SECOND FIVE-YEAR REVIEW REPORT
U.S. RADIUM SUPERFUND SITE
ESSEX COUNTY, NEW JERSEY

Prepared by

U.S. Environmental Protection Agency
Region 2
New York, New York

May 2016

Approved by: _____

Walter E. Mugdan, Director
Emergency and Remedial Response Division

Date: May 9, 2016

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Executive Summary

This is the second five-year review for the U.S. Radium Superfund Site located in Essex County, New Jersey. The purpose of this five-year review is to review information to determine if the remedy is and will continue to be protective of human health and the environment. The triggering action for this policy five-year review is the completion of the previous five-year review in July 2011. The remedy will not result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure. However, it is the policy of the U.S. Environmental Protection Agency (EPA) to conduct five-year reviews when remedial activities, including monitoring, will continue for more than five years. Because it may take more than five years to attain federal or state drinking water standards, EPA has conducted a policy review.

Three Records of Decision (RODs) have been signed for the Site. The first ROD was signed in September 1993 and selected a remedy to address radium-contaminated soil and building material for Operable Unit 1 (OU1) of the Site. The second ROD was signed in August 1995 and selected essentially the same remedy as the 1993 ROD, but for a different set of properties (OU2). The third ROD was signed in September 2006 and selected a no-action remedy, with monitoring, for groundwater at the Site (OU3). The Site is now considered construction complete, after the signing of the Preliminary Site Close Out Report in September 2006. All of the work covered by the three RODs has been funded by EPA and the State of New Jersey.

Remediation of the Site is essentially complete. The contaminated soil and building material portion of the remedy (OU1 and OU2) was completed in September 2005; one residential property that could not be remediated at the time of the other properties due to access issues is scheduled to be completed by summer 2016. The groundwater portion of the remedy (OU3) was completed in September 2006 with the signing of the OU3 ROD, and groundwater monitoring is ongoing. All work has been performed in accordance with the RODs and Remedial Designs prepared for the Site, with oversight by EPA and the U.S. Army Corps of Engineers (USACE). The New Jersey Department of Environmental Protection (NJDEP) has concurred with all activities conducted as part of OU1 and OU2 of the Site. NJDEP has deferred concurrence on the OU3 ROD until it can evaluate the post-ROD monitoring results.

Based upon a review of the RODs, a number of reports, and inspections of the Site, EPA has concluded that the remedies at the Site continue to function as intended by the RODs and continue to protect human health and the environment.

SITE IDENTIFICATION		
Site Name: U.S. Radium		
EPA ID: NJD980654172		
Region: 2	**State:** NJ	**City/County:** City of Orange Township, Essex County

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: EPA ***[If "Other Federal Agency", enter Agency name]*:** Click here to enter text.
Author name (Federal or State Project Manager): Anne Rosenblatt
Author affiliation: EPA
Review period: 7/1/2011 – 7/1/2016
Date of site inspection: 11/5/2015
Type of review: Policy
Review number: 2
Triggering action date: 7/1/2011
Due date *(five years after triggering action date)*: 7/1/2016

Five-Year Review Summary Form

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
There are no recommendations or follow-up actions stemming from this five-year review, other than continuing to monitor the effectiveness of the OU3 remedy.

Protectiveness Statement(s)	
Operable Unit:	*Protectiveness Determination:*
OU3	Protective

Protectiveness Statement:
The implemented remedy at OU3 is expected to be protective upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

Sitewide Protectiveness Statement

Protectiveness Determination:
Protective

Protectiveness Statement:
Remedies for all three OUs are considered protective of human health and the environment because contaminated properties have been remediated to allow for unlimited use and unrestricted exposure. Exposure pathways to groundwater that could result in unacceptable risk are being controlled.

Introduction

The purpose of a five-year review is to evaluate the implementation and performance of a remedy to determine if the remedy is and will continue to be protective of human health and the environment and is functioning as intended by the decision documents. The methods, findings, and conclusions of reviews are documented in the five-year review. In addition, five-year review reports identify issues found during the review, if any, and document recommendations to address them.

This is the second five-year review for the U.S. Radium Site, located in the City of Orange Township, Essex County, New Jersey. This five-year review was conducted by the Environmental Protection Agency (EPA) Remedial Project Manager (RPM) Anne Rosenblatt. The review was conducted pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. §9601 *et seq.* and 40 CFR 300.430(f)(4)(ii), and in accordance with the *Comprehensive Five-Year Review Guidance,* OSWER Directive 9355.7-03B-P (June 2001). This report will become part of the Site file.

The triggering action for this policy review is the July 2011 completion of the previous five-year review. A five-year review is required at this Site because the remedial action will not leave hazardous substances, pollutants or contaminants on Site above levels that allow for unlimited use and unrestricted exposure, but requires five or more years to complete. The Site consists of three Operable Units (OUs). OU1 addressed vicinity properties and satellite properties, OU2 addressed the remaining vicinity and satellite properties as well as the High and Alden Streets Properties, where the U.S Radium facility was located. OU3 addresses groundwater at the Site. The final property associated with OU1 is scheduled to be completed by summer 2016, and the remedial action for OU2 was completed in September 2005. The OU3 remedy for groundwater was completed in September 2006 with the selection of a no-action remedy, with monitoring. OU3 is addressed in this five-year review.

