium-230	EPA 901.1	15	-146.34	R	4,098.5	-556.08	R	6,459.8	1,102.8	R	2,944.5	-1,434.1	R	4,686.1	957.12	R	2,426.4
Thorium-232	EPA 901.1	15	0	R	4,645.6	7,023.1	R	8,713.9	2,582.7	R	4,330.8	991.07	R	8,318.9	279.61	R	4,017.7
Thorium-234	EPA 901.1	135	103.57	UJ	398.94	0	UJ	494.72	0	UJ	132.57	0	UJ	234.56	0	UJ	151.23
Uranium-234	EPA 901.1	15	103.57	R	398.94	0	R	494.72	0	R	132.57	0	R	234.56	0	R	151.23
Uranium-235	EPA 901.1	15	0	R	17.91	13.95	R	55.7	17.15	R	49	0	R	19.14	0	R	28.75
Uranium-238	EPA 901.1	15	0	UJ	75.06	49.15	UJ	146.44	0	UJ	101.4	0	UJ	103.74	45.49	UJ	122.67
Radium-226	EPA 903.1	5	**7.18**		1.71	0.92	J	0.62	**45.8**		6.39	**315**		37.7	0.24	U	0.46
Radium-228	EPA 904.0	0.702	**2.69**	J	0.74	**1.14**	J	0.42	**57**		10.3	**46.7**		8.46	0.65	J	0.3
Thorium-228	HSL-300	15	0.23	J	0.2	0.52	J	0.26	0.25	J	0.2	0.4	J	0.23	0.3	J	0.2
Thorium-230	HSL-300	15	0.3	J	0.2	0.24	J	0.17	3.23	J	0.74	8.4	J	1.6	0.05	J	0.08
Thorium-232	HSL-300	15	0.13	J	0.11	0.31	J	0.18	0.14	J	0.11	0.33	J	0.18	0.02	U	0.08
Uranium-233/234	HSL-300	15	0.63	J	0.22	1.06		0.29	0.54	J	0.21	0.38	J	0.16	0.16	J	0.12
Uranium-235/236	HSL-300	15	0.11	J	0.09	0.09	J	0.09	0.12	J	0.1	0.08	J	0.07	0.11		0.01
Uranium-238	HSL-300	15	0.34	J	0.16	0.82		0.24	0.56	J	0.2	0.29	J	0.14	0.15		0.1

Notes:
RST 3 - Removal Support Team 3.
U - Not detected, J - Estimated result.
R - Rejected result.
pCi/L - picocuries per liter.
[1]U.S. Environmental Protection Agency (EPA) Site-Specific Action Levels (SSAL) are presented in pCi/L.
EPA 900.0 - Gross Alpha/Beta.
EPA 901.1 - Gamma Spectroscopy.
EPA 903.1 - Radium-226 (ingrowth).
EPA 904.0 - Radium-228.
HSL-300 - Actinides.
Values in red equal or exceed the EPA SSAL for the respective radioisotope.

ATTACHMENT C

Chain of Custody Record and FedEx Airbill

30205674

USEPA
DateShipped: 12/14/2016
CarrierName: FedEx
AirbillNo: [redacted] 8101-1945-2540

CHAIN OF CUSTODY RECORD
Case #: 419
Contact Name: Bernard Nwosu
Contact Phone: 908-565-2980

No: 2-121416-162810-0009
Lab: PACE Analytical Services
Lab Contact: Justin Hensley
Lab Phone: 724-850-5600

Lab #	Sample #	Sample Date	Sample Time	Analyses	Matrix	Preservative	Lab QC	Numb Cont	Container	Analytical_Method
001	TW-1-01	12/14/2016	09:19	Gamma Spec (EPA 901.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 901.1
	TW-1-01	12/14/2016	09:19	Radium-226 (EPA 903.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 903.1
	TW-1-01	12/14/2016	09:19	Radium-228 (EPA 904.0)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 904.0
	TW-1-01	12/14/2016	09:19	Other Alpha Emitting Actinides	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02
	TW-1-01	12/14/2016	09:19	Isotopic Thorium & Uranium	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02
002	TW-2-01	12/14/2016	10:10	Gamma Spec (EPA 901.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 901.1
	TW-2-01	12/14/2016	10:10	Radium-226 (EPA 903.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 903.1
	TW-2-01	12/14/2016	10:10	Radium-228 (EPA 904.0)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 904.0
	TW-2-01	12/14/2016	10:10	Isotopic Thorium & Uranium	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02
	TW-2-01	12/14/2016	10:10	Other Alpha Emitting Actinides	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02

001

002

Special Instructions: Sample Analysis: Gamma Spectroscopy analysis to include: Ra-226 (in-growth), Ra-228, K-40, Tl-208, Bi-212, Bi-214, Pb-212, Pb-214, Ra-226, Ra-228, Th-234, U-235, Pb-210, Bi-210. Email results to s.sumbaly@westonsolutions.com and ben.nwosu@westonsolutions.com

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
	[signature] RST 3	12/14/16	[signature]	12-15-16 1145	Good

WO#:30205674

30205674

30205674

USEPA
DateShipped: 12/14/2016
CarrierName: FedEx
AirbillNo: [redacted] 8101-1945-2540

CHAIN OF CUSTODY RECORD
Case #: 419
Contact Name: Bernard Nwosu
Contact Phone: 908-565-2980

No: 2-121416-162810-0009
Lab: PACE Analytical Services
Lab Contact: Justin Hensley
Lab Phone: 724-850-5600

Lab #	Sample #	Sample Date	Sample Time	Analyses	Matrix	Preservative	Lab QC	Numb Cont	Container	Analytical_Method
003,004, 005	TW-3-01	12/14/2016	11:48	Gamma Spec (EPA 901.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 901.1
	TW-3-01	12/14/2016	11:48	Radium-226 (EPA 903.1)	Ground Water	HNO3 pH<2	Y	2	1 L poly bottle	EPA 903.1
	TW-3-01	12/14/2016	11:48	Radium-228 (EPA 904.0)	Ground Water	HNO3 pH<2	Y	2	1 L poly bottle	EPA 904.0
	TW-3-01	12/14/2016	11:48	Other Alpha Emitting Actinides	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02
	TW-3-01	12/14/2016	11:48	Isotopic Thorium & Uranium	Ground Water	HNO3 pH<2	Y	2	1 L poly bottle	HASL-300/U-02
006	TW-3-02	12/14/2016	12:30	Gamma Spec (EPA 901.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 901.1
	TW-3-02	12/14/2016	12:30	Radium-226 (EPA 903.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 903.1
	TW-3-02	12/14/2016	12:30	Radium-228 (EPA 904.0)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 904.0
	TW-3-02	12/14/2016	12:30	Other Alpha Emitting Actinides	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02
	TW-3-02	12/14/2016	12:30	Isotopic Thorium & Uranium	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02

003,004, 005

006

Special Instructions: Sample Analysis: Gamma Spectroscopy analysis to include: Ra-226 (in-growth), Ra-228, K-40, Tl-208, Bi-212, Bi-214, Pb-212, Pb-214, Ra-226, Ra-228, Th-234, U-235, Pb-210, Bi-210. Email results to s.sumbaly@westonsolutions.com and ben.nwosu@westonsolutions.com

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
	Bernard Nwosu RST3	12/14/16	Kiran Hill	12-15-16 1145	Good

30205674

USEPA
DateShipped: 12/14/2016
CarrierName: FedEx
AirbillNo: [redacted] 8101-1945-2540 (BN)

CHAIN OF CUSTODY RECORD
Case #: 419
Contact Name: Bernard Nwosu
Contact Phone: 908-565-2980

No: 2-121416-162810-0009
Lab: PACE Analytical Services
Lab Contact: Justin Hensley
Lab Phone: 724-850-5600

Lab #	Sample #	Sample Date	Sample Time	Analyses	Matrix	Preservative	Lab QC	Numb Cont	Container	Analytical_Method
007	RB-121416	12/14/2016	12:45	Gamma Spec (EPA 901.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 901.1
	RB-121416	12/14/2016	12:45	Radium-226 (EPA 903.1)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 903.1
	RB-121416	12/14/2016	12:45	Radium-228 (EPA 904.0)	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	EPA 904.0
	RB-121416	12/14/2016	12:45	Isotopic Thorium & Uranium	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02
	RB-121416	12/14/2016	12:45	Other Alpha Emitting Actinides	Ground Water	HNO3 pH<2	N	1	1 L poly bottle	HASL-300/U-02

007

Special Instructions: Sample Analysis: Gamma Spectroscopy analysis to include: Ra-226 (in-growth), Ra-228, K-40, Tl-208, Bi-212, Bi-214, Pb-212, Pb-214, Ra-226, Ra-228, Th-234, U-235, Pb-210, Bi-210. Email results to s.sumbaly@westonsolutions.com and ben.nwosu@westonsolutions.com

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
	Bernard Nwosu RT3	12/14/16	Karen Hill	12-15-16 1145	Good

FedEx Express Package US Airbill

FedEx Tracking Number 8101 1945 2540

Form ID No. 0200 — Sender's Copy

1 From *Please print and press hard.*

Date 12/14/16 — Sender's FedEx Account Number 402356103-

Sender's Name Bernard Nwosu — Phone (908) 565-2980

Company Weston Solutions, Inc, Suite 201

Address 1090 King Georges Post Rd. — Dept./Floor/Suite/Room

City Edison — State NJ — ZIP 08837

2 Your Internal Billing Reference First 24 characters will appear on invoice. 30400.031.007-3023

3 To

Recipient's Name Justin Hensley — Phone (724) 850-5600

Company Pace Analytical Services

Address 1638 Roseytown Road, ~~Suite 2,3,4~~ — Dept./Floor/Suite/Room

We cannot deliver to P.O. boxes or P.O. ZIP codes.

Address Suite 2,3,4

Use this line for the HOLD location address or for continuation of your shipping address.

City Greensburg — State PA — ZIP 15601

☐ Hold Weekday — FedEx location address REQUIRED. NOT available for FedEx First Overnight.

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- ☑ FedEx Priority Overnight — Next business morning.* Friday shipments will be delivered on Monday unless Saturday Delivery is selected.
- ☐ FedEx Standard Overnight — Next business afternoon.* Saturday Delivery NOT available.

2 or 3 Business Days

- ☐ FedEx 2Day A.M. — Second business morning.* Saturday Delivery NOT available.
- ☐ FedEx 2Day — Second business afternoon.* Thursday shipments will be delivered on Monday unless Saturday Delivery is selected.
- ☐ FedEx Express Saver — Third business day.* Saturday Delivery NOT available.

