

Radioactive Contamination from 1920-50s at an Urban Site of the New York City and Interim Remedial Action - 15630

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ABSTRACT

The former Wolff-Alport Chemical Company operated at the location in densely populated urban area in Queens, New York, between 1920 to about 1954. The company imported, stored on-site and processed monazite sand ores from the Belgium Congo. The extracted refined products enriched in rare-earth metals were sold on the commercial market. The process residues, rich in thorium and its progeny, were originally disposed of directly to the city sewer line and probably on-site also. The site's buildings are currently occupied by the auto shops, corner delicatessen store, light construction company, ice maker/distributor, and two residential apartments. Preliminary site investigations found multiple areas with elevated levels of direct gamma radiation with the maximum reported rates of 22 microsievert/hour (2.2 millirem/hour) at surface level and 40 microsievert/hour (4 millirem/hour) inside sewer manhole access. The thoron (Rn-220) gas air concentration in outdoor areas was reported reaching 13.5 kBq/m³ (366 pCi/L) and the radon (Rn-222) gas air concentrations was reported exceeding 148 Bq/ m³ (4 pCi/L) in some buildings. The dose assessments indicated that, under realistic scenarios, some members of the public were likely to receive the radiation exposure from this contamination in excess of the New York City and Nuclear Regulatory Commission general public radiation dose limit of 1 millisievert /yr (100 millirem/yr).

The interim remedial action was planned and conducted by the U.S. Environmental Protection Agency (U.S. EPA) Region 2 in close cooperation with the New York City and New York State in 2012-13. The purpose of the action was to take necessary interim measures to reduce annual public dose below limit of 1 millisievert/yr (100 millirem/yr) and reduce radon gas concentration levels in impacted indoor spaces below U.S. EPA Action Level for residencies of 148 Bq/ m³ (4 pCi/L). In order to achieve these goals, the following actions were taken: detailed radiological and occupancy surveys; development of realistic exposure scenarios; dose assessments; installation of the fence and gates around the “backyard” portion of the site; vegetation removal; development and detailed assessment of the radiation shielding options; application of the multilayer radiation shielding in some buildings, portions of the sidewalk and unpaved areas; mitigation of radon/thoron gas entry point; and installation of the radon mitigation system in one of the buildings. The preliminary post-action analyses indicated that the action goal would likely be achieved. The interim remedial action was conducted in a tight urban setting; it has significantly reduced public health risk from radiation without closure of businesses that continued operating within the site perimeter.

INTRODUCTION AND SITE HISTORY

The former Wolff-Alport Chemical Company operated at the location in densely populated urban area on the border of Brooklyn and Queens boroughs in New York City between 1920s to about 1954 (Fig. 1). About 1940, the company began importing monazite sand from the Belgian Congo through the rail spur located behind the processing buildings. The monazite sand is rich in thorium and rare earth metals that the company wished to extract. Large amounts of such ores were stored on-site. The rare earth metal compounds were extracted from ores using application of heat and acid. The extracted refined products enriched in rare earth metals were sold on the commercial market. The process residues, rich in thorium and its progeny, were originally disposed of directly and for many years to the city sewer line running along the city street. Probably, some residues were disposed of on-site. In 1947, the now defunct

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Atomic Energy Commission (AEC) ordered the company to halt sewer disposal of thorium byproducts. In later years of company's operations, the process residues were instead stored on-site in drums. Some thorium contained residues in form of thorium oxalate and thorium nitrate were in the 1950s sold to the U.S. Government for its high thorium content [1]. In subsequent years, the same buildings used by the chemical company and adjacent buildings have been used by many different companies and, currently are occupied by the auto shops, corner store and delicatessen, light construction company, ice maker/distributor, and two residential apartments (Fig. 2). The "backyard" portion of the site is located behind the buildings, where railroad line spur was active during company's operations. By 2013, the railroad spur was inactive, most of rail was removed, the area was covered by dense bush, not paved, not occupied, used as a staging area for construction equipment and frequently visited by homeless people and trespassers. The neighborhood where the site is located consists of the mix of light industry businesses, private homes, multi-apartment residencies, schools, day care centers, stores, and art workshops in a dense urban setting. About 1.8 million people live within 6.4 km (4 mile) distance the site; 24,724 people live within 0.8 km (0.5 mile) distance [2]. The site proper is bounded by Irving Avenue, Cooper Street, Moffat Street and a railroad (Fig. 1 and 2). In 1984, the U.S. Environmental Protection Agency (U.S. EPA), New York City (NYC) and New York State (NYS) were made aware by the Department of Energy (DOE) of the potential site contamination.