This five-year for OU3 review finds that the selected remedy remains protective of human health and the environment.

Site Chronology

See Table 1 for the Site chronology.

Background

Physical Characteristics

The former U.S. Radium Corporation facility, which covers two acres in the City of Orange Township, Essex County, New Jersey, is a former radium-processing plant where extraction, production, application, and distribution took place from about 1915 through 1926 (See Figure 1). Approximately ½ to 2 tons of ore per day were processed and disposed of on and off the property. The U.S. Radium Corporation also conducted operations at properties in the vicinity of the processing plant. As a result of those operations, the processing plant buildings and soil became contaminated with radionuclides. In addition, radium-contaminated soil and debris were identified at approximately 250 non-contiguous properties in the vicinity of the former plant and at various other locations throughout the municipalities of Orange, West Orange, and South

Orange. The non-contiguous affected properties are residences, light industries, offices, grocery stores, and apartment buildings. The Site is comprised of the former processing plant and the non-contiguous properties contaminated with radionuclides. The main portion of the Site is located in a densely populated, urban residential neighborhood.

Site Geology/Hydrogeology

The Site lies within the lower valley portion of the Passaic River Drainage Basin. Groundwater is present in the unconsolidated glacial sediments (shallow overburden aquifer) and in Passaic Formation bedrock (deeper aquifer). Groundwater flow in the overburden is generally to the east-southeast. A slight upward flow of groundwater is present at the Site, particularly in wells immediately down gradient of the former U.S. Radium facility. The upward gradient between the deeper groundwater and the shallow overburden groundwater limits the downward movement of groundwater. The overburden aquifer currently is not used for domestic or industrial water supply purposes.

Land and Resource Use

Land use at the Site and in the vicinity of the Site is mostly residential, with some commercial and light industrial establishments. The State of New Jersey has classified the aquifer as Class II-A, a current source of drinking water. All area residents are supplied with municipal water provided through state-regulated water supply companies.

History of Contamination

The U.S. Radium Corporation, formerly known as the Radium Luminous Materials Corporation, operated a radium-processing plant at the corner of High and Alden Streets in Orange, New Jersey from about 1915 through 1926. The U.S. Radium Corporation conducted operations at other properties in the vicinity of the processing plant. A primary activity at the High and Alden Streets processing plant was the extraction and purification of radium from carnotite ore. Because each ton of ore produced only a few milligrams of radium, large volumes of ore were required. As a result, large quantities of process wastes, or "tailings," were generated, which contained radioactive elements at elevated levels. The tailings were temporarily discarded on unused areas of the processing plant and ultimately disposed of off-site in nearby areas.

In addition to the production and sale of radium itself, the U.S. Radium Corporation also manufactured a radium-based luminous paint. At one time, the company employed more than 100 workers to paint instruments and watch dials with this luminous paint. Reports indicate that dial painting took place at the High and Alden Streets processing plant and at several satellite properties. The U.S. Radium Corporation discontinued radium processing operations in 1926, while continuing its dial-painting business. In the 1940s, the U.S. Radium Corporation sold its properties at High and Alden Streets, and no subsequent occupants of the properties are known to have processed or used radium.

Initial Response

In 1979, EPA and the New Jersey Department of Environmental Protection (NJDEP) initiated a program to identify and investigate locations within New Jersey where radium-processing activities had taken place. The former U.S. Radium Corporation processing plant was included in that program. In May 1981, EPA conducted an aerial gamma radiation survey covering

approximately 12 square miles centered on the High and Alden Streets processing plant. The aerial survey detected about 25 acres of land with elevated levels of gamma radiation around the High and Alden Streets processing plant. This same survey identified areas of elevated gamma radiation in the nearby communities of Montclair, West Orange, and Glen Ridge; the affected properties in these areas comprise two other Superfund sites, the Montclair/West Orange Radium site and the Glen Ridge Radium site. Similar contamination was found in these areas and was remediated concurrently with the U.S. Radium Site. Construction was completed at both sites in 2005 and both have since been deleted from the National Priorities List (NPL) of Superfund sites.

In 1982, the U.S. Radium Site was proposed for inclusion on the NPL, and the Site was placed on the NPL in September 1983. Ground-level surveys conducted in the early 1980s showed elevated gamma radiation and radon gas in most of the buildings at the High and Alden Streets processing plant. In 1984, NJDEP performed preliminary field investigations of 31 properties near the processing plant. While those investigations found elevated levels of gamma radiation at some properties, NJDEP found only small pockets of radium-contaminated soil, and detected no elevated radon gas levels. Working from U.S. Radium Corporation documents and other historical records, EPA and NJDEP initially identified 22 satellite properties at which the U.S. Radium Corporation had conducted operations. Initial investigations of some of the satellite properties in 1983 and 1986 indicated elevated levels of gamma radiation, with a few instances of elevated radon gas in basements.

EPA initiated a broader remedial investigation and feasibility study (RI/FS) in October 1989 to determine the nature and extent of contamination at the Site. By October 1992, more than 160 investigations had been performed, and 63 radium-contaminated properties had been identified. As part of a removal action begun in 1991, EPA installed radon mitigation systems and gamma radiation shielding at four properties where elevated radiation levels were detected.