5 Packaging * Declared value limit $500.

☐ FedEx Envelope* ☐ FedEx Pak* ☐ FedEx Box ☐ FedEx Tube ☑ Other

6 Special Handling and Delivery Signature Options Fees may apply. See the FedEx Service Guide.

☐ Saturday Delivery — NOT available for FedEx Standard Overnight, FedEx 2Day A.M., or FedEx Express Saver.

☐ No Signature Required — Package may be left without obtaining a signature for delivery.

☑ Direct Signature — Someone at recipient's address may sign for delivery.

☐ Indirect Signature — If no one is available at recipient's address, someone at a neighboring address may sign for delivery. For residential deliveries only.

Does this shipment contain dangerous goods?

Due box must be checked.

☑ No ☐ Yes — As per attached Shipper's Declaration. ☐ Yes — Shipper's Declaration not required. ☐ Dry Ice — Dry Ice, 9, UN 1845 ..... x ..... kg

Restrictions apply for dangerous goods — see the current FedEx Service Guide. ☐ Cargo Aircraft Only

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FedEx Acct. No. / Credit Card No. 402356103 — Exp. Date

Total Packages ____ Total Weight ____ lbs. Total Declared Value† $ ____ .00

†Our liability is limited to US$100 unless you declare a higher value. See back for details. By using this airbill you agree to the service conditions on the back of this airbill and in the current FedEx Service Guide, including terms that limit our liability.

644

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ATTACHMENT D

Photographic Documentation Log

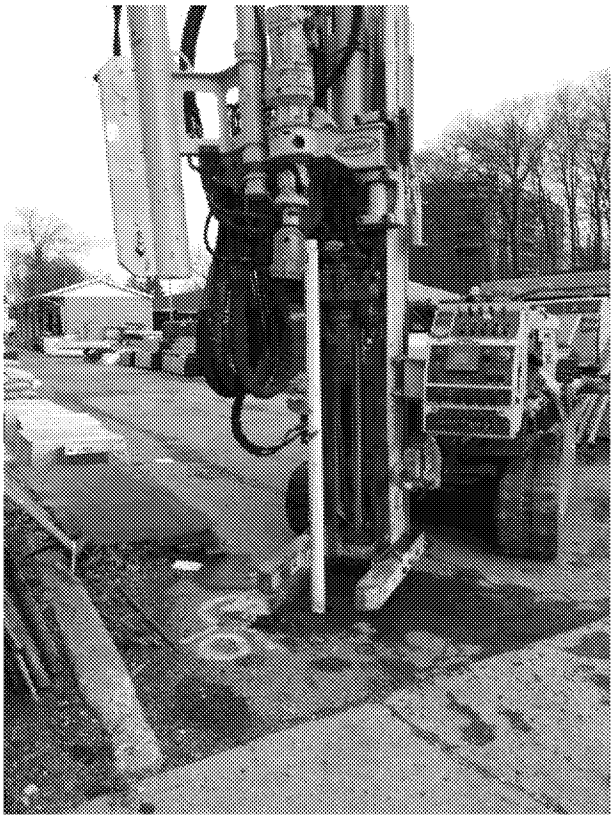
Photographic Documentation Log
Canadian Radium and Uranium Corp. Site
Mount Kisco, Westchester County, New York
December 12 through 14, 2016

Photograph 1: Weston Solutions, Inc., Removal Support Team 3 (RST 3) personnel conducting gamma survey at the parking lot immediately adjacent to the Site on the eastern side of the railroad tracks and fronting on North Moger Avenue (Property C007) using a Ludlum-2241 Scaler Ratemeter with sodium iodide (NaI) 3x3 scintillator attachment. A baby buggy stroller was utilized to provide mobility for the survey instrumentation setup.

Photograph 2: Prior to conducting any drilling activities on-site, RST 3 drilling subcontractor, Environmental Field Services, Inc. (EFS), cleared each proposed temporary well point location for subsurface utilities using a ground penetrating radar (GPR).

ED_006395_00001949-00030

Photograph 3: EFS installed the temporary well points using a Geoprobe™ (Model 7822DT) to advance borings to the desired depths.

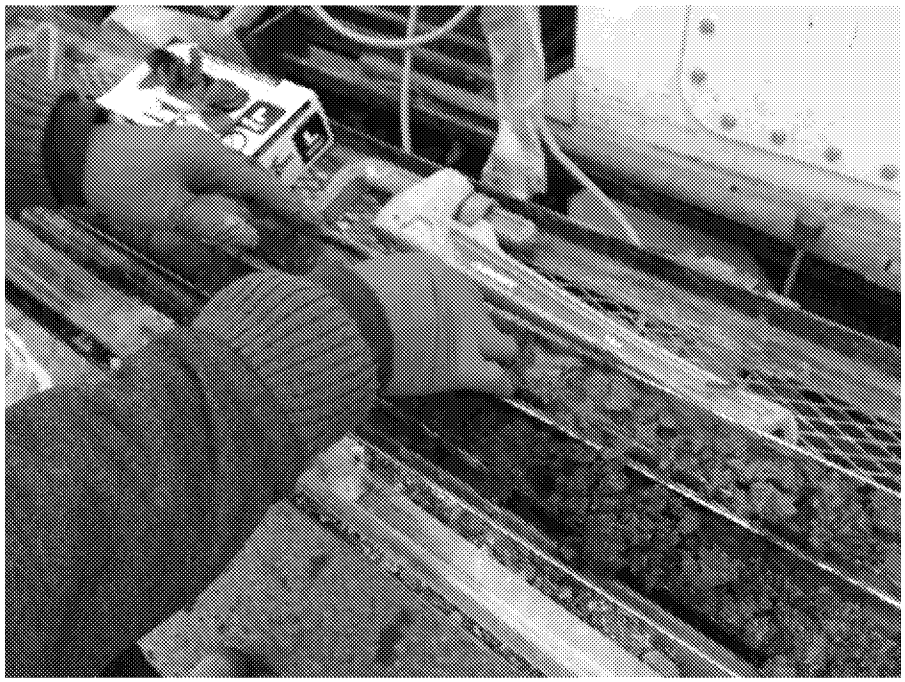


Photograph 4: The construction of each temporary well point consisted of a 10 foot 2-inch Schedule 40 polyvinyl chloride (PVC) screen (0.01 slot) plugged at the base with a PVC cap, and a 5 foot 2-inch Schedule 40 PVC casing with at least a 1 foot riser.

Photograph 5: After the temporary well points were installed, they were purged and surged with a Whale pump to facilitate influx of fresh groundwater from the aquifer, and then allowed to stabilize overnight.

Photograph 6: A Solinst water level meter was utilized by RST 3 to record the water levels and total depths of the temporary well points prior to purging for sampling purposes. Utilizing a non-dedicated submersible Grundfos pump fitted with Teflon™ tubing, RST 3 purged at least three well volumes from each temporary well prior to sample collection.

Photograph 7: Decontamination of the non-dedicated submersible pump was performed before and after sampling each temporary well point, and it involved scrubbing the pump exterior with an industrial soap (Alconox) and water, running the pump in a bucket of Alconox and water for 5 minutes, rinsing the pump exterior with tap water, running the pump in a bucket of tap water, steam cleaning the pump with deionized (DI) water, and air dry.



Photograph 8: RST 3 documented the physical characteristics and description of the soils extracted in each core from each boring location

Photograph 9: RST 3 collected groundwater samples directly from the dedicated Teflon™ tubing utilized to purge each temporary well.

Photograph 10: Per the EPA OSC's directive, once the temporary well points were sampled, the investigation-derived waste (IDW), including well development purge water, sampling purge water, and decontamination fluid, were pumped back into each temporary well point. The boreholes were then backfilled in reverse order with the extracted soil in the cores, tamped down, and sealed with bentonite.

ATTACHMENT E

Temporary Well Construction Log

TEMPORARY WELL CONSTRUCTION LOG

Well No. TW-1	Drilling Location:	Project/Client: Removal Assessment/U.S. EPA	TDD No.:
Boring No. C003-SB003	Canadian Radium and Uranium Corp. Site	Site Contact: Bernard Nwosu	TO-0007-0023
Contractor: Environmental Field Services, Inc. (EFS)		Site Location:	Background Gamma:
Crew:	Date: 12/13/2016	105 Kisco Avenue, Mount Kisco, Westchester County, New York	17 - 20 kcpm
Tom Wysocki and Doug Frar	Time Start: 10:30	Weather: Sunny, 34°F	Ground Elevation (NAVD 88): 289.50
Drill Method: Direct Push	Time End: 11:15	Logged By: Kathryn Donohue	TOC Elevation (NAVD 88): 290.85
Equipment Type: Geoprobe Model: 7822DT		Well Location: Latitude: 41°12'44.84939" Longitude: 73°43'37.49893"	Notes: Groundwater gauged on 12/14/2016

Recovery % ft. in.	Sample No. / Depth	Blow Counts	Gamma (kcpm)	Depth (feet)	Soil Details	Well Details	Geological Information:
							Casing stickup = 1.35 feet above ground surface (ags)
				0			0 - 5 feet: Asphalt (2 inches), brown angular SAND and fill, black at bottom
				1			
				2			
50%				3			
				4			
							Depth to water from top of casing = 5.36 feet
				5			5 - 8 feet: Grey silty SAND, wet
				6			
50%			18 - 20	7			
				8			
				9			
							9.5 - 10 feet: Brown peat
				10			10 - 15 feet: Light grey silty SAND, wet, some clay
				11			
60%				12			
				13			
							End of well construction @ 13.75 feet below ground surface (bgs)
				14			Total Well depth (screen + casing + casing stickup) = 15.1 feet
				15			End of Boring @ 15 feet bgs

Boring Information

Well Construction: Asphalt, Casing, Screen, Sand Pack, Bentonite, Grout, Casing stickup, Depth to Groundwater

Soil Characterization: Transitional Material, Primarily Sand, Primarily Silt, Primarily Clay, Shale, Heterogeneous Mixture, Fill Material

Well Construction Information:

Well Depth:	15.1 feet	Well Dia. (OD):	2 inches	Auger Dia. (OD):	3 inches
Screen length:	10 feet	Casing length:	4.1 feet bgs	Locked:	NA
Screen size:	0.10 slot	Casing stickup:	1.35 feet ags	Grout:	NA
Sand pack length:	NA	Casing Type:	Schedule 40 PVC	Bentonite:	NA
Sand pack Type:	NA	Sceen Type:	Schedule 40 PVC		

Comments:

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phone: (732) 585-4400 Fax: (732) 225-7037