SITE CONTAMINATION AND ITS RADIOLOGICAL ENVIRONMENT

Several radiological surveys [1], [2], [3], [4] conducted since revealed the radioactive contamination of the areas occupied by the former Wolff-Alport Chemical Company, adjacent areas and the city's sewer line. The radioactive materials were found underneath building floors, paved sidewalks and roadways, in the unpaved area of the former railroad spur and, inside sewer line manhole accesses.

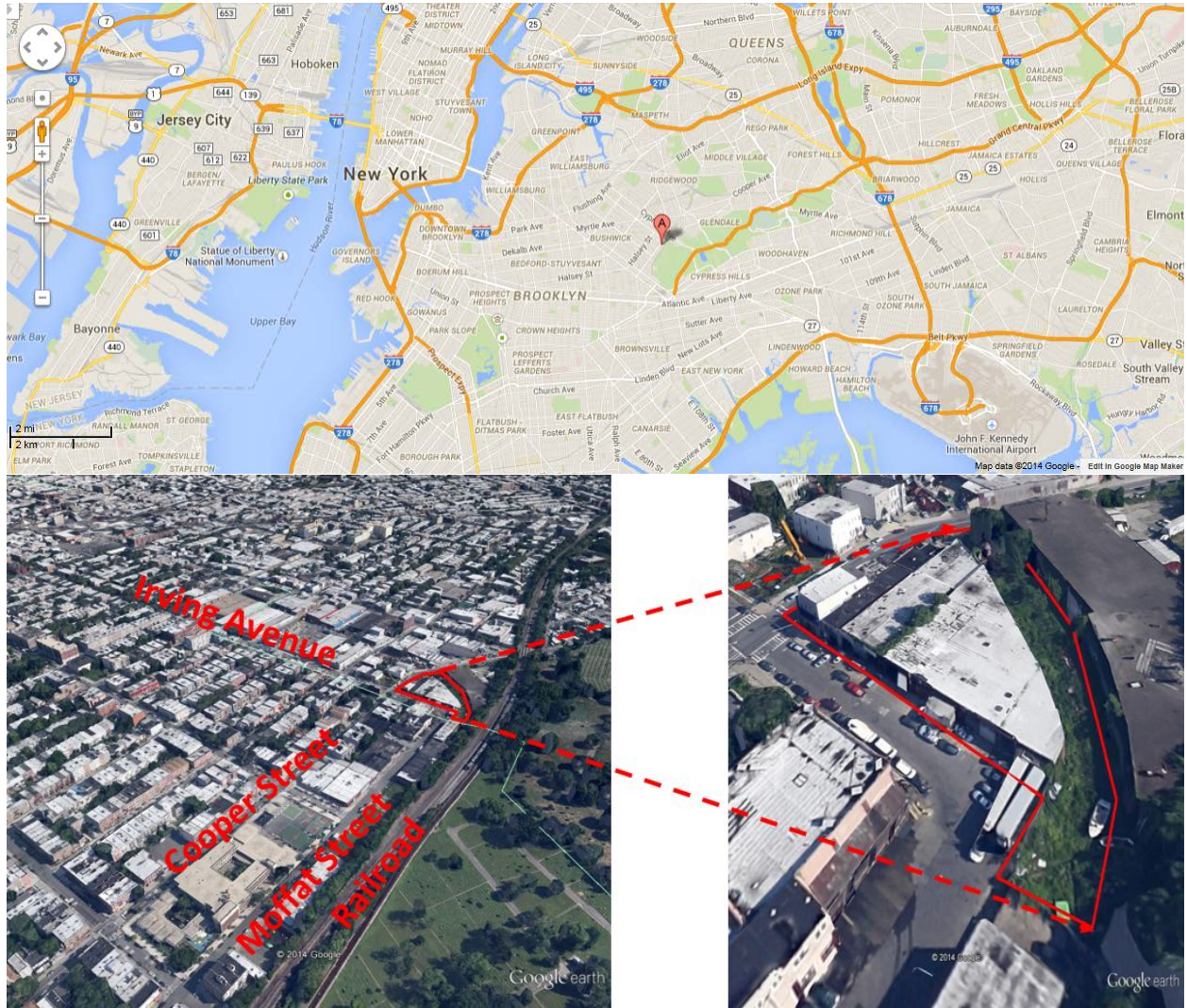


Fig. 1. The Former Wolff-Alport Chemical Company site in New York City is located in New York City on Brooklyn/Queens border and bounded by Irving Avenue, Cooper Street, Moffat Street and a railroad.