In October 1992, with the investigation of the former processing plant and the satellite properties still ongoing, EPA elected to organize the other properties into a first operable unit (OU1), and to propose a remedy for those properties. With about 160 investigations completed, it was clear that performing studies on additional properties would not assist EPA in better understanding the problem, and would unnecessarily delay the process of proposing a remedy and cleaning up the radium-contaminated properties. An RI/FS report was prepared in 1993 which documented the nature and extent of contamination at the already investigated properties, and provided a detailed evaluation of remedial alternatives.

Groundwater sampling was conducted during the initial RI/FS at the Site, but the results were not conclusive. Therefore, a more comprehensive groundwater investigation at the Site was initiated in 2003; this was after most of the contaminated source material was removed during an earlier phase completed in September 2001. As a result of this investigation and further sampling rounds from 2004 to 2006, EPA identified a small area of remaining soil with elevated uranium at the location of the former processing plant on the High and Alden Streets property. In August 2006 EPA excavated an additional 250 cubic yards of soil with slightly elevated concentrations of uranium.

Basis for Taking Action

Remedial action at this Site was necessary to protect human health and the environment from actual and potential releases of hazardous substances from the Site into the environment. The

contaminants found in the soil and groundwater at the Site included radionuclides, particularly radium (in soil) and uranium (in groundwater). The following pathways were evaluated during the human health risk assessments:

- Inhalation of radon decay products;
- Exposure to external gamma radiation emanating from radium-contaminated material;
- Ingestion of radionuclides in soil;
- Ingestion of radionuclides in locally grown produce;
- Inhalation of radioactive particulates; and
- Ingestion of uranium-contaminated groundwater from the shallow overburden aquifer if it were used as a drinking water resource.

Remedial Actions

Remedy Selection

Based on the results of the RI/FS, a Proposed Plan for OU1 was issued to the public for comment on April 28, 1993. OU1 consisted of mostly residential properties. On September 21, 1993, a Record of Decision (ROD) was signed for the OU1 properties, selecting a remedy of excavation of radium-contaminated material from affected properties, restoration of the excavated areas, and off-site disposal of the radium-contaminated material.

A Proposed Plan for OU2 of the Site was issued to the public for comment on May 23, 1995, along with an OU2 RI/FS Report. OU2 consisted of the remainder of the Site; namely, the former U.S. Radium processing plant at High and Alden Streets, plus four other commercial properties used by the former U.S. Radium Corporation. On August 29, 1995, a ROD was signed for the OU2 properties, selecting essentially the same remedy as that for the OU1 properties: excavation of radium-contaminated material, restoration of the excavated areas, and off-site disposal of the radium-contaminated material.

The remedial action objectives for OU1 and OU2 were:

- Prevent exposure to gamma radiation in excess of 20 microroentgen per hour (uR/hr) above background;
- Prevent exposure to indoor concentrations of radon gas in excess of 4 picocuries per liter (pCi/l) and radon decay products in excess of 0.02 Working Levels (WL);
- Prevent ingestion of and general contact with radium-contaminated material (e.g., soil) with concentrations in excess of 5 picocuries per gram (pCi/g); and
- Prevent migration of material contaminated with radium in excess of 5 pCi/g that could result in the exposures described above.

Based on the results of the groundwater (OU3) RI/FS, a no-action remedy, with monitoring, was selected in a September 2006 ROD. A small area with elevated concentrations of uranium was identified in the shallow aquifer. After consideration of the site-specific details and analysis of all data collected, EPA determined that a no-action approach was protective of human health and the environment, primarily because the shallow aquifer is not currently used as a drinking water source. Since nearby residents are supplied with municipal water, the use of shallow groundwater as a drinking water source in the future is considered highly unlikely; and because the source of contamination in the soil has been removed, the concentration of uranium in the groundwater in this limited area should decrease with time.

To summarize, the OU1, OU2, and OU3 remedies included the following major components:

Soil and Building Materials

- Excavation or removal of radium-contaminated material exceeding remedial action objectives from all affected properties

- Off-site disposal of the radium-contaminated material

Groundwater

- No action other than appropriate environmental monitoring to ensure the effectiveness of the remedy

Remedy Implementation

Soil and Building Materials

Under a contract with the USACE, Sevenson Environmental Services, Inc., (SES) performed the remedial action; the New York District USACE and EPA provided oversight. Field work of the first group of OU1 properties, including excavation and backfilling of areas with elevated gamma radiation measurements, was initiated in 1997. Investigations of additional area properties continued during the cleanup and, when additional radium-contaminated properties were identified, designs for their cleanup were prepared. The OU1 remedial action is scheduled to be completed by summer 2016 and OU2 remedial action was completed in 2005. Overall, approximately 650 properties were investigated during Site investigations and approximately 250 were identified as requiring remediation under the selected actions. These actions are complete, as described below.

The OU1 and OU2 cleanup was performed in phases. Phases 1 and 2 of the remedial action were completed in December 1998 and resulted in the removal of approximately 25,000 cubic yards (approximately 38,400 tons) of radium-contaminated material. Phase 3 was completed in October 1999 and resulted in the removal of approximately 9,000 cubic yards (approximately 14,400 tons) of radium-contaminated material. Phase 4, completed in September 2001, included the former U.S. Radium Corporation processing plant located at High and Alden Streets, and resulted in the removal of approximately 34,000 cubic yards (approximately 54,400 tons) of radium-contaminated material. Phase 5 was completed in December 2002 and resulted in the removal of approximately 10,000 cubic yards (approximately 16,000 tons) of radium-contaminated material. Phase 6 was completed in September 2003 and resulted in the removal of

approximately 5,000 cubic yards (approximately 8,000 tons) of radium-contaminated material. Phase 7 was completed in September 2005 and resulted in the removal of approximately 1,996 cubic yards (approximately 3,200 tons) of radium-contaminated material. Due to access issues that were recently resolved, construction on the remaining residential property was not begun until September 2015. It is scheduled to be completed by summer 2016.