TEMPORARY WELL CONSTRUCTION LOG

Well No. TW-2	Drilling Location:	Project/Client: Removal Assessment/U.S. EPA	TDD No.:
Boring No. C003-SB008	Canadian Radium and Uranium Corp. Site	Site Contact: Bernard Nwosu	TO-0007-0023
Contractor: Environmental Field Services, Inc. (EFS)		Site Location:	Background Gamma:
Crew:	Date: 12/13/2016	105 Kisco Avenue, Mount Kisco, Westchester County, New York	17 - 20 kcpm
Tom Wysocki and Doug Frar	Time Start: 11:30	Weather: Sunny, 34°F	Ground Elevation (NAVD 88): 289.77
Drill Method: Direct Push	Time End: 12:30	Logged By: Kathryn Donohue	TOC Elevation (NAVD 88): 291.25
Equipment Type: Geoprobe Model: 7822DT		Well Location: Latitude: 41°12'43.52507" Longitude: 73°43'36.75453"	Notes: Groundwater gauged on 12/14/2016

Recovery % ft. in.	Sample No. / Depth	Blow Counts	Gamma (kcpm)	Depth (feet)	Soil Details	Well Details	Geological Information:
							Casing stickup = 1.48 feet above ground surface (ags)
				0			0 - 1 feet: Asphalt, fill, concrete
				1			1 - 5 feet: Black coarse SAND, fill, concrete, hydrocarbon odor at 2.5 to 5 feet
50%				2			
				3			
				4			
							Depth to water from top of casing = 5.17 feet
				5			5 - 6 feet: Black coarse SAND, some peat at bottom
				6			6 - 7 feet: Grey silty SAND, trace clay
70%			14 - 18	7			7 - 10 feet: Grey CLAY
				8			
				9			
				10			10 - 15 feet: Light grey silty sandy CLAY
				11			
80%				12			
				13			
							End of well construction @ 14.64 feet below ground surface (bgs)
				14			Total Well depth (screen + casing + casing stickup) = 16.12 feet
				15			End of Boring @ 15 feet bgs

Boring Information

Well Construction: Asphalt, Casing, Screen, Sand Pack, Bentonite, Grout, Casing stickup, Depth to Groundwater

Soil Characterization: Transitional Material, Primarily Sand, Primarily Silt, Primarily Clay, Shale, Heterogeneous Mixture, Fill Material

Well Construction Information:

Well Depth:	16.12 feet	Well Dia. (OD):	2 inches	Auger Dia. (OD):	3 inches
Screen length:	10 feet	Casing length:	4.64 feet bgs	Locked:	NA
Screen size:	0.10 slot	Casing stickup:	1.48 feet ags	Grout:	NA
Sand pack length:	NA	Casing Type:	Schedule 40 PVC	Bentonite:	NA
Sand pack Type:	NA	Sceen Type:	Schedule 40 PVC		

Comments:

WESTON SOLUTIONS
1090 King Georges Post Road, Edison, New Jersey
phone: (732) 585-4400 Fax: (732) 225-7037

TEMPORARY WELL CONSTRUCTION LOG

Well No. TW-3	Drilling Location:	Project/Client: Removal Assessment/U.S. EPA	TDD No.:
Boring No. C003-SB010	Canadian Radium and Uranium Corp. Site	Site Contact: Bernard Nwosu	TO-0007-0023
Contractor: Environmental Field Services, Inc. (EFS)		Site Location: 105 Kisco Avenue, Mount Kisco, Westchester County, New York	Background Gamma: 17 - 20 kcpm
Crew: Tom Wysocki and Doug Frar	Date: 12/13/2016		
	Time Start: 13:20	Weather: Sunny, 34°F	Ground Elevation (NAVD 88): 292.06
Drill Method: Direct Push	Time End: 14:00	Logged By: Kathryn Donohue	TOC Elevation (NAVD 88): 293.80
Equipment Type: Geoprobe Model: 7822DT		Well Location: Latitude: 41°12'42.22776" Longitude: 73°43'39.03325"	Notes: Groundwater gauged on 12/14/2016

Recovery % ft. in.	Sample No. / Depth	Blow Counts	Gamma (kcpm)	Depth (feet)	Soil Details	Well Details	Geological Information:
							Casing stickup = 1.74 feet above ground surface (ags)
				0			0 - 2 feet: Asphalt (2 inches), crushed concrete
				1			
70%				2			2 - 3 feet: Brown coarse SAND, gravel, and crushed concrete
				3			3 - 4 feet: Brown medium SAND, some gravel and concrete
				4			4 - 5 feet: Grey medium to coarse SAND, 3 inches of wood chips at 30 kcpm
				5			
							Depth to water from top of casing = 5.95 feet
				6			6 - 7 feet: Dark brown coarse SAND and dark grey gravel, wet
90%			15 - 18	7			7 - 10 feet: Greenish grey SILT
				8			
				9			
				10			10 - 12 feet: Light grey silty SAND
				11			
80%				12			12 - 15 feet: Grey yellow SILT
				13			
							End of well construction @ 14.99 feet below ground surface (bgs)
				14			Total Well depth (screen + casing + casing stickup) = 16.73 feet
				15			End of Boring @ 15 feet bgs

Boring Information

Well Construction: Asphalt, Casing, Screen, Sand Pack, Bentonite, Grout, Casing stickup, Depth to Groundwater

Soil Characterization: Transitional Material, Primarily Sand, Primarily Silt, Primarily Clay, Shale, Heterogeneous Mixture, Fill Material

Well Construction Information:

Well Depth:	16.73 feet	Well Dia. (OD):	2 inches	Auger Dia. (OD):	3 inches
Screen length:	10 feet	Casing length:	4.99 feet bgs	Locked:	NA
Screen size:	0.10 slot	Casing stickup:	1.74 feet ags	Grout:	NA
Sand pack length:	NA	Casing Type:	Schedule 40 PVC	Bentonite:	NA
Sand pack Type:	NA	Sceen Type:	Schedule 40 PVC		

Comments:

WESTON
1090 King Georges Post Road, Edison, New Jersey
phone: (732) 585-4400 Fax: (732) 225-7037

ATTACHMENT F

Data Validation Report

DATE: February 13, 2017

SUBJECT: Radiochemical data validation for Pace Analytical, data package 30205674 in regards to Canadian Radium Site, Mount Kisco, West Chester County, New York, revision 0

FROM: Rick Haaker; CHP, CIH, Chemist

RF Haacker

TO: Daniel Gaughan USEPA On-Scene Coordinator

Bernard Nwosu, Weston Solutions RST 3 Site Project Manager

DCN: RST3-03-F-0052, Revision 0

Associated TDD: TO-0007-0014

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1 OVERVIEW

This report addresses the following data packages that were analyzed by Pace Analytical Laboratories in Greensburg, PA.

Table 1: Chain of Custody No. and Pace Internal Work Order No.

Pace Internal Work Order #	Chain of Custody #
30205674	2-121416-162810-0009

The analytes (isotopes) that were reported and the methods used are provided in the following table.

Table 2: Isotopes Reported and Analytical Methods.

Method	Description	Isotope
HSL-300	Alpha Spectroscopy	Thorium-228, Thorium-230, Thorium-232, U-233/234, U-235/236, Uranium-238
EPA 901.1	Gamma Spectroscopy	Actinium-228,Americium-241,Bismuth-212,Bismuth-214,Cesium-137,Cobalt-60,Lead-210,Lead-212,Lead-214,Potassium-40,Radium-224,Radium-226,Radium-228,Thallium-208,Thorium-228,Thorium-230,Thorium-232,Thorium-234,Uranium-234,Uranium-235,Uranium-238.
EPA 903.1	Radium-226 in Drinking Water	Radium-226
EPA 904.0	Radium-228 in Drinking Water	Radium-228

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EPA 900.0	Gross Alpha /Gross Beta in water	Radium-228

2 INTRODUCTION

Five water samples were collected at the site on December 14, 2016. The following tables provide information on which samples were analyzed by the various analytical methods. The samples were submitted under one "Chain of Custody." Pace Analytical reported the results in a brief pdf format data report. Each report provided analytical results, chain of custody, case narrative, but no raw data. An electronic data deliverables (EDD) was provided, which contained analytical results as well as information that was useful in assigning data qualifiers in a readily accessible format.

The radio-analytical data were validated to Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) *Chapter 8 - Radiochemical Data Verification and Validation*[1]and the requirements of the quality assurance project plan (QAPP).[2] The depth of the validation was necessarily limited because Derived Concentration Guidelines (DCGL), and some specific data performance requirements have not been designated.

2.1 DATA VALIDATION PRECAUTIONS AND LIMITATIONS

It should be noted that this technical report describes method validation and is not intended to provide guidance for validation of overall program/project objectives and requirements. Project validation is generally performed by project management personnel and involves a comprehensive review of all aspects (and objectives) of a sampling and analysis project. The samples having a client ID that begins with "RB" are rinse blanks.

Table 3: Cross Reference of Weston sample ID (ClientID) and Laboratory Internal ID (InternalID).

Table 3. Cross reference	
ClientID	InternalID
RB-121416	30205674007
TW-1-01	30205674001
TW-2-01	30205674002

Table 3. Cross reference	
ClientID	InternalID
TW-3-01	30205674003
TW-3-02	30205674006

2.2 Chain of Custody Remarks

Sample shipments to Pace Analytical observed normal chain of custody and sample preservation procedures and no exceptions were noted.

No data qualifiers were assigned on the basis of these chain of custody discrepancies.

[1] Multi-Agency Radiological Laboratory Analytical Protocols Manual, Volume I, NUREG-1576, EPA 402-B-04-001A, NTIS PB2004-105421, July 2004.

[2] SITE-SPECIFIC UFP QUALITY ASSURANCE PROJECT PLAN NIAGARA FALLS BOULEVARD SITE, NIAGARA FALLS, NIAGARA COUNTY, NEW YORK, DC No.: RST3-02-D-0033, TDD No.: TO-0006-0061. AUGUST 2015.

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3 DATA QUALIFIERS

Final Data qualifiers are codes placed on an analytical result that alert data users to the validator's concern about the result. These qualifiers may be summarized as U, J, R, or Q in the final validation report.

None the analysis was performed and radioactivity was detected. The result is statistically positive at the 95% confidence level, above the critical level and above the MDC. The radionuclide is considered to be present in the sample.

U A normal, not detected (< critical value) result.

UJ The analyte was not detected, but the required MDA was not attained. A number of specific problems also resulted in assignment of a J qualifier where results were more uncertain than usual.

Q A reported combined standard uncertainty, which exceeds the project's required method uncertainty. (In this report Q was only used as an intermediate or preliminary qualifier.)

