Challenges and Lessons Learned Performing Subsurface Investigations at a Radiologically Contaminated Site in an Urban Area – 17391

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ABSTRACT

At the Formerly Utilized Sites Remedial Action Program (FUSRAP) Maywood Superfund Site (FMSS) the U.S. Army Corps of Engineers (USACE) has performed minimally intrusive (i.e. non-excavation) sub-surface investigations in soils, underneath roadways, and within buildings to generate information needed to determine whether contaminated material was present and to delineate the nature and extent. Given that thorium-232 (Th-232) contaminated material is present below various surfaces and that the current iteration of the Multi-Agency Radiation survey and Site Investigation Manual (MARSSIM) [1] has only marginal guidance on evaluating and releasing subsurface data, survey design and implementation required detailed up front planning and post investigation analysis and reporting. This paper will discuss the approaches USACE utilized during a recent roadway investigation, some of the challenges encountered, a discussion of techniques used and results obtained, and an overall summary of pitfalls identified and lessons learned for future efforts.

In order to evaluate selected areas, direct push technology was utilized in conjunction with plastic tubing to facilitate core capture and sample collection. PVC piping was inserted in each bore hole to prevent borehole collapse and facilitate downhole gamma logging. Soil samples were collected from the surface, from native material or the bottom of the boring, and from the interval or intervals which exhibited elevated downhole gamma readings, and from areas with an identifiable marker of contamination (i.e. soil discoloration) at the judgement of the field staff.

Data was collected and evaluated using the approaches laid out in MARSSIM as best possible. As MARSSIM was developed to only address surface contamination, USACE, in agreement with regulators and stakeholders, utilized a “varying plane” approach, where samples are evaluated as if on a single plane, and only the highest concentration encountered at any point is considered. Because the areas investigated were not easily cast into simple geometric shapes adhering to MARSSIM design criteria, it was important to ensure that Survey Unit design for Class 1 Survey Units were reasonable. All Class 1 SUs were contiguous survey units. Class 2 survey units were allowed to be non-contiguous provided that they are situated in close proximity to one another and share the same geology, conceptual site model, history, and radionuclide concentrations.

The information contained in this paper will benefit Projects working with subsurface contamination which may require subsurface investigation and an understanding of the logistical, technological, and regulatory challenges. The

ultimate outcome of this effort was the successful delineation of areas of contamination which will facilitate current utility work and guide future remediation.

INTRODUCTION

Background

The FMSS is located approximately 20 kilometers (12 miles) north-northwest of New York City and 21 kilometers (13 miles) northeast of Newark, NJ. Properties are located in a highly developed area of northeastern NJ in the Boroughs of Maywood and Lodi and the Township of Rochelle Park.

The FMSS originally consisted of 88 formally designated properties. The United States Environmental Protection Agency (EPA) and United States Department of Energy (EDOE) agreed to divide the 88 properties into phases of efforts. Four additional properties have since been added by USACE, bringing the total number of properties to undergo some type of action to 92.

Residential properties were identified as Phase 1 properties. Commercial and Government-owned properties were identified as Phase 2 properties. Later, undesignated properties (those not included in the National Priorities List designation) were identified by USACE as Phase 3 properties. The majority of these properties were surveyed by the Government (DOE and USACE) but not designated as FMSS vicinity properties based on data and action levels in use at the time of the investigations.

The Government addressed the Phase 1 properties with Removal Actions and other remedial measures between 1984 and 1999 under a DOE Action Memorandum. The Phase 2 properties are addressed in the 2003 Soils and Buildings Record of Decision (ROD) [2] for the Site. The Phase 3 properties are being addressed in a separate technical memorandum. The EPA conducted a Five-Year Review (FYR) in 2009 and identified several Phase 1 and Phase 2 properties that required additional actions such as Land Use Controls (LUCs) or further investigation [3]. Areas identified as RPIs span over Phase 1, 2, and 3 properties and are currently being addressed.

This full characterization of roads, streets, easements, rights of way (ROW), etc. herein referred to as Real Property Interests (RPI), has not been done throughout the FMSS area. In the 1980's, DOE conducted aerial and mobile drive-by scans of the FMSS area, all streets in Lodi, and five additional streets in Maywood. One RPI, the I-80 West Right of Way, was addressed in the Engineering Evaluation/Cost Analysis for a Removal Action in Support of the New Jersey Department of Transportation (NJDOT) Roadway Improvement Projects at the FUSRAP Maywood Superfund Site [4]. Other RPIs are known or suspected to be contaminated based on contamination assessment of adjacent properties. RPIs would meet the definition of inaccessible material as defined in the 2003 Soils and Buildings ROD.

The Lodi Brook is a perennial stream originating on the FMSS. Most of the original stream channel was diverted to an underground storm drain culvert in the 1960's to accommodate rapid development in the Site area. The former channel pathways essentially match the distribution of contaminated materials in the Borough of Lodi. Much of the culvert's path was therefore considered an RPI area of concern and in need of further investigation.

Purpose

The purpose of this investigation was to document and evaluate the status of RPIs subject to FMSS activities. RPIs are areas such as streets or rights-of-way (ROW) that were not specifically addressed on their own or in conjunction with nearby property investigations but are nonetheless potentially impacted by the FMSS contamination.

The specific objectives of the surveys were to:

- Identify the presence or absence of radioactive contamination (as defined in the 2003 Site ROD) in surface or subsurface soils.
- If no contamination is present, collect sufficient supporting data to demonstrate no further assessment or action is warranted.
- If contamination is present, delineate the extent of contamination to allow for the design of appropriate remediation measures.