Groundwater

As part of the 2006 no-action remedy, EPA initiated a groundwater monitoring program in September 2006. The monitoring was implemented by the EPA Environmental Response Team (ERT) and the Response Engineering and Analytical Contract (REAC). This monitoring is done to assure that the no-action remedy remains protective of human health and the environment. Originally the monitoring program consisted of periodic sampling of six groundwater monitoring wells installed as part of the OU3 RI/FS, which was conducted from 2003 to 2006. The monitoring program is modified on an as needed basis depending on the sampling results obtained. Additional measures, such as the installation of additional monitoring wells, may be taken if monitoring shows that it is warranted. If all results clearly show that uranium concentrations in groundwater decrease to levels below drinking water standards, then monitoring may be discontinued.

System Operations/Operation and Maintenance

Soil and Building Materials:

No operation or maintenance activities were necessary for OU1 or OU2. A Quality Assurance/Quality Control (QA/QC) program was used in the development of the remedial design and throughout the remedial action. All necessary sampling and testing results indicated that the cleanup and restoration work was properly performed to the degree needed to assure that the remedial action was implemented properly and was consistent with the RODs.

The excavation areas were determined during the remedial design. To assure that all soil that was supposed to be removed was addressed, samples were obtained from the sides and bottom of each excavation and analyzed. Where appropriate, wipe or other sampling techniques were utilized to assure the cleanup was complete. The USACE conducted inspections of all cleanup activities. All site activities were conducted in accordance with the relevant Health and Safety and QA/QC plans. All material brought to the Site for restoration, including general backfill, structural fill, and topsoil, was tested to ensure that it met specifications prior to use. In addition, fill placed in all restored areas was compacted to specified levels to assure its structural integrity and was surveyed to assure appropriate that elevations were met.

Groundwater

The first round of post-ROD groundwater sampling was conducted in December 2006. A total of 15 post-ROD sampling events have been conducted, the most recent in November 2015. Groundwater sampling is continuing periodically.

Climate Change

Potential Site impacts from climate change have been assessed, and the performance of the remedy is currently not at risk due to the expected effects of climate change in the region and

near the Site.

Progress Since Last Five-Year Review

The first five-year review conducted in 2011 concluded that the implemented remedy for OU1 was protective of human health and the environment because all properties were remediated to allow for unlimited use and unrestricted exposure. As discussed above, the remaining residence still to be addressed as of 2011 is scheduled to be completed by summer 2016.

The OU2 remedy was complete as of the last five-year review, resulting in no hazardous subtances remaining on-site.

The selected remedy for OU3 is expected to be protective upon completion, and in the interim, monitoring is being performed, and exposure pathways that could result in unacceptable risks are being controlled.

Because the remedial actions at all OUs are, or will be protective, the first five-year review concluded that the Site is protective of human health and the environment.

Five-Year Review Process

Administrative Components

The five-year review team included Anne Rosenblatt (EPA-RPM), Edward Modica (EPA-Hydrogeologist), Marian Olsen (EPA-Human Health Risk Assessor), Mindy Pensak (EPA-Ecological Risk Assessor) and Pat Seppi (EPA-Community Involvement Coordinator - CIC). This is a Fund-lead Site.

Community Involvement

On November 19, 2015, EPA Region 2 posted a notice on its website indicating that it would be reviewing site cleanups and remedies at 32 Superfund sites and four federal facilities in New York and New Jersey, including the U.S. Radium Superfund Site. The announcement can be found at the following web address: http://www2.epa.gov/sites/production/files/2015-11/documents/fy_16_fyr_public_website_summary.pdf.

This five-year review will be made available at both local site repositories: the Orange Public Library, 348 Main Street, Orange, New Jersey; and the West Orange Public Library, 46 Mount Pleasant Avenue, West Orange, New Jersey; as well as at the U.S. Environmental Protection Agency Records Center, 290 Broadway, 18th Floor, New York, New York 10007-1866. In addition, efforts will be made to reach out to local public officials to inform them of the results.

Document Review

The documents, data and information which were reviewed in completing this five-year review are summarized in Table 4.

Data Review

Soil and Building Materials

Since the actions taken to address soil and building materials at the Site are considered final, and no further monitoring is required, there was no additional data to review as part of this five-year review.

Groundwater

During this five-year review period a total of five groundwater sampling events were conducted. A total of 15 post-ROD groundwater sampling events have been conducted. Figure 2 shows the location of the wells that are tested as part of the post-ROD monitoring program. Groundwater from each well is analyzed for the following radiological parameters: uranium-234, uranium-235, uranium-238, radium-226, and radium-228. The water is also analyzed for the following metals and other physical parameters: calcium, iron, magnesium, manganese, potassium, sodium, alkalinity (as calcium carbonate, or $CaCO_3$), bicarbonate (as $CaCO_3$), carbonate (as $CaCO_3$), chloride, ferrous iron, nitrate plus nitrite as N, phosphate (Ortho as P), sulfate, total fluoride, and total organic carbon.