J An unusually uncertain or estimated result.

R A rejected result: the problems (quantitative or qualitative) are so severe that the data cannot be used.

The data validator should be aware that a data qualifier or a set of qualifiers does not apply to all similar data. The data validator should incorporate the project MQOs into the testing and qualifying decision-making process.

During the data validation process the data validator may use additional qualifiers based on QC sample results and acceptance criteria. The final validation reports should also include a summary of QC sample performance for use by the data assessor. Intermediate or preliminary qualifiers, such as 'S', 'B' or 'P' are assigned on the basis of QC sample performance and these are taken into consideration in assignment of a final qualifier to an analytical result.

E An "E*" means that something is non-compliant with a MARLAP requirement, or is typically provided but is absent from the package, or cannot be determined from the information provided. The * is a second alphabetic character that describes the particular aspect of the data issue. For example, "EA" represents a result for which no aliquot information is provided. An intermediate "E*" qualifier may not be based on a QAPP requirement, and by itself does not lead to assignment of a final qualifier.

J1+ A result for a sample whose associated blank contained detected activity above the critical level and the result for the sample was less than 5 times the result for the blank.

S A result with a related spike result (laboratory control sample [LCS], matrix spike [MS] or matrix spike duplicate [MSD]) that is outside the control limit for recovery (%R); S+ or S- used to indicate high or low recovery.

P A result with an associated replicate result that exceeds the control limit.

P1 A result for a particular analyte and sample that has associated with it a relatively poorly performing pair of field replicates, which have a duplicate error ratio between 1.96 and 2.58.

PP1 A result for a particular analyte and sample that has associated with it a poorly performing pair of field replicates, which have a duplicate error ratio greater than 2.58.

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B A result with associated blank result, which is outside the control limit, B+ or B- used to indicate high or low results.

M An alpha spectroscopy result whose alpha spectra clearly appear to be affected by mass attenuation resulting in loss of counts from regions of interest.

The logic for mapping preliminary data qualifiers to final data qualifiers is provided in the next table. Each sample result has only one final data qualifier, but may have several preliminary or intermediate data qualifiers that represent aspects of data quality. Sixteen intermediate data qualifiers, each delimited by a comma, are given in the final table in a column entitled "Intermediate Qualifier Summary"in the following order:

- Blank Qualifier
- Spike Qualifier
- Intermediate Detection Qualifier
- Field Duplicate Qualifier
- Lab Duplicate Qualifier
- Rinse Blank Qualifier
- Tracer Recovery Qualifier
- Mass Attenuation Qualifier
- Aliquot Qualifier
- Ingrowth Qualifier
- Detector Tracking Qualifier
- NIST Qualifier
- Efficiency Qualifier
- Resolution Qualifier
- Mass Attenuation Qualifier
- Count Time Qualifier.

Table 4: Preliminary (intermediate) and final data qualifiers for this dataset.

Intermediate Qualifier Summary	Final Qualifier
,,,,,,,EM,EA,,ET,EN,,,EM,EC	-
,,,,,,,EM,EA,,ET,EN,,ER,EM,EC	-
,,,,,J+,,EM,EA,,ET,EN,,,EM,EC	J
,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J
,,,P1,,,,EM,EA,,ET,EN,,ER,EM,EC	-
,,,P1,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J
,,,PP1,,,,EM,EA,,ET,EN,,,EM,EC	-
,,,PP1,,J+,,EM,EA,,ET,EN,,,EM,EC	J
,,J,,,,,EM,EA,,ET,EN,,,EM,EC	J
,,J,,,,,EM,EA,,ET,EN,,ER,EM,EC	J
,,J,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J
,,U,,,,,EM,EA,,ET,EN,,,EM,EC	U
,,U,PP1,,,,EM,EA,,ET,EN,,,EM,EC	U

Intermediate Qualifier Summary	Final Qualifier
,S,,,,,,,EA,,ET,EN,,ER,,EC	J
,S,,,,,,,EA,J,ET,EN,,ER,,EC	J
,S,,,,,,EM,EA,,ET,EN,,ER,EM,EC	J
,S,,,,J+,,,EA,,ET,EN,,ER,,EC	J
,S,,,,J+,,,EA,J,ET,EN,,ER,,EC	J
,S,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J
,S,,PP1,,,,,EA,,ET,EN,,ER,,EC	J
,S,,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J
,S,J,,,,,,EA,,ET,EN,,ER,,EC	J
,S,J,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J
,S,J,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J
,S,R,,,,,,EA,,ET,EN,,ER,,EC	R
,S,R,,,,,,EA,,ET,EN,,R,,EC	R

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Intermediate Qualifier Summary	Final Qualifier
,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R
,S,U,,,,,EM,EA,,ET,EN,,ER,EM,EC	U
,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ
,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ
,S,UJ,PP1,,,,,EA,,ET,EN,,ER,,EC	UJ
B+,,,,,,,EM,EA,,ET,EN,,,EM,EC	J
B+,,,,,,J+,,EM,EA,,ET,EN,,,EM,EC	J
B+,S,,,,,,,EA,,ET,EN,,ER,,EC	J
B+,S,,,,J+,,,EA,J,ET,EN,,ER,,EC	J
B+,S,J,,,,,,EA,,ET,EN,,ER,,EC	J

Intermediate Qualifier Summary	Final Qualifier
B+,S,J,,,,,,EA,J,ET,EN,,ER,,EC	J
B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R
B+,S,R,,,,,,EA,,ET,EN,,R,,EC	R
B+,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R
B+,S,R,,,J+,,,EA,,ET,EN,,R,,EC	R
B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ
B+,S,UJ,,,,,,EA,J,ET,EN,,ER,,EC	UJ
B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ
B+,S,UJ,PP1,,,,,EA,,ET,EN,,ER,,EC	UJ

4 Equations

The following equations are frequently used to compare the performance of pairs of aliquots that were drawn from the same sample.

4.1 Duplicate error ratio

The duplicate error ratio is the relative error in a pair of measurements and takes into account the measurement results, Ma and Mb, as well as the standard errors associated with the measurements, 2Sa and 2Sb.

By convention, laboratories report analytical errors as 2 times the standard deviation, 2 Sa and 2 Sb. If Ma and Mb are results from duplicate aliquots that were taken from a homogeneous sample, then 95% of the time the DER is expected to be less than 1.96 and 99% percent of the time it is expected to be less than 2.58.

$$DER = 2 \times \frac{Abs(Ma - Mb)}{\sqrt{(2\,Sa)^2 + (2\,Sb)^2}}$$

4.2 Relative Percent Difference

The relative percent difference (RPctD) is a measure of consistency of measured concentration between two aliquots of a sample.

$$RPctD = 200\% \times \frac{Abs(Ma - Mb)}{Ma + Mb}$$

4.3 Matrix Spike Percent Difference

$$MSPctD = 100\% \times \frac{Spike\ Result - Unspiked\ Result}{Spike}$$

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4.4 Matrix Spike Normalized Difference

$$MSND = 2 \times \frac{Spike\ Result - Unspiked\ Result - Spike}{((2\,S_{Spike\ Result})^2 + (2\,S_{UnSpiked\ Result})^2 + (2\,S_{Spike\ Result})^2)^{0.5}}$$

Ninety-five percent of the time the absolute value of the matrix spike normalized difference is expected to be less than 1.96, and 99% of the time it should be less than 2.58.

5 SAMPLE HANDLING AND ANALYSIS EVALUATION

This section contains the technical review comments describing the findings and observations for each of the main verification and validation parameters described in MARLAP Chapter 8 - Radiochemical Data Verification and Validation.

5.1 Sample Descriptors (MARLAP 8.5.1.1)

Each sample should have a unique identification code that can be cross-referenced to a unique laboratory identification number.

Discussion

The laboratory identification numbers were listed in the cover page/case narrative in the data packages along with client ID numbers for all field samples.

No data qualifiers were assigned on sample descriptors.

5.2 Aliquot Size (MARLAP 8.5.1.2)

The aliquot or sample size used for analysis should be documented so that it can be checked when reviewing calculations, examining dilution factors or analyzing any data that requires aliquant as an input. It is also imperative that the appropriate unit (liter, kilogram, etc.) is assigned to the aliquant.

Discussion

The aliquot sizes as well as its units <u>were not</u> provided in the laboratory data packages or the EDD.

According to MARLAP, a data verifier would normally flag <u>all</u> of the results that are missing an aliquot size with an "EA," meaning that something about the sample result is non-compliant, and the data validator would flag such results with a 'J'. Since the aliquot size and other raw data is not provided, it is not possible to actually verify that the results are correct, should a person wish to actually do so.

No data qualifiers were assigned on this basis because there is no stated requirement in the QAPP.

5.3 Dates of Sample Collection, Preparation, and Analysis (MARLAP 8.5.1.3)

The analytical data package should report date of sampling, preparation, and analysis. These data are used to calculate radiological holding times, some of which may be specified in the Field Sampling Plan.

Discussion

Data were provided and the holding time requirements (i.e. <6 months) were met for every analysis in the data package. No issues of this type were recognized and no qualifiers were assigned on the basis of holding time exceedances.

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EPA Method 901.1 requires an ingrowth time on the order of 21 days to ensure that radon-222 is in secular equilibrium with radium-226 before the sample is counted. This ingrowth time begins on the day the sample is prepared and sealed into a container and ends when the sample is counted in a gamma spectrometer. The sample preparation /sealed date is not provided for gamma spec samples in the pdf report or in the EDD.

Since the ingrowth time is not stated, the reported concentrations of lead-214 and bismuth-214 are more uncertain than usual and possibly could have a high or a low bias. Lead and bismuth-214 results were assigned a "J" intermediate qualifier based on professional judgement and EPA method 901.1.

5.4 Preservation (MARLAP 8.5.1.4)

Appropriate preservation is dependent upon analyte and matrix and should be defined in sampling and analysis documentation. These requirements are stated in the draft QAPP, Worksheet 19.

Discussion

The Draft QAPP states that no sample preservation is required for soil samples. It also states that aqueous samples, such as rinse blanks, are to be preserved by cooling to 4 C.

Overall, it appears that the preservation conditions were consistent with QAPP requirements for the samples. No qualifiers were assigned on this basis.

5.5 Tracking (MARLAP 8.5.1.5)

Each analytical result should be linked to the instrument or detector on which it was counted.

Discussion

The detectors that were used for a particular sample could **not** be surmised from the information provided in the data packages. Thus an intermediate tracking qualifier of 'ET' was assigned to each result to alert users that information was missing that is normally provided in the data packages.