Fig. 2. The businesses located within the site perimeter and typical business activities at the site on Irving Avenue sidewalk

The elevated Rn-222 and Rn-220 air concentrations were found inside some buildings at surface level and, in some basements of the on- and off-site buildings. The typical radiation background rate for the area is 0.06 – 0.1 microsievert/hr (6 – 10 microrem/hour). Most of the site areas have elevated gamma radiation levels, as shown in Figs. 3 and 4, with multiple “hot spots”, reaching about 22 microsievert/hour (2.2 millirem/hour) level on the Irving Avenue roadway [5]. At one “hot spot” inside the sewer manhole the gamma radiation was recorded at about 40 microsievert/hour (4 millirem/hour) [4]. Surface soil samples from the “backyard” area had elevated levels of Th-232 reaching 17.5 Bq/g (472 pCi/g) and Ra-226 reaching at 0.9 Bq/g (25 pCi/g). The subsurface soil samples were collected using a Geoprobe™ system with a 5.08 cm (2-inch) diameter soil core to depths ranging from 3 to 6 meters (10 to 20 feet). Subsurface soil samples acquired from boreholes directly under the pavement had elevated

levels of Th-232 reaching 42 Bq/g (1,133 pCi/g) and Ra-226 reaching at 5.7 Bq/g (154 pCi/g) at one location [1]. Vertically, contamination extends at least down to 6 meters (20 feet). The outdoor vents of thoron (Rn-220) gas were found throughout the site. The thoron air concentration level at one of the outdoor vents was reaching 13.5 kBq/m³ (366 pCi/L) and 10.4 kBq/m³ (280 pCi/L) [5], [6] while the typical for the area site-specific background levels are 3.7 Bq/m³ (0.1 pCi/L). The air concentration of radon (Rn-222) inside two of the on-site buildings slightly exceeded 148 Bq/m³ (4 pCi/L) U.S. EPA Action Level for residences, reaching 159 – 170 Bq/m³ (4.3 – 4.6 pCi/L). In the basement of one of the off-site building located within 0.4 km (0.25 miles) distance from the site, the gas entry point was found with radon and thoron levels fluctuating by an order of magnitude during 14-day measurement period peaking simultaneously to 1.04 and 0.6 kBq/m³ (28 and 16 pCi/L) for radon and thoron, respectively, as averaged during 2-hour measurements [6]. The building is currently occupied by the Independent School 384, but the basement is only sporadically occupied by staff or students. No surface contamination was found inside the site’s buildings or on the public sidewalk.

RADIATION DOSE ASSESSMENTS

The radiation dose assessments conducted by various agencies confirmed that the estimated annual radiological dose to a member of the public from radioactive materials on the site would exceed 1 millisievert (100 millirem), the NYC [7] and Nuclear Regulatory Commission (NRC) [8] general public radiation dose limit. The Agency for Toxic Substances and Disease Registry of U.S. Department of Health And Human Services (ATSDR of USDOHHS) performed a Health Consultation in 2012 [9]. The ATSDR findings indicate that there is no immediate threat to nearby residents, employees or customers of businesses in the affected area along Irving and Cooper Avenues. However, as ATSDR noted [9], the exposure to this residual radioactive contamination may pose a health threat under certain long-term exposure scenarios. The ATSDR developed various realistic exposure scenarios. In order to more realistically account for contributions of multiple “hot spots” to the receptors’ exposure and varying occupancy times, ATSDR assigned statistical distributions to the input parameters, such as external dose

rate, occupancy time, soil ingestion rate, and performed Monte-Carlo dose analysis. The outcome distributions were analyzed, the average and high-end (upper 95-percentile) dose estimates were reported. For several scenarios, the average estimated annual dose exceeded 1 millisievert (100 millirem). For the bounding scenario of sidewalk auto repair work, the average and high-end annual doses were reported as 3.15 and 8.86 millisievert (315 and 886 millirem), respectively. The estimated lifetime cancer incidence risk for the high-end scenario was reported at 2.61×10^{-2} level.