The rationale for selecting the parameters for analysis was that during the OU3 remedial investigation, the only parameter that was detected at elevated concentrations (i.e., above federal and state drinking water standards, also called Maximum Contaminant Levels, or MCLs) was uranium. Thus, EPA focused its efforts on monitoring uranium concentrations in groundwater over time. However, since radium was the primary contaminant of concern in the soil, EPA included radium (and its isotopes) in the monitoring program. The other parameters listed above are analyzed to monitor the aquifer conditions that EPA anticipates will cause the concentration of uranium in groundwater to decrease over time due to natural attenuation processes. The geochemical balance of groundwater in the area of contamination is such that the uranium should precipitate from the water and/or adsorb onto the soil matrix over time, thus reducing the uranium concentration in groundwater. Once bound to the soil, the uranium concentrations should remain low enough such that they will pose no unacceptable risk to human health or the environment. EPA is analyzing the groundwater for the geochemical parameters listed above to assure that the physical characteristics of the groundwater do not change over time in such a way that the uranium concentrations will stop decreasing naturally.

Since the time of the RI, all monitoring results have been consistent with the above-described scenario. All radium results continue to remain well below the MCL. Uranium concentrations in the two wells closest to the area of soil uranium contamination removed in July 2006, are the only two wells to show uranium concentrations above the MCL.

Figure 3 shows uranium concentrations over time for three of the wells being monitored. Two of the wells depicted, MW-P2 and MW-P7, have had uranium concentrations above the MCL for uranium, 30 micrograms/liter (ug/l), since at least the time that the ROD was signed for OU3. The figure shows that uranium concentrations in both wells have decreased significantly since removal of the source area of soil contamination from the former processing plant was completed (note that the figure includes pre-ROD results). Uranium concentrations in MW-P7 have been increasing since the May 2012 sampling event and slightly exceeded the MCL in the most recent sampling event in November 2015. Even though contaminant levels have increased above the MCL, the remedy remains protective since there is no exposure pathway to this water. The well will continue to be monitored as usual.

Data for a third well, MW-P3, is also included in Figure 3. While the uranium results at this well

have never exceeded the MCL, they are elevated above what may be considered to be naturally occurring background conditions. As such, EPA is tracking the results at this well to assure that the remedy remains effective.

Table 3 shows the actual total uranium data collected at all wells being monitored. The data shows that at wells P4, P5, P6, and P7D detected concentrations of uranium have remained at relatively consistent low levels, with minor fluctuations over time.

Site Inspection

An inspection of the Site was conducted on November 5, 2015. In attendance were Anne Rosenblatt and Stephanie Vaughn of EPA; Marty Mayes, the Public Works Director for City of Orange; Adrienne Wooten, the Deputy Director of Recreation for City of Orange; and Perry Novak of Sevenson Environmental. The purpose of the inspection was to assess the protectiveness of the remedy.

The Site inspection revealed the monitoring wells at the Site were intact. The City of Orange has developed the former facility as a park.

Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

Yes, the remedy is functioning as intended by the OU1, OU2, and OU3 RODs. Work at the majority of the Site is complete, and the groundwater continues to be monitored to assure protectiveness.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid?

Since the selection of cleanup levels for the Site, a new guidance "Radiation Risk Assessment At CERCLA Sites: Q&A" (OSWER 9285.6-20) dated June 2014 was issued explaining the updates included in EPA's Federal Guidance Report 13. The updated risk estimates included in this guidance do not change the overall conclusion that the remedy and clean-up goals are protective. The process that was used in the human health risk assessment is still valid.

Exposure Assumptions and Toxicity Data

a. Soil and Building Materials. The exposure assumptions and toxicity values that were used to estimate the potential cancer risks and noncancer hazards in the risk assessment supporting 1993 and 1995 RODs for human health followed the Risk Assessment Guidance for Superfund and other appropriate risk assessment guidelines and policies. The process that was used in the human health risk assessment is still valid. Now that the remedy has been implemented, no radium-contaminated material is known to remain on the Site. As such, the site-related risk due to exposure to contaminated soil and/or building material has been eliminated.

b. Groundwater. The exposure assumptions and toxicity values that were used to estimate the potential cancer risks and non-cancer hazards in the risk assessment supporting the 2006 ROD which selected a remedy for groundwater followed the Risk Assessment Guidance for Superfund and other appropriate risk assessment guidance and guidelines. Since the last five-

year review, OSWER issued an updated Standard Default Exposure Assumptions document, OSWER Directive 9200.1-120, available at: https://rais.ornl.gov/documents/OSWER-Directive-9200-1-120-Exposure-Factors_corrected.pdf . The updated exposure assumptions do not change the overall conclusion that the remedy and clean-up goals are protective. The process that was used in the human health risk assessment is still valid.