No samples were issued a final qualifier on the basis of missing detector information because this type of tracking is not required by the QAPP.

5.6 Traceability (MARLAP 8.5.1.6)

The traceability of standards and reference materials to be used during the analysis should be specified in the Field Sampling Plan.

Discussion

The Field Sampling Plan did not provide specific requirements for traceability. However, there is documentation that all radioactive standards are directly or indirectly traceable to NIST. Thus an intermediate traceability qualifier of 'EN' was assigned to each result to alert users that information was missing that is normally provided in the data packages. No final qualifiers were assigned on this basis.

5.7 QC Types and Linkages (MARLAP 8.5.1.7)

The type and quantity of QC samples should be identified and listed in the SOW and the results provided by the laboratory in a summary report. Replicates and matrix spike results should be linked to the original sample results.

The information obtained from the analysis of laboratory-generated duplicates is useful to evaluate analytical variability and laboratory precision. Results from the analysis of laboratory-generated duplicate samples can also reflect the homogeneity or inhomogeneity of individual samples or groups of samples of the same matrices.

Discussion

The QAPP did not require matrix spike and matrix spike duplicates for water samples. In addition the QAPP is ambiguous about the number of matrix spike and matrix spike duplicates that are required per QA batch.

There were blank, laboratory control standard (LCS) and duplicate LCS (LCSD) and matrix spikes /matrix spike duplicates (MS and MSD) results for each method. The MS/MSD QC samples were not required by the QAPP. The only lab duplicates tend to be LCS / LCSD pairs or MS / MSD pairs.

Field samples of solids typically had a client ID that was a string of alpha numeric characters that describe the sample location and this root tends to have either a '-01' or '-02' suffix appended. Field sample pairs whose IDs have the same root but have different suffixes are field duplicate samples. For example, if there were samples BKGRD-S015-0006-02 and BKGRD-S015-0006-01, they would be a field duplicate pair.

No deficiencies were recognized and no qualifiers were assigned on the basis of QC types and linkages as a consequence

5.8 Chemical Separation (Yield) (MARLAP 8.5.1.8)

Yield assesses the effects of the sample matrix and the chemical separation steps on the analytical result and estimates the analyte loss throughout the total analytical process.

The evaluation of an analytical yield serves to evaluate the efficiency of radiochemical separations utilized when preparing samples for measurement or analysis. The use of a tracer is conducted when a known amount of a chemical tracer is added to unknown samples; during analysis, a yield or recovery of the tracer material is used to determine the efficiency of the entire analytical process. The tracer that is chosen is used because it mimics the properties of one or more target radionuclides. A tracer refers to a radioactive isotope, while a carrier is a non-radioactive substance.

Discussion

The analyses that employed a tracer or carrier include: HSL-300 in drinking water according to the EDD. None of the reported tracer recoveries for field samples were reported in the EDD to lie outside of the acceptance range and no qualifiers were assigned on the basis of tracer recovery.

5.9 Self-Absorption (MARLAP 8.5.1.9)

For some radiochemical analytical methods, the SOW may specify the generation of a self-absorption curve, which correlates mass of sample deposited in a known geometry to detector efficiency.

Discussion

The laboratory typically performs a self-absorption calibration for radium-228 (EPA Method 904) but these were not provided. There appears to be no aspect of EPA Method 903.1 where an explicit self-absorption correction is necessary. Insufficient information was provided to conclude whether EPA Method 901.1 (gamma spectroscopy) results required an absorption correction.

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Alpha spectroscopy (HSL-300) is very sensitive to self-absorption effects, but self-absorption problems by this analytical method become evident from peak shape and the tendency of peaks to be smeared out of their regions of interest to lower energies. The alpha spectra of field samples and QC samples were not available for review.

None of the information required to assess self-absorption was provided. Therefore all sample results other than those obtained by EPA Method 901.1 were assigned an intermediate "E" qualifier, which is a caution to data users that some information concerning mass attenuation that is usually provided in level 4 data packages was missing.

No final data qualifiers were assigned as a result of self-absorption issues.

5.10 Efficiency, Calibration Curves, and Instrument Background (MARLAP 8.5.1.10)

The determination of detector efficiency is a detailed process that is best checked during an audit of the laboratory's capabilities and is usually not part of the verification and validation process.

Discussion

No documentation was provided in each data package that the equipment used was calibrated, that backgrounds were determined, and that the efficiencies of the detectors were well determined.

The laboratory data package QA narratives did not identify any deficiencies related to calibration curves, efficiency and instrument backgrounds. An "E" qualifier, which is a caution to data users that some information concerning efficiency, calibration curves and instrument background that is usually provided in level 4 data packages was missing.

No final data qualifiers were assigned as a result of missing efficiency, calibration curves and instrument background.

5.11 Spectrometry Resolution (MARLAP 8.5.1.11)

The measured resolution of alpha and gamma spectrometers, and spectral information should be provided in the data package to evaluate if proper peak identification and separation was made.

Discussion

The data package does not provide FWHM data or any spectrometry resolution data.

There is a well-known interference between radium-226 and uranium-235 by gamma spectroscopy since both have gamma emissions at 186 KeV and the spectrometer resolution is typically insufficient to resolve the contributions of the respective isotopes.

Radium-226 and uranium-235 results from gamma spectroscopy (EPA 901.1) were rejected because of the probable interference, and because both analytes are reported by other methods that are more reliable in this data package.

Due to the lack of spectrometry resolution data, all other results from EPA 901.1 and HSL-300 were assigned an intermediate resolution qualifier of "ER, " which is a caution to data users that some information like spectra and resolution data that is usually provided in level 4 data packages was missing.

No final qualifiers were assigned on this basis.

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5.12 Dilution and Correction Factors (MARLAP 8.5.1.12)

Samples for radiochemistry are usually not diluted. If required, dilution and correction factors (i.e., dry weight correction, ash weight correction) should be provided in the data package so that the final calculations of all data affected by dilution factors can be recalculated and confirmed.

Discussion

The entire last sections of the .pdf lab reports titled "Standards" does not provide detailed information about dilutions and the certifications of standards used in the analyses. In addition, dilution calculations and records are not provided for the calibration of instruments. For each dilution calculation, the aliquot size and units were not listed as in accordance with MARLAP 8.5.1.2.

Due to the lack of data, all results except those from EPA 901.1 were assigned an intermediate resolution qualifier of "E, " which is a caution to data users that some information like dilution and correction factors that is usually provided in level 4 data packages was missing.

No final qualifiers were assigned on this basis.

5.13 Counts and Count Time (Duration) (MARLAP 8.5.1.13)

The count time for each sample, QC analysis, and instrument background should be recorded in the data package. The ability to detect radionuclides is directly related to the count time.

Discussion

Count times, QC analyses, and backgrounds are not documented in the data package. Count times were nearly always sufficient for results to have the required MDC, except for EPA 901.1. EPA 901.1 is rarely used for environmental water samples because it does not offer a useful detection limit in most cases for a reasonable count time.

Due to the lack of data, all results were assigned an intermediate resolution qualifier of "E, " which is a caution to data users that some information like count times that is usually provided in level 4 data packages was missing.

No final qualifiers were assigned on this basis.

5.14 Result of Measurement, Uncertainty, Minimum Detectable Concentration, and Units (MARLAP 8.5.1.14)

The result of each measurement, its expanded measurement uncertainty, and the estimated sample- or analyte-specific MDC should be reported for each sample in the appropriate units.

Discussion

No issues with these factors were recognized and no qualifiers were assigned on this basis.

Three isotopes that were requested by gamma spectroscopy require discussion: bismuth-210, lead-210 and uranium-235. Bismuth-210 is a pure beta emitter, so it cannot be determined directly by gamma spectroscopy.

Lead-210 emits a low-energy 46 keV gamma ray with a low (4%) abundance. It can be detected by gamma spectroscopy at relatively low levels provided that the sample geometry and detector is optimized for low energy gamma emitters and there are not elevated concentrations of other gamma emitting isotopes in the sample. It does not appear that all three of these requirements were met for

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the analytical results in these data packages. If lead-210 is a contaminant of concern, then it is preferable to quantify it by measurement of its daughter, polonium-210 by alpha spectroscopy using method HSL-300. The detection limit for lead-210 by EPA Method 901.1 is not low enough that good risk-based decisions can always be made concerning clean-up.

When reported from EPA Method 901.1, thorium-232, uranium-234, thorium-228, thorium-230 and radium-226 were rejected because more reliable results for these isotopes are reported from other methods in this report. Some of these isotopes were reported frim EPA 901.1 by Pace but not requested by EPA. .

6 QUALITY CONTROL SAMPLES TECHNICAL REVIEW

6.1 Method Blanks (MARLAP 8.5.2.1)

The requirement for a method blank is usually established in the SOW and appropriate plan documents. Check to see if a method blank was analyzed and no detected concentration/activity found in the results.

Discussion

Method blank results were provided for every analyte in the data package. No activity was reported in any blank at concentrations that exceeded the minimum detectable activity or the critical level, except as noted in the table below. If no qualifier value is provided for a method blank, then the analyte of interest was detected above the minimum detectable concentration MDC, which is undesirable.

A blank qualifier value of 'J+' for a field sample would mean that the analyte was detected above the critical level in the associated method blank, but less than five times the result reported for the blank.

Final qualifiers were assigned on the basis of blank performance for two radium-228 field samples.

Table 5: Method blank QC sample results assigned a data qualifier.

Internal ID	Batch	Method	Isotope	Result	MDA	Critical Level	Report Units	Qualifier
1207382	RADC33287	EPA 904.0	Radium-228	0.506	0.612	0.24	pCi/L	J,

6.2 Laboratory Control Samples (MARLAP 8.5.2.2)

Laboratory control samples (LCS) and LCS duplicates (LCSD) were run for each batch and analysis type. Spike recoveries were acceptable, except as noted in the following table. In every case the duplicate error ratios were acceptable, but the spike recovery percentages for sample 1, sample 2, or both were outside of the expected range.

Table 6: Method blank QC sample results assigned a data qualifier.

Attribute	Value	Value	Value	Value
Internal ID 1	LCSD33130	LCSD33130	LCSD33130	LCSD33329
InternalID 2	LCS33130	LCS33130	LCS33130	LCS33329
Matrix	Water	Water	Water	Water
Isotope	Americium-241	Cesium-137	Cobalt-60	Thorium-230
Method	EPA 901.1	EPA 901.1	EPA 901.1	HSL-300
Batch	RADC33130	RADC33130	RADC33130	RADC33329
Result 1	462	92.3	48.1	6.48

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Attribute	Value	Value	Value	Value
Result 2	439	99.8	38.8	6.51
Rel % Diff	5.11	7.81	21.4	0.46
Dup Error Ratio	0.29	0.58	1.04	0.04
Recovery % 1	87	110	94	75
Recovery % 2	83	119	76	76

The gamma spectroscopy lab control results were either high or low for all three spike isotopes: americium-241, cesium-137 and cobalt-60. In addition the only thorium spike was thorium-230 and both the LCS and LCSD performed poorly. All gamma spectroscopy results and all thorium results by method HSL-300 were assigned an 'S' spike qualifier.