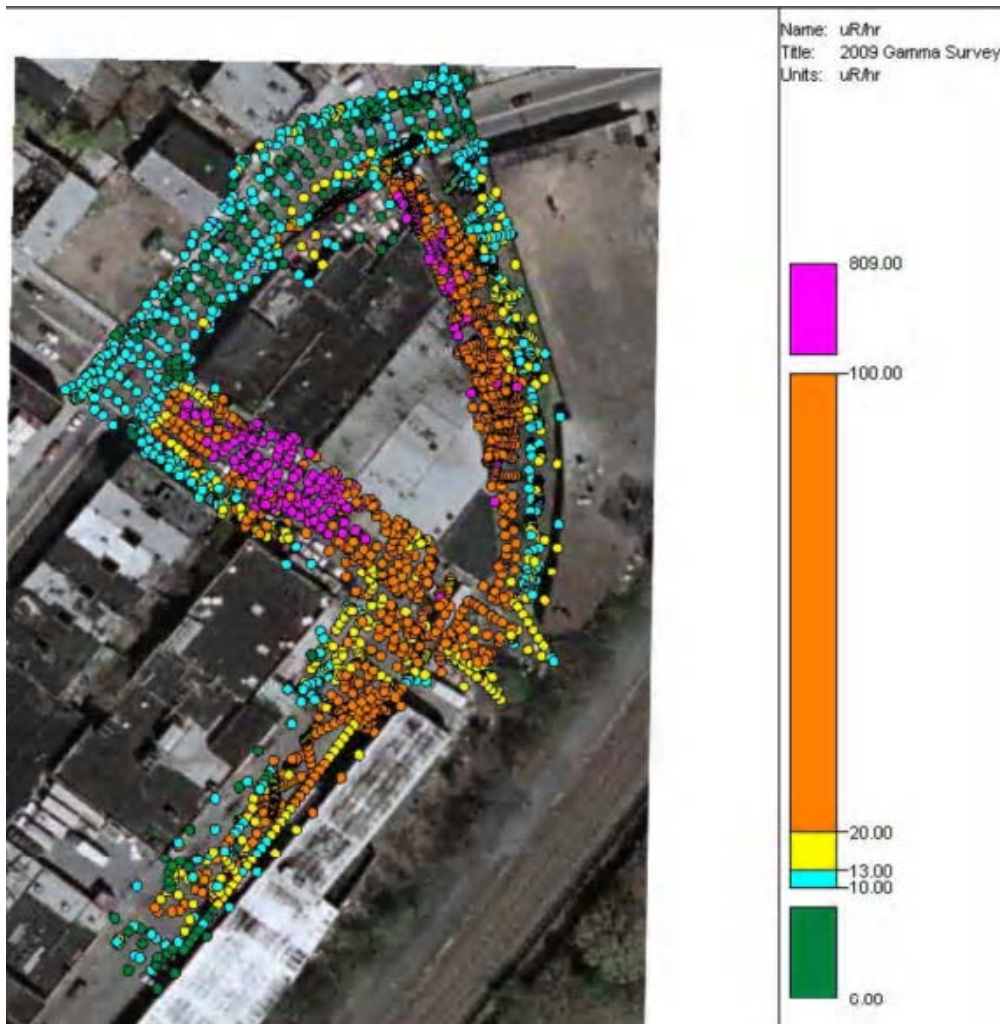


Fig. 3. Results of outdoor gamma survey at Former Wolff-Alport Chemical Company site in New York City. Approximate unit conversion: 100 microR/hr ~ 1 microsievert/hr.