The ongoing groundwater monitoring is assuring that the remedy remains protective. The exposure assumptions used in the 2006 ROD, including the land-use patterns and restrictions in the area have not changed – the area remains a densely developed, urban-residential neighborhood; installation of any groundwater well would require a permit and all drinking water in the community continues to be supplied by state-regulated municipal sources. As such, there is no exposure pathway to the area of contamination and, thus, no site-related risk due to exposure to contaminated groundwater.

c. Vapor Intrusion. Vapor intrusion is not a concern related to this Site as the only contaminants of concern are radionuclides. However, radon gas, which can become elevated indoors much like volatile contaminants that pose a risk of vapor intrusion, was investigated. All properties investigated were tested for radon gas, and elevated radon concentrations were not commonly found. However, when elevated radon results were detected, in nearly all cases EPA removed the source of the radon contamination (through excavation or removal of radium-contaminated material, since radon gas is a radioactive decay product of radium) rather than install a radon-mitigation system.

Ecological Risk Assessment

It was determined in the ROD that an ecological risk assessment was not required at this Site because there are no exposure pathways for ecological receptors. That decision remains valid.

Cleanup Values

The cleanup values selected in the 1993, 1995, and 2006 RODs remain valid. No federal standards for soil or groundwater have changed since the signing of the RODs, and the state does not have its own standards for the contaminants of concern.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Based on the evaluation of the potential human exposures at the Site, there is no new information that has been developed that could call into question the protectiveness of this remedy. There have been no changes in the physical conditions or land uses of the Site that would affect the protectives of the remedy. It was determined that an ecological risk assessment was not required at this Site and that decision remains valid.

Technical Assessment Summary

According to the data reviewed and the Site inspection, the soil and groundwater remedies are functioning as intended by the RODs. There have been no changes in the physical conditions of the Site that would affect the protectiveness of the remedy. There have been no changes in the toxicity factors of the contaminants of concern or in the risk assessment procedures that would affect the protectiveness of the remedy.

Issues, Recommendations and Follow-Up Actions

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
There are no recommendations or follow-up actions stemming from this five-year review, other than continuing to monitor the effectiveness of the OU3 remedy.

Protectiveness Statement

Protectiveness Statement(s)	
Operable Unit: OU3	*Protectiveness Determination:* Protective
Protectiveness Statement: The implemented remedy at OU3 is expected to be protective upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.	

Sitewide Protectiveness Statement
Protectiveness Determination: Protective
Protectiveness Statement: Remedies for all three OUs are considered protective of human health and the environment because contaminated properties have been remediated to allow for unlimited use and unrestricted exposure. Exposure pathways to groundwater that could result in unacceptable risk are being controlled.

Next Review

The next five-year review report for the U.S. Radium Superfund Site is required five years from the completion date of this review.

Attachments

Attachment 1: Tables

Attachment 2: Figures

Table 1
Chronology of Site Events

Event	Date
EPA and NJDEP initiate a program to identify and investigate locations in New Jersey where radium processing activities had taken place.	1979
EPA conducts an aerial gamma radiation survey covering approximately 12 square miles centered on the High and Alden Street properties. This aerial survey locates about 25 acres around the High and Alden Street properties where elevated readings of gamma radiation were detected.	May 1981
U.S. Radium Corporation Facility and the associated Vicinity and Satellite Properties are proposed to be added to the NPL.	December 1982
The U.S. Radium site is placed on the NPL.	September 1983
EPA initiates an RI/FS to determine the nature and extent of contamination at the site	October 1989
The RI/FS report for OU1 is released to the public.	April 1993
EPA signs the ROD for OU1 which includes 59 residential properties.	September 1993
Remedial Design for Phase I/II initiated.	September 1993
MPI completes the RI/FS for OU2.	May 1995
EPA signs the ROD for OU2 which includes four commercial properties and the U.S. Radium Corporation property.	August 1995
Remedial Design for Phase I submitted, which includes 18 properties.	October 1995
Remedial Design for Phase II submitted, including 41 properties.	May 1996
Field work for Phase I/II is initiated.	January 21, 1997
Remedial design for Phase III initiated.	September 17, 1996
Remedial design for Phase III complete, which includes 44 properties.	August 8, 1997
Remedial design for Phase IV initiated.	October 1, 1997
Remedial design for Phase V initiated.	May 21, 1998
Field work for Phase III is initiated.	July 27, 1998
Remedial design for Phase IV submitted.	August 12, 1998
Field work for Phase IV is initiated.	February 12, 1999

Remedial design for Phase VI initiated.	September 10, 1999
Phase III restoration is substantially completed. EPA, COE and SES perform a final site inspection for Phase III.	October 21, 1999
Remedial design for Phase V complete.	June 26, 2000
Field work for Phase V is initiated.	April 24, 2001
Phase IV restoration is substantially completed. EPA, COE, and SES perform a final site inspection for Phase IV.	May 3, 2001
Remedial design for Phase VI complete.	September 26, 2001
Remedial Design for Phase VII initiated.	November 30, 2001
Phase V restoration is substantially completed. EPA, COE, and SES perform a final site inspection for Phase V.	August 22, 2002
Remedial design for Phase VII complete.	September 24, 2002
Remedial design for Phase VIII (remaining property with access issues) initiated.	September 28, 2002
Notice to Proceed for Phase VII is issued.	May 27, 2003
Phase VI restoration is substantially completed. EPA, COE, and SES perform a final site inspection for Phase VI.	June 19, 2003
Phase VII restoration is substantially completed. EPA, COE, and SES perform a final site inspection for Phase VII.	April 28, 2005
OU3, groundwater, RI/FS is completed.	August 2006
EPA signs the ROD for OU3.	September 27, 2006
EPA signs the Preliminary Site Closeout Report for the site.	September 28, 2006
Remedial Action VIII Property in OU1 is begun.	August 3, 2015
Construction Phase VIII Property in OU1 is completed.	Summer 2016