6.3 Laboratory Replicates (MARLAP 8.5.2.3)

The objective of replicate analyses are to measure laboratory precision based on each sample matrix. Check to see if laboratory replicate was analyzed and within control limits.

Discussion

Laboratory replicates in this data package were of principally two types, lab control standards and matrix spikes. Pace Analytical does not typically make lab duplicates of ordinary field samples. There is no requirement in the QAPP for water samples to have MS or MSD, so their performance was not examined. LCS and LCSD samples were addressed in section 6.2, "Laboratory Control Samples (MARLAP 8.5.2.2)" and none had duplicate error ratios greater than 1.96. Consequently, no qualifiers were assigned on the basis of discordant results for replicate pairs.

6.4 Matrix Spikes and Matrix Spike Duplicates (MARLAP 8.5.2.4)

Matrix spike samples provide information about the effect of each sample matrix on the preparation and measurement methodology. The test uncovers the possible existence of recovery problems, based on either a statistical test or a specified fixed control limit.

Discussion

There appears to be no requirement for matrix spikes and matrix spike duplicates in the QAPP for water samples. I often examine the performance of MS / MSD sample pairs as a surrogate for other lab duplicates, but it is difficult to do this without information from a complete PDF data report (which Pace did not provide) because MS and MSDs sometimes involve different aliquot sizes. No qualifiers were assigned on the basis of their performance since these were not required QC samples.

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6.5 Field Replicate Sample Performance

Field replicates or duplicates are given in the following table.

Table 7 Field replicate samples.

Batch	Client ID # 1	Client ID #2	Internal ID #1	Internal ID #2	Method	Isotope
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Actinium-228
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Bismuth-212
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Bismuth-214
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Cesium-137
RADC33118	TW-3-01	TW-3-02	30205674003	30205674006	EPA 900.0	Gross Alpha
RADC33118	TW-3-01	TW-3-02	30205674003	30205674006	EPA 900.0	Gross Beta
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Lead-210
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Lead-212
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Lead-214
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Potassium-40
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Radium-224
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Radium-226
RADC33286	TW-3-01	TW-3-02	30205674003	30205674006	EPA 903.1	Radium-226
RADC33287	TW-3-01	TW-3-02	30205674003	30205674006	EPA 904.0	Radium-228
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Radium-228
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Thallium-208
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Thorium-228
RADC33329	TW-3-01	TW-3-02	30205674003	30205674006	HSL-300	Thorium-228
RADC33329	TW-3-01	TW-3-02	30205674003	30205674006	HSL-300	Thorium-230
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Thorium-230
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Thorium-232
RADC33329	TW-3-01	TW-3-02	30205674003	30205674006	HSL-300	Thorium-232
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Thorium-234

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Table 7 Field replicate samples.

Batch	Client ID # 1	Client ID #2	Internal ID #1	Internal ID #2	Method	Isotope
RADC33329	TW-3-01	TW-3-02	30205674003	30205674006	HSL-300	U-233/234
RADC33329	TW-3-01	TW-3-02	30205674003	30205674006	HSL-300	U-235/236
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Uranium-234
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Uranium-235
RADC33329	TW-3-01	TW-3-02	30205674003	30205674006	HSL-300	Uranium-238
RADC33130	TW-3-01	TW-3-02	30205674003	30205674006	EPA 901.1	Uranium-238

No criteria for field duplicates *per se* are given in the QAPP other than Worksheet 35, which states "Compare results of field duplicate (or replicate) analyses with RPD criteria.

The relative percent differences (R%D) were calculated for the field duplicate pairs of samples. This statistic potentially can provide indications of the uniformity of the analyte in the media sampled. High values of relative percent difference greater than 40% suggest that the distribution of contaminants in the media sampled might be relatively heterogeneous or that the results are rather uncertain. The Relative Error Ratio requirement of < 1% provided in the QAPP appears not to make sense and would cause practically every result ever analyzed for this site to fail; it was ignored. Duplicate error ratios greater than 1.96 suggest that a pair of results are significantly more discrepant than usual. The more discordant field duplicates are provided in the table below.

Table 8: Relatively discrepant field replicate results.

qFieldDup2_keep						
Batch	Method	ClientID1	ClientID2	Isotope	RelDiff%	DER
RADC33329	HSL-300	TW-3-01	TW-3-02	Uranium-238	62.75	2.21
RADC33130	EPA 901.1	TW-3-01	TW-3-02	Radium-224	200	2.62
RADC33329	HSL-300	TW-3-01	TW-3-02	Thorium-230	88.91	5.87
RADC33286	EPA 903.1	TW-3-01	TW-3-02	Radium-226	149.22	14.08

No final data qualifiers were assigned to regular samples / analytes associated with these field duplicate QA sample pair results, although the results that

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are associated with the poorly performinig field replicate samples carry an intermediate qualifier of 'P1' or 'PP1.'

6.6 Rinse Blank Sample Performance

There were no rinse blank duplicates in these data packages. Rinse blanks with activity reported in excess of the nominal critical level, but less than the minimum detectable activity, are denoted with a "J" intermediate qualifier in the following table. If the analyte was reported as present at levels greater than the MDA in a rinse blank, a highly undesirable situation, then no intermediate qualifier appears in the following table. Concentrations (Conc), the uncertainty at 2 standard deviations (2 S) and nominal critical level are all in units of pCi/L.

The samples of primary interest in this investigation are water samples. The potential presence of a small amount of activity in the rinse blanks listed in the following table is a concern.

Field samples having results that are associated with these rinse blanks were assigned an intermediate rinse blank qualifier of 'J+' if the analytical result was less than 5 times that reported in the field blank. Such samples also are assigned a final data qualifier.

Table 9: Poorly performing rinse blanks.

InternalID	ClientID	Method	Isotope	Conc	2 S	MDA	Nominal Critical Level	Intermediate Qualifier
30205674007	RB-121416	EPA 904.0	Radium-228	0.65	0.302	0.495	0.194	,
30205674007	RB-121416	HSL-300	Thorium-228	0.3	0.198	0.269	0.0809	,
30205674007	RB-121416	HSL-300	U-235/236	0.113	0.099	0.111	0.0235	,
30205674007	RB-121416	HSL-300	Uranium-238	0.152	0.104	0.116	0.0307	,
30205674007	RB-121416	EPA 900.0	Gross Alpha	0.53	0.339	0.549	0.233	J,
30205674007	RB-121416	EPA 901.1	Lead-214	12.336	16.725	20.53	10.265	J,
30205674007	RB-121416	HSL-300	Thorium-230	0.048	0.084	0.169	0.042	J,
30205674007	RB-121416	HSL-300	U-233/234	0.164	0.12	0.172	0.0539	J,

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7 TEST OF DETECTION AND UNUSUAL UNCERTAINTY EVALUATION

7.1 Detection (MARLAP 8.5.3.1 and 8.5.3.2)

The general list of data qualifiers is provided in Section 3 and there is a Consolidated Table of Analytical Results with qualifiers in Section 10 of this report. The Intermediate Qualifier Summary field provides information on sixteen aspects of data quality, and the qualifiers for each aspect are delimited by a comma. The information in the third of these comma separated fields is specific to detection.

Discussion

The detection qualifier assumed six different values in this data set as follows.

Table 10: Intermediate detection qualifiers.

Intermediate Detection Qualifier	Explanation
,	A result that was reported to be greater than the MDA without obvious interference. This is the symbol for "no data qualifier needed to be assigned."
J,	A result that was reported to be greater than the nominal critical level but less than the MDA. .
J+,	Radium-226, estimated from the 186 KeV gamma emission that was counted one day after sealing tends to carry a 'J+' detection qualifier. These sample results have a positive bias and are less reliable than usual. Taking that limitation into account, they still can be useful as a prompt estimate of the radium-226 concentration.
R,	A result, such as uranium-235 by method EPA 901.1, which is severely affected by interference and should be disregarded.
U,	A result that was reported to be less than the associated nominal critical level and the associated MDA was reported to be less than the required MDA (1 pCi/g or 1pCi/L).
UJ,	A result that was reported to be less than the associated nominal critical level and the associated MDA was greater than the required MDA (1 pCi/g or 1pCi/L).

To avoid redundancy, the list of sample results that carry a detection qualifier is not provided in this section.

The required MDA was specified in the QAPP as 1 pCi/g and 1 pCi/L. It seems that these values were obtained from the TestAmerica laboratory. It appears that the QAPP did not anticipate that water samples might be analyzed by gamma spectroscopy, and 1 pCi/L is an unrealistically low detection limit for that method. It also appears that Pace Analytical may not have been aware of the required MDAs. Pace Analytical set the required MDA for a result to be the same as the MDA for that result in every case. Forty-eight results for field samples have detection qualifiers of "UJ" where no activity was detected but the required detection limit was not attained.

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7.2 Large or Unusual Uncertainty (MARLAP 8.5.3.3)

When method blanks have detected activity, the analytical results for associated samples may be more uncertain than usual.

Discussion

Sample results were assigned a blank qualifier that included the characters 'B+' if activity was detected in a blank and an associated sample result was less than 5 times the blank result. The blank qualifiers are denoted by the characters ending with the first comma in the intermediate qualifier summary field in the table provided in Section 10 of this report.

Forty-nine sample results were assigned a blank qualifier 'B+'.

8 SUMMARY OF DATA USABILITY

Of 145 field sample results, there were a total of 128 radionuclide results that carry a data qualifier. The meaning of each qualifier is described in section 3 of this report. The count of each final qualifier type for field samples is provided in the following table.

Table 11: Number of each of the various final data qualifiers.

Final Qualifier	Frequency
-	17
J	47
R	30
U	3
UJ	48

The distribution of qualifiers among field samples is further broken down in the following table.

Table 12: Number of each of the various final data qualifiers by method.