INTERIM REMEDIAL ACTION

In 2012, responding to the New York State Department of Environmental Conservation (DEC) request and following and expanding on the ATSDR's Health Consultation's recommendations, the U.S. EPA was authorized to perform a remedial action at the site to address the potential health risks associated with exposure to ionizing radiation. U.S. EPA's short term remedial action included fencing, radiation shielding, air monitoring/air sampling, and installation of a radon mitigation system. The main

areas of concern included the former rail spur behind the buildings, interior space within the buildings and sidewalks and street areas with the highest levels of radiation. The objective of the action was to reduce impact of the radioactive contamination on the members of the public exposed to this contaminant: the employees of businesses operating directly within the footprint of the former Wolff Alport Chemical Company's facility, residents, pedestrians and visitors. The interim remedial action was planned and conducted by the U.S. EPA Region 2 in close coordination with the New York City and New York State in 2012-13. It was decided to limit the remedial action's scope to the footprint of the former Wolff Alport

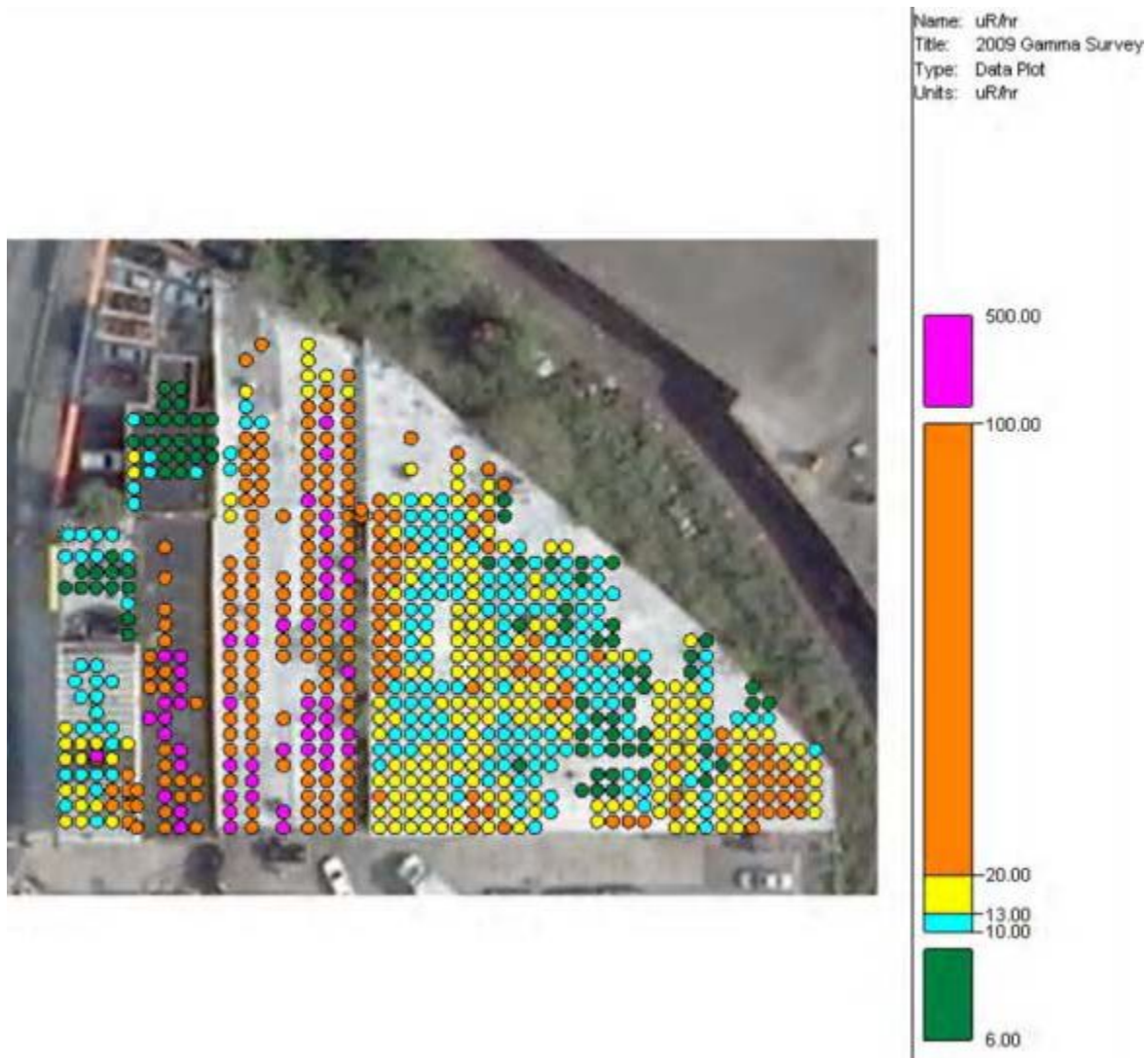


Fig. 4. Results of indoor gamma survey at Former Wolff-Alport Chemical Company site in New York City. Approximate unit conversion: 100 microR/hr ~ 1 microsievert/hr.