Table 2: Federal and State Drinking Water Standards (MCLs)		
Analyte	**Federal MCL**	**State MCL**
Radium-226 and Radium-228 (combined)	5 pCi/l	none
Total Uranium	30 ug/l	none
Gross Alpha	15 pCi/l	none
Gross Beta	4 mrem/year (1)	none
Isotopic Thorium	NS	none
Radon-222	NS	None

Table 3: Total Uranium Groundwater Results Over Time Since 2011 FYR							
Date	**Feb-11**	**Apr-11**	**Aug-11**	**May-12**	**Aug-12**	**Nov-12**	**Nov-15**
Round	**Round 13**	**Round 14**	**Round 15**	**Round 16**	**Round 17**	**Round 18**	**Round 19**
P2	64.80	64.51	98.39	79.67	81.75	75.51	45.07
P7	23.45	19.17	17.45	11.03	13.26	25.54	32.61
P3	22.00	11.24	16.97	14.89	15.52	10.17	16.94
P4	7.76	6.00	2.21	5.56	8.23	2.31	1.46
P5	3.98	4.49	0.87	-	-	-	-
P6	nd	0.51	nd	0.17	0.45	0.31	0.95
P7D	2.49	1.47	nd	2.12	1.42	2.09	2.29

a: Concentrations in micrograms per liter (ug/l)

b: Round 5 considered the first post-remediation sampling round

c: Maximum Contaminant Level of Total Uranium in Groundwater is 30 ug/l. Elevated results are shown in bold.

d: nd = non-detect

Table 4: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Document Title, Author	**Submittal Date**
Record of Decision Operable Unit 1	September 1993
Record of Decision Operable Unit 2	September 1995

Table 4: Documents, Data and Information Reviewed in Completing the Five-Year Review	
Record of Decision Operable Unit 3	September 2006
Final Remedial Investigation Report, Operable Unit 3 – Groundwater, U.S. Radium Superfund Site, Orange, New Jersey, prepared by CDM under contract to the USACE	August 2006
Comprehensive Five-Year Review Guidance, EPA Office of Emergency and Remedial Response, EPA 540-R-01-007, OSWER No. 9355.7-03B-P	June 2001
Groundwater Site Assessment for Isotopic Uranium and Radium, U.S. Radium Site, prepared by Lockheed Martin under the ERT/SERAS contract, Trip Reports	August 2011, May 2012, August 2012, November 2012, November 2015
Radiation Risk Assessment at CERCLA Sites: Q & A, OSWER 9285.6-20	June 2014
Standard Default Exposure Assumptions document, OSWER Directive 9200.1-120	February 2014