Description	Method	Final Qualifier	Number of Occurrences
Alpha Spectroscopy	HSL-300	-	4
Alpha Spectroscopy	HSL-300	J	25
Alpha Spectroscopy	HSL-300	U	1
Gamma Sepectroscopy	EPA 901.1	J	17
Gamma Sepectroscopy	EPA 901.1	R	30
Gamma Sepectroscopy	EPA 901.1	UJ	48
Gross Alpha/Beta	EPA 900.0	-	8
Gross Alpha/Beta	EPA 900.0	J	1
Gross Alpha/Beta	EPA 900.0	U	1

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Description	Method	Final Qualifier	Number of Occurrences
Radium-226 in Drinking Water	EPA 903.1	-	3
Radium-226 in Drinking Water	EPA 903.1	J	1
Radium-226 in Drinking Water	EPA 903.1	U	1
Radium-228 in Drinking Water	EPA 904.0	-	2
Radium-228 in Drinking Water	EPA 904.0	J	3

9 REFERENCES

Site Specific UFP Quality Assurance Project Plan Niagara Falls Boulevard Site, Niagara Falls, Niagara County, New York, DC No.: RST3-02-D-0033, TDD No.: TO-0006-0061. August 2015.

Multi-Agency Radiological Laboratory Analytical Protocols Manual, Volume I, NUREG-1576, EPA 402-B-04-001A, NTIS PB2004-105421, July 2004.

10 APPENDED DOCUMENTS

Consolidated table of analytical results with qualifiers (5 pages).

Radiological Data Verification/Validation Checklist (2 pages).

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Canadian Radium and Uranium Site

DCN RST3-03-F-0052 Revision 0

Client ID	Isotope	Method	Lab Sample ID	Matrix	Conc	2S	MDC	Intermediate Qualifier Summary	Final Qualifier	Units
RB-121416										
	Actinium-228	EPA 901.1	3020567400	Water	0	15.36	41.58	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-212	EPA 901.1	3020567400	Water	0	16.24	116.7	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-214	EPA 901.1	3020567400	Water	0	13.37	24.88	B+,S,UJ,,,,,,EA,J,ET,EN,,ER,,EC	UJ	pCi/L
	Cesium-137	EPA 901.1	3020567400	Water	0	1.15	9.54	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Gross Alpha	EPA 900.0	3020567400	Water	0.53	0.34	0.55	,,J,,,,,EM,EA,,ET,EN,,,EM,EC	J	pCi/L
	Gross Beta	EPA 900.0	3020567400	Water	-0.08	0.35	0.67	,,U,,,,,EM,EA,,ET,EN,,,EM,EC	U	pCi/L
	Lead-210	EPA 901.1	3020567400	Water	36.99	391.48	514.3	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Lead-212	EPA 901.1	3020567400	Water	0	9.39	19.04	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Lead-214	EPA 901.1	3020567400	Water	12.34	16.72	20.53	B+,S,J,,,,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Potassium-40	EPA 901.1	3020567400	Water	0	48.01	151.5	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-224	EPA 901.1	3020567400	Water	-41.38	184.26	220	B+,S,UJ,PP1,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-226	EPA 903.1	3020567400	Water	0.24	0.46	0.85	,,U,PP1,,,,EM,EA,,ET,EN,,,EM,EC	U	pCi/L
	Radium-226	EPA 901.1	3020567400	Water	47.62	158.97	205.4	B+,S,R,,,,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Radium-228	EPA 901.1	3020567400	Water	0	15.36	41.58	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-228	EPA 904.0	3020567400	Water	0.65	0.3	0.5	B+,,,,,,,EM,EA,,ET,EN,,,EM,EC	J	pCi/L
	Thallium-208	EPA 901.1	3020567400	Water	2.62	6.26	8.2	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Thorium-228	HSL-300	3020567400	Water	0.3	0.2	0.27	,S,,,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-228	EPA 901.1	3020567400	Water	194.78	598.36	738.9	,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-230	HSL-300	3020567400	Water	0.05	0.08	0.17	,S,J,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-230	EPA 901.1	3020567400	Water	957.12	2426.4	3059	,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-232	HSL-300	3020567400	Water	0.02	0.08	0.06	,S,U,,,,,EM,EA,,ET,EN,,ER,EM,EC	U	pCi/L
	Thorium-232	EPA 901.1	3020567400	Water	279.61	4017.7	5001	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-234	EPA 901.1	3020567400	Water	0	151.23	295	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	U-233/234	HSL-300	3020567400	Water	0.16	0.12	0.17	,,J,,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	U-235/236	HSL-300	3020567400	Water	0.11	0.1	0.11	,,,,,,,EM,EA,,ET,EN,,ER,EM,EC	-	pCi/L
	Uranium-234	EPA 901.1	3020567400	Water	0	151.23	295	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Uranium-235	EPA 901.1	3020567400	Water	0	28.75	64.02	,S,R,,,,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Uranium-238	EPA 901.1	3020567400	Water	45.49	122.67	159.4	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L

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Client ID	Isotope	Method	Lab Sample ID	Matrix	Conc	2S	MDC	Intermediate Qualifier Summary	Final Qualifier	Units
	Uranium-238	HSL-300	3020567400	Water	0.15	0.1	0.12	,,,P1,,,,EM,EA,,ET,EN,,ER,EM,EC	-	pCi/L
TW-1-01										
	Actinium-228	EPA 901.1	3020567400	Water	0	12.7	23.65	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-212	EPA 901.1	3020567400	Water	28.07	48.56	54.71	B+,S,J,,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Bismuth-214	EPA 901.1	3020567400	Water	6.51	11.18	11.94	B+,S,J,,,,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Cesium-137	EPA 901.1	3020567400	Water	-1.88	5.4	5.83	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Gross Alpha	EPA 900.0	3020567400	Water	72.5	27.5	36.1	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Gross Beta	EPA 900.0	3020567400	Water	105	24.3	21	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Lead-210	EPA 901.1	3020567400	Water	157.39	1984.5	2591	,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Lead-212	EPA 901.1	3020567400	Water	8.78	16.7	9.78	B+,S,J,,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Lead-214	EPA 901.1	3020567400	Water	13.11	12.83	10.47	B+,S,,,,J+,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Potassium-40	EPA 901.1	3020567400	Water	11.29	53.78	58.68	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-224	EPA 901.1	3020567400	Water	0	42.49	112.8	,S,UJ,PP1,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-226	EPA 901.1	3020567400	Water	0	70.61	135.6	B+,S,R,,,J+,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Radium-226	EPA 903.1	3020567400	Water	7.18	1.71	0.58	,,,PP1,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Radium-228	EPA 904.0	3020567400	Water	2.69	0.74	0.82	,,,,,J+,,EM,EA,,ET,EN,,,EM,EC	J	pCi/L
	Radium-228	EPA 901.1	3020567400	Water	0	12.7	23.65	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Thallium-208	EPA 901.1	3020567400	Water	5.61	4.21	4.23	,S,,,,J+,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Thorium-228	EPA 901.1	3020567400	Water	126.89	171.54	634.9	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-228	HSL-300	3020567400	Water	0.23	0.2	0.33	,S,J,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-230	HSL-300	3020567400	Water	0.3	0.2	0.26	,S,,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-230	EPA 901.1	3020567400	Water	-146.34	4098.5	5108	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-232	HSL-300	3020567400	Water	0.13	0.11	0.06	,S,,,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-232	EPA 901.1	3020567400	Water	0	4645.6	10330	B+,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-234	EPA 901.1	3020567400	Water	103.57	398.94	505.7	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	U-233/234	HSL-300	3020567400	Water	0.63	0.22	0.18	,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	U-235/236	HSL-300	3020567400	Water	0.11	0.09	0.08	,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Uranium-234	EPA 901.1	3020567400	Water	103.57	398.94	505.7	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Uranium-235	EPA 901.1	3020567400	Water	0	17.91	35.3	,S,R,,,,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Uranium-238	HSL-300	3020567400	Water	0.34	0.16	0.12	,,,P1,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Uranium-238	EPA 901.1	3020567400	Water	0	75.06	133.3	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
TW-2-01										

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Client ID	Isotope	Method	Lab Sample ID	Matrix	Conc	2S	MDC	Intermediate Qualifier Summary	Final Qualifier	Units
	Actinium-228	EPA 901.1	3020567400	Water	0	15.15	30.04	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-212	EPA 901.1	3020567400	Water	0	37.34	86	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-214	EPA 901.1	3020567400	Water	516.08	61	20.9	,S,,,,,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Cesium-137	EPA 901.1	3020567400	Water	-1.19	6.83	7.36	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Gross Alpha	EPA 900.0	3020567400	Water	44.1	10.8	8.65	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Gross Beta	EPA 900.0	3020567400	Water	29.6	5.91	2.88	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Lead-210	EPA 901.1	3020567400	Water	0	2431.7	5252	,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Lead-212	EPA 901.1	3020567400	Water	137.25	49.85	15.55	,S,,,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Lead-214	EPA 901.1	3020567400	Water	569.97	67.5	18.88	,S,,,,,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Potassium-40	EPA 901.1	3020567400	Water	22.57	77.23	77.51	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-224	EPA 901.1	3020567400	Water	90.78	150.19	246.7	,S,UJ,PP1,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-226	EPA 901.1	3020567400	Water	55	168.77	201.1	B+,S,R,,,J+,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Radium-226	EPA 903.1	3020567400	Water	0.92	0.62	0.77	,,,PP1,,J+,,EM,EA,,ET,EN,,,EM,EC	J	pCi/L
	Radium-228	EPA 901.1	3020567400	Water	0	15.15	30.04	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-228	EPA 904.0	3020567400	Water	1.14	0.42	0.58	B+,,,,,J+,,EM,EA,,ET,EN,,,EM,EC	J	pCi/L
	Thallium-208	EPA 901.1	3020567400	Water	0.69	7.46	8.2	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Thorium-228	HSL-300	3020567400	Water	0.52	0.26	0.3	,S,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-228	EPA 901.1	3020567400	Water	456.74	561.52	951.3	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-230	EPA 901.1	3020567400	Water	-556.08	6459.8	7907	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-230	HSL-300	3020567400	Water	0.24	0.17	0.22	,S,,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-232	HSL-300	3020567400	Water	0.31	0.18	0.12	,S,,,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-232	EPA 901.1	3020567400	Water	7023.1	8713.9	11460	,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-234	EPA 901.1	3020567400	Water	0	494.72	735.2	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	U-233/234	HSL-300	3020567400	Water	1.06	0.29	0.18	,,,,,,,EM,EA,,ET,EN,,ER,EM,EC	-	pCi/L
	U-235/236	HSL-300	3020567400	Water	0.09	0.09	0.14	,,J,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Uranium-234	EPA 901.1	3020567400	Water	0	494.72	735.2	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Uranium-235	EPA 901.1	3020567400	Water	13.95	55.7	67.98	,S,R,,,,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Uranium-238	HSL-300	3020567400	Water	0.82	0.24	0.08	,,,P1,,,,EM,EA,,ET,EN,,ER,EM,EC	-	pCi/L
	Uranium-238	EPA 901.1	3020567400	Water	49.15	146.44	182.7	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
TW-3-01										
	Actinium-228	EPA 901.1	3020567400	Water	0	24.06	50.34	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-212	EPA 901.1	3020567400	Water	6.11	117.29	140.9	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L