Chemical Company's facility per se excluding adjacent areas, roadways and sewer line. It was also decided not to close, even temporarily, the companies operating on-site and conduct remedial action with as little impact on their operations as realistically possible. The numerical goal of the action was to take necessary interim measures to reduce annual radiation dose to the public and workers below NRC and NYC public dose limit of 1 millisievert/yr (100 millirem/yr) and reduce radon gas concentration levels in impacted indoor spaces below EPA Action Level of 148 Bq/m^3 (4 pCi/L) [10]. The U.S. EPA has no

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specific guideline for thoron levels in homes, therefore thoron inhalation was considered as one of the

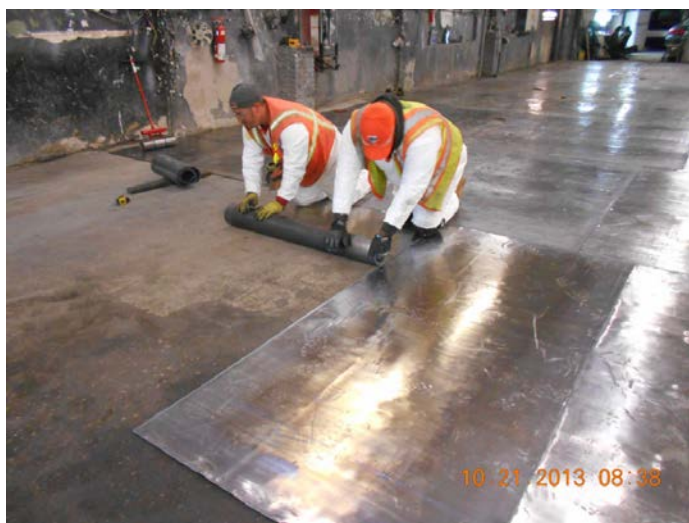
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exposure pathways in annual dose assessment. In order to achieve these goals, it was decided to fence and

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lock the backyard area (former railroad spur), install radiation shielding indoors and outdoors and install

radon mitigation systems where necessary. The site had multiple “hot spots” of elevated gamma radiation. The bounding “hot spot” dose rate and maximum occupancy rate values would produce unrealistically high annual dose assessments for the receptors at the site. If the radiation shielding were developed based on these bounding assessments and given other project constraints, the businesses would be unable to operate after shielding is applied. In order to make realistic exposure estimates to reasonably maximum exposed individuals, the U.S. EPA and NYC performed thorough radiological gamma surveys of the most contaminated areas, measured radon and thoron levels inside the occupied indoor spaces and conducted a one-day occupancy survey of the site-based workers. Based on these surveys, the site was divided into several subareas. Each subarea was characterized by the range of external radiation rate (millirems per hour) and corresponding occupancy factor (hours per day). For each of the subarea, the annual radiation dose assessment was made. The 1 millisievert (100 mrem) dose limit is specified by the NRC’s 10 CFR Part 20.1302 for “the individual likely to receive the highest dose from the licensed operation”, or by other words, the dose limit is specified for a reasonably maximum exposed individual. For that reason, the high-end (upper 95th percentile) annual dose values were reported along with the dose average values. High-end estimates of annual radiation doses are reported as the upper 95th percentiles of the dose ranges yielded by stochastic simulations over available parameter ranges using the Oracle Crystal Ball[®] Release 11.1.2.3.500 software package developed by Oracle Inc. For each subarea, the shielding options were developed based on the attenuation of external radiation necessary to achieve the action goals. Such attenuation was calculated by the shielding calculations using MicroShield[®] Version 9.04 software developed by Grove Software Inc. Because of the uncertainties in geometry and material composition of the below ground source term, the multiple assumptions were made in shielding calculations, such as homogeneous distribution of Th-232 and Ra-226, normal soil density, thickness, density of the pavement and floors and geometry of the source. In order to validate the calculated shielding attenuation factors, U.S. EPA conducted the pilot shielding study when concrete blocks and steel plates of known thickness were placed on the certain “hot spots” and radiation attenuation were measured and then compared with calculations. The operational constraints of the site-based companies and NYC Department of Transportation’s regulations were taken into account in course of the development of the shielding options. For example, the shielding thickness at the buildings’ gates had a limiting gate clearance factor, so that incoming and outgoing trucks of certain height could continue to safely clear the gates. No such constraints existed for the backyard area, so the most cost-effective option was developed for that subarea.