Figure 1
U.S. Radium Site Location Map

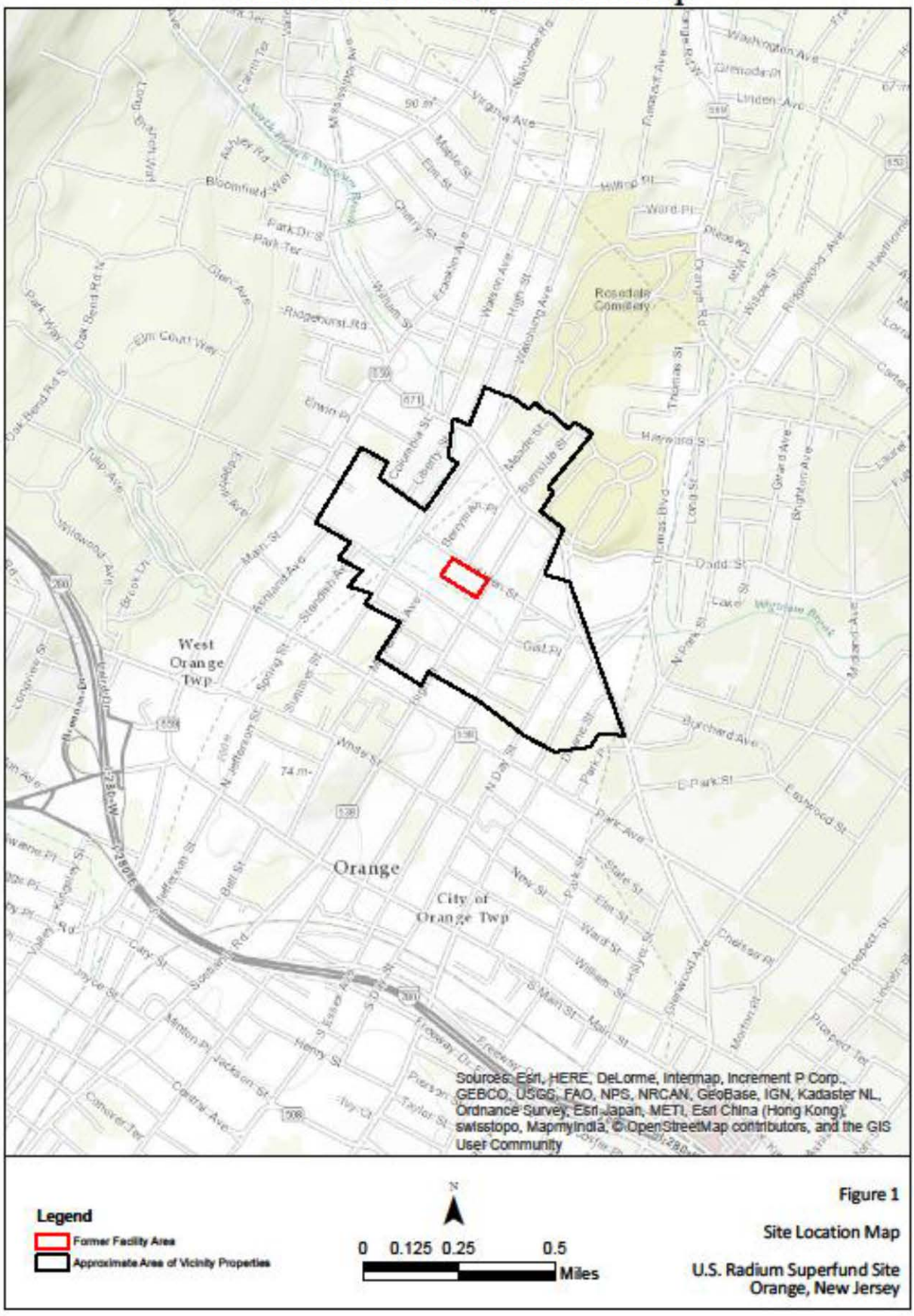

Figure 2
Well Location Map

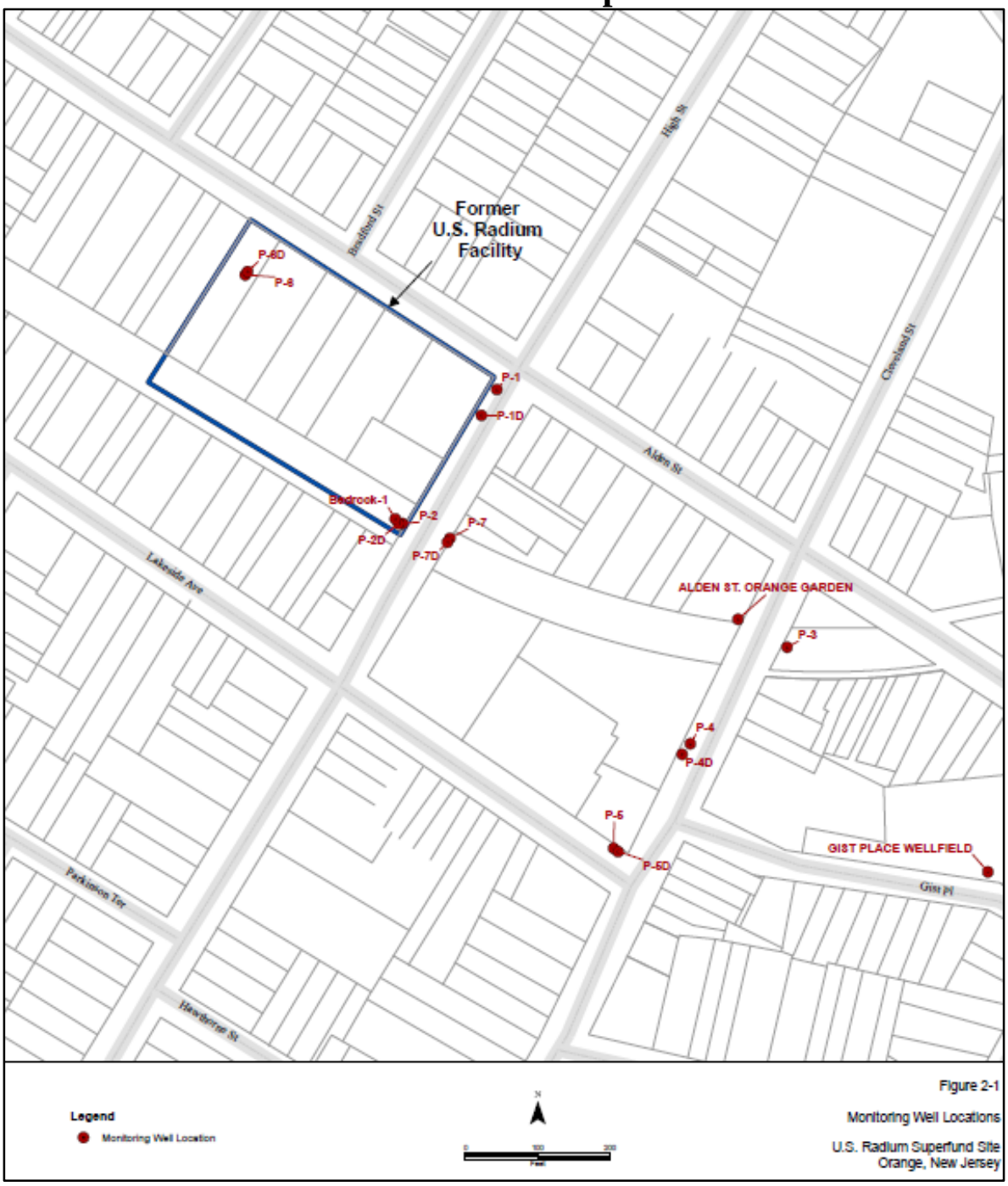

Figure 3
Total Uranium Concentrations Over Time