Client ID	Isotope	Method	Lab Sample ID	Matrix	Conc	2S	MDC	Intermediate Qualifier Summary	Final Qualifier	Units
	Bismuth-214	EPA 901.1	3020567400	Water	59.87	19.58	17.15	,S,,,,,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Cesium-137	EPA 901.1	3020567400	Water	0.93	8.22	9.54	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Gross Alpha	EPA 900.0	3020567400	Water	109	31.2	29.9	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Gross Beta	EPA 900.0	3020567400	Water	202	40	18.9	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Lead-210	EPA 901.1	3020567400	Water	0	289.13	604.3	,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Lead-212	EPA 901.1	3020567400	Water	11.65	10.97	16.84	B+,S,J,,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Lead-214	EPA 901.1	3020567400	Water	59.6	19.15	17.07	,S,,,,J+,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Potassium-40	EPA 901.1	3020567400	Water	0	48.01	121.9	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-224	EPA 901.1	3020567400	Water	156.65	115.85	128.3	,S,,PP1,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Radium-226	EPA 903.1	3020567400	Water	45.8	6.39	0.53	,,,PP1,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Radium-226	EPA 901.1	3020567400	Water	120.95	167.94	211	B+,S,R,,,J+,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Radium-228	EPA 904.0	3020567400	Water	57	10.3	0.69	,,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Radium-228	EPA 901.1	3020567400	Water	0	24.06	50.34	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Thallium-208	EPA 901.1	3020567400	Water	0	2.65	12.2	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Thorium-228	HSL-300	3020567400	Water	0.25	0.2	0.32	,S,J,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-228	EPA 901.1	3020567400	Water	42.76	613.3	766	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-230	HSL-300	3020567400	Water	3.23	0.74	0.22	,S,,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-230	EPA 901.1	3020567400	Water	-1102.8	2944.5	3692	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-232	HSL-300	3020567400	Water	0.14	0.11	0.06	,S,,,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-232	EPA 901.1	3020567400	Water	2582.7	4330.8	5241	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-234	EPA 901.1	3020567400	Water	0	132.57	360.2	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	U-233/234	HSL-300	3020567400	Water	0.54	0.21	0.19	,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	U-235/236	HSL-300	3020567400	Water	0.12	0.1	0.05	,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Uranium-234	EPA 901.1	3020567400	Water	0	132.57	360.2	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Uranium-235	EPA 901.1	3020567400	Water	17.15	49	59.77	,S,R,,,,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Uranium-238	EPA 901.1	3020567400	Water	0	101.4	182.2	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Uranium-238	HSL-300	3020567400	Water	0.56	0.2	0.11	,,,P1,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
TW-3-02										
	Actinium-228	EPA 901.1	3020567400	Water	1.68	18.9	21.06	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-212	EPA 901.1	3020567400	Water	0	19.83	65.83	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Bismuth-214	EPA 901.1	3020567400	Water	77.36	15.56	9.87	,S,,,,,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Cesium-137	EPA 901.1	3020567400	Water	1.73	4.59	4.99	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L

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Client ID	Isotope	Method	Lab Sample ID	Matrix	Conc	2S	MDC	Intermediate Qualifier Summary	Final Qualifier	Units
	Gross Alpha	EPA 900.0	3020567400	Water	83.6	28.6	32.9	,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Gross Beta	EPA 900.0	3020567400	Water	197	40.7	23.5	,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Lead-210	EPA 901.1	3020567400	Water	0	1301.6	2847	,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Lead-212	EPA 901.1	3020567400	Water	9.61	6.3	9.4	B+,S,,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Lead-214	EPA 901.1	3020567400	Water	60.28	11.95	11.39	,S,,,J+,,,EA,J,ET,EN,,ER,,EC	J	pCi/L
	Potassium-40	EPA 901.1	3020567400	Water	47.7	51.01	54.04	,S,J,,,,,,EA,,ET,EN,,ER,,EC	J	pCi/L
	Radium-224	EPA 901.1	3020567400	Water	0	29.44	100.5	,S,UJ,PP1,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-226	EPA 901.1	3020567400	Water	172.59	114.02	132.9	B+,S,R,,,J+,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Radium-226	EPA 903.1	3020567400	Water	315	37.7	0.74	,,,PP1,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Radium-228	EPA 901.1	3020567400	Water	1.68	18.9	21.06	,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Radium-228	EPA 904.0	3020567400	Water	46.7	8.46	0.54	,,,,,,EM,EA,,ET,EN,,,EM,EC	-	pCi/L
	Thallium-208	EPA 901.1	3020567400	Water	1.37	4.94	5.43	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	Thorium-228	EPA 901.1	3020567400	Water	0	714.29	732.6	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-228	HSL-300	3020567400	Water	0.4	0.23	0.28	,S,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-230	EPA 901.1	3020567400	Water	-1434.1	4686.4	5748	,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-230	HSL-300	3020567400	Water	8.4	1.6	0.29	,S,,PP1,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-232	HSL-300	3020567400	Water	0.33	0.18	0.12	,S,,,,,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Thorium-232	EPA 901.1	3020567400	Water	991.07	8318.9	10330	B+,S,R,,,J+,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Thorium-234	EPA 901.1	3020567400	Water	0	234.56	637.3	B+,S,UJ,,,,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L
	U-233/234	HSL-300	3020567400	Water	0.38	0.16	0.14	,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	U-235/236	HSL-300	3020567400	Water	0.08	0.07	0.05	,,,,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Uranium-234	EPA 901.1	3020567400	Water	0	234.56	637.3	B+,S,R,,,,,,EA,,ET,EN,,ER,,EC	R	pCi/L
	Uranium-235	EPA 901.1	3020567400	Water	0	19.14	45.01	,S,R,,,,,,EA,,ET,EN,,R,,EC	R	pCi/L
	Uranium-238	HSL-300	3020567400	Water	0.29	0.14	0.1	,,,P1,,J+,,EM,EA,,ET,EN,,ER,EM,EC	J	pCi/L
	Uranium-238	EPA 901.1	3020567400	Water	0	103.74	157.6	B+,S,UJ,,,J+,,,EA,,ET,EN,,ER,,EC	UJ	pCi/L

Qualifier Explanation: See section 3 of the Memo DCN RST3-03-F-0052 Revision 0
Conc: Concentration
2 S: Total propagated uncertainty at 2 standard deviations
MDC: Minimum detectable concentration

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Radiological Data Verification/Validation Checklist

Site Name: Canadian Radium Site, Mount Kisco, West Chester County, NY **Analytical Laboratory** Pace Analytical Laboratories
Case Number_____* _____ **Reviewer**_____ Rick Haaker, CHP, CIH __ _____ **Date**_____February 13, 2017_____
RF Haaker

Part 1 - Sample Handling and Analysis Evaluation

MARLAP Ref.	Criteria	Yes	No	NA	Comments
8.5.1.1	Sample Descriptors - Each sample has a unique ID code which is cross-reference to unique Lab ID	X			
8.5.1.2	Aliquant Size - amount of sample used in analysis provided		X		The document provided was not a Level 4 equivalent package.
8.5.1.3	Dates of sample collection, sample prep and sample analysis provided		X		Sample sealed (prep) dates for EPA 901.1 samples were not in data package.
8.5.1.4	Samples properly preserved	X			
8.5.1.5	Each analytical result linked to instrument/detector		X		This information was not provided in the package.
8.5.1.6	Traceability of standards and reference materials provided		X		This information was not provided in the package
8.5.1.7	QC samples analyzed	X			No field replicates but there were LCS/LCSD pairs, blanks and tracer resuls.
8.5.1.8	Yield (chemical separation, carrier and/or radiotracer) within acceptable ranges	X			Except where noted and qualified otherwise
8.5.1.9	Self-absorption curve provided		X		Not provided.
8.5.1.10	Efficiency, calibration curves and instrument background information provided		X		This information was not provided in the package.
8.5.1.11	Spectrometry resolution data provided		X		This information was not provided in the package.
8.5.1.12	Dilution factors and corrections factors addressed and documentation provided.		X		This information was not provided in the package.
8.5.1.13	Count Time for each sample, QC analysis and instrument background provided		X		This information was not provided in the package.
8.5.1.14	For each measurement: 1) Measurement uncertainty reported 2) Analyte MDC reported 3) Appropriate units used	 X X X			

Part 2 - Quality Control

MARLAP Ref.	Criteria	Yes	No	NA	Comments
8.5.2.1	Method Blanks analyzed and no detected concentration/activity found		X		Activity reported above critical level in MB for Ra-228 (EPA 904.0).
8.5.2.2	Laboratory Control Samples analyzed and within acceptable ranges	X			Except where noted in report section 6.2. Some LCS samples had out of range spike recoveries.
8.5.2.3	Laboratory replicates analyzed and within control limits	X			Except where noted in report section 6.2. LSC/LCSD replicate values had satisfactory agreement but some had out of range spike recoveries.
8.5.2.4	Matrix Spikes/Matrix Spike Duplicate analyzed and within established criteria			X	No required by QAPP for water samples.
8.5.3.1	Test of detection information (critical value) provided.			X	The MDC was provided based on alpha = beta = 0.05. The critical value was not required by QAPP. The critical level was approximated as 50% of the MDC where not provided.
8.5.3.2	Detection Capability: Required Minimum Detectable Concentration (RMDC) less than the Minimum Detectable Concentration (MDC) for each analyte		X		Except that the required MDC was not attained for all samples. See the validation report for details. RMDC for gamma spectroscopy was set unrealistically low in QAPP.
8.5.3.3	Uncertainty 1. Laboratory's combined standard uncertainty at concentrations lower that the action level less than required method uncertainty (expressed in concentration units) 2. Laboratory's relative combined standard uncertainty at concentrations above the action level less than required relative method uncertainty (express as a percent)			X X	No precision criteria was specified in the QAPP for individual analytical results.

Additional Comments: Gamma spectroscopy results for U-235, U-234, Th-228, Th-230, Th-232, Ra-226 were rejected due to poor detection capability, the results from HSL-300 or EPA 903.1 should be used instead.

Pace Analytical package number: 30205674

Chain of Custody number: 2-121416-162810-0009