On the sidewalk, the shielding had to effectively mitigate gamma radiation exposure while being durable without creating a slip/trip-hazard to pedestrian traffic. The finalized shielding options for each subarea varied from pure concrete to combinations of steel, lead and concrete with projected attenuation of gamma radiation ranging from 66 to 96 percent. The roadway was not remediated during this action, so the radiation “shine” from the roadway to the sidewalk had to be accounted for in development of shielding options. While prior to application of shielding the roadway component to the exposure level was

relatively small, after the shielding application, that component became significant. While the shielding options were being developed, the backyard area was cleared of vegetation and fenced off by the security fence along its perimeter. Then, the most contaminated portion of the backyard was covered by 30.5 cm (1 foot) of concrete and the rest - by about 10.2 cm (4 inches) of the dense grade aggregate (DGA). After shielding options were finalized, the radiation shielding application process has begun (Figs. 5, 6 and 7). Work was conducted in four stages: removing all items and debris from the property floors, preparing the floor for concrete, installing lead sheeting and concrete based on design specifications, and returning all items to their original location after a 14-day concrete cure period. During the removal stage, all items were stored behind the staging area in the backyard covered by the DGA. Material that could not be left outside was stored in 20-foot storage containers. The application of radiation shielding was conducted in September – December 2013. Earlier, the radon mitigation system was installed in office space of one of the buildings in June 2013. In the second building with elevated radon levels, these levels drop below U.S. EPA Action Levels after shielding was installed on the floor, so no mitigation system was installed in that building. The gas entry point in the off-site school building's basement was remediated by the concrete plug with post-remediation radon and thoron concentrations dropping to the local background levels.



Fig. 6. Installation of steel plates as parts of the radiation shielding on Irving Avenue public sidewalk

Preliminary results of the post-shielding radiological surveys and radon concentration measurements indicate that goals of the remedial action are likely to be achieved i.e., annual radiation dose levels for public were reduced to levels below public annual dose limit and radon gas air concentrations were reduced to below EPA Action Level for residencies. Periodic observations of the

Fig. 5. Lead sheating as part of the radiation shielding installation inside auto repair shop.

sidewalk performed to inspect shielding for warping and damaging in hot summer

months did not identify major deformations. Some minor steel plate deformations were found and repaired.



Fig. 7. Application of concrete pad as part of the radiation shielding inside auto repair shop's building

CONCLUSIONS, CURRENT STATUS AND OTHER CONSIDERATIONS

The interim remedial action was conducted in an urban setting; preliminary results indicate that the action has reduced public health risk from radiation to the levels below regulatory limits without closure of businesses operating within the site perimeter. The final results are not yet available. The site was added to the National Priority List in May 2014. The site's activities pertinent to the Remedial Investigation/Feasibility Study (RI/FS) prescribed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup process were initiated soon after that. The U.S. Army Corps of Engineers (USACE) is conducting its own investigation on potential eligibility of the site for a cleanup under the DOE's Formerly Utilized Sites Remediation Action Program (FUSRAP). Also, in July – August 2013, U.S. EPA, New York City and New York State conducted radiological assessment of the site and the site's surrounding areas within 0.8 km (0.5 mile) distance [11]. A gamma walkover and vehicle based surveys of these areas were performed. Soil samples were collected and analyzed. Rn-220 measurements were taken at multiple locations within 0.8 km (0.5 mile) distance from the site. The study did not find any indications of the significant spread of the thorium containing material to off-site areas not directly adjacent to the site. The thorium contamination was not detected on the vast majority of the avenues and streets chosen for this survey, it is likely that the contamination is confined to the area proximal to the site proper. Independent of the above mentioned studies, the NYC Department of Environmental Protection surveyed the city sewer line originating at the site and preliminarily confirmed

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the contamination of the line and its manholes extending at least several city blocks from the site. The water from the sewer line is treated at the Newtown Creek Sewage Treatment Plant and eventually discharges to the Newtown Creek in Brooklyn, NY. This study is in progress and no final results are available yet. The Newtown Creek ecological assessment will be conducted as part of the RI/FS.

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