Conceptual Site Model

From about 1916 through 1955, the Maywood Chemical Works (MCW) processed radioactive thorium ore. The residues (or tailings) from the process operation were a clay-like dirt that contained significant quantities of low-level radioactive materials. Other MCW processing operations generated additional waste products, such as lanthanum, lithium compounds, detergents, alkaloids, essential oils and products from tea and cocoa leave processing. MCW pumped process wastes to diked areas west of the plant.

In 1932, New Jersey Route 17 was built through the disposal areas. Portions of the former disposal area west of Route 17 were sold and are now private properties in Rochelle Park, NJ. Process wastes migrated (via streams and mechanical means) onto adjacent properties in Rochelle Park, NJ and Maywood, NJ. Some waste materials were excavated and used as fill dirt and mulch for nearby properties. Waste materials were also transported via Lodi Brook (much of which was later replaced by a storm water drainage system) and to a lesser extent Westerly Brook. Properties impacted by contaminants of concern are being remediated. However, RPIs for the most part have not been remediated under FUSRAP. The majority of the RPIs are roads and storm water culverts adjacent to properties previously remediated.

A significant amount of historic investigation, characterization, and remediation reports were reviewed to determine where past efforts may have either identified inaccessible contamination or noted areas which could not be fully investigated at that time. In addition, a significant amount of historic aerial imagery was evaluated. Two examples of online tools available and utilized for this effort include the following:

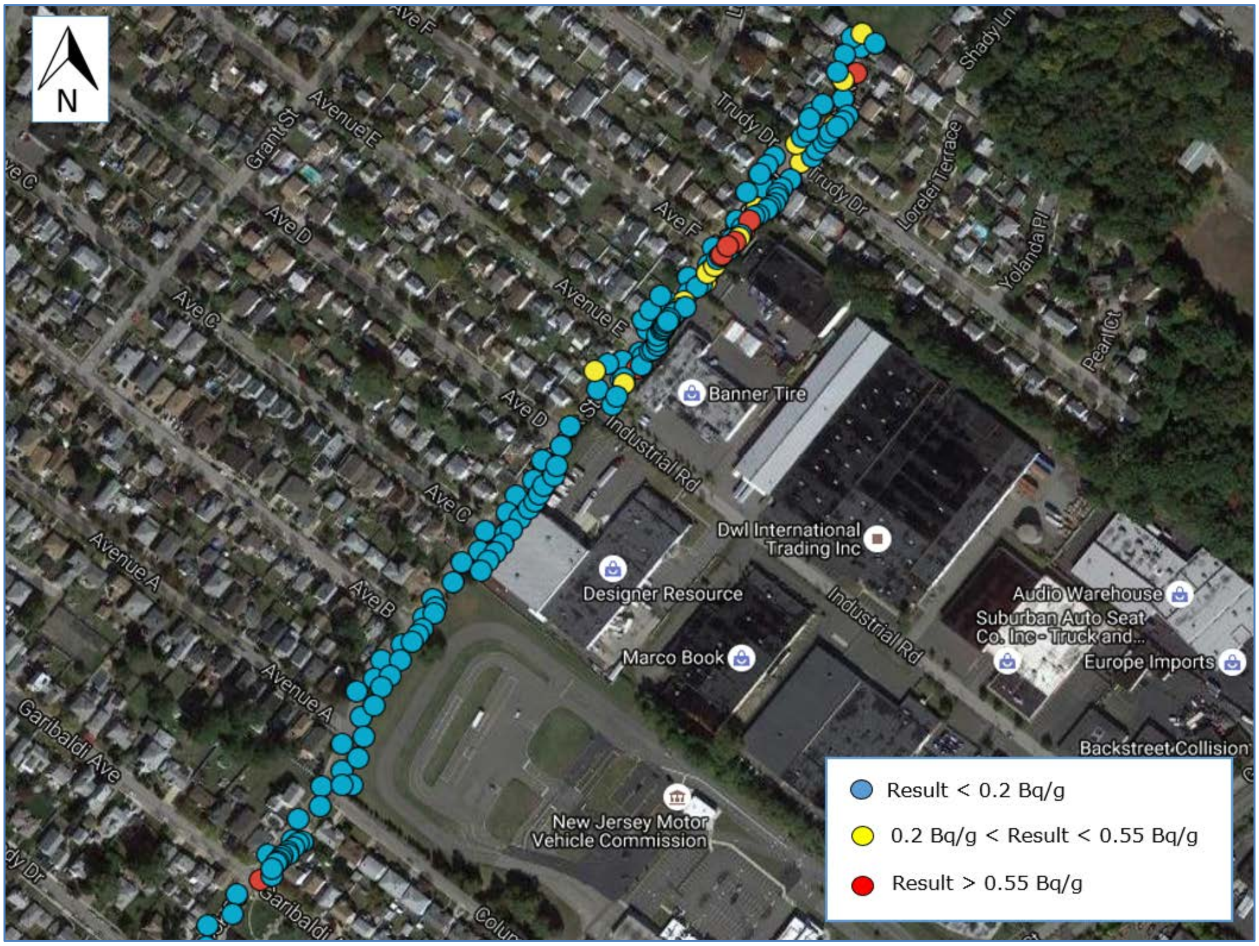
USGS Historical Topographic Map Explorer
http://historicalmaps.arcgis.com/usgs/

Nationwide Environmental Title Research Historic Aerials
http://www.historicaerials.com/

A good example of where historic imagery served to explain sample results is the following historic topographic map showing the flow direction of the Lodi Brook during the time contamination was thought to migrate. It can be seen that contamination occurs along the eastern portion of the roadway known as Hancock Street until it abruptly is no longer found at the intersection of Hancock Street and Avenue D, before being identified again further south. The areas of identified contamination, both in borings and in documented inaccessible soil from previous remediation activities at the properties along the eastern side of Hancock Street are shown in Figure 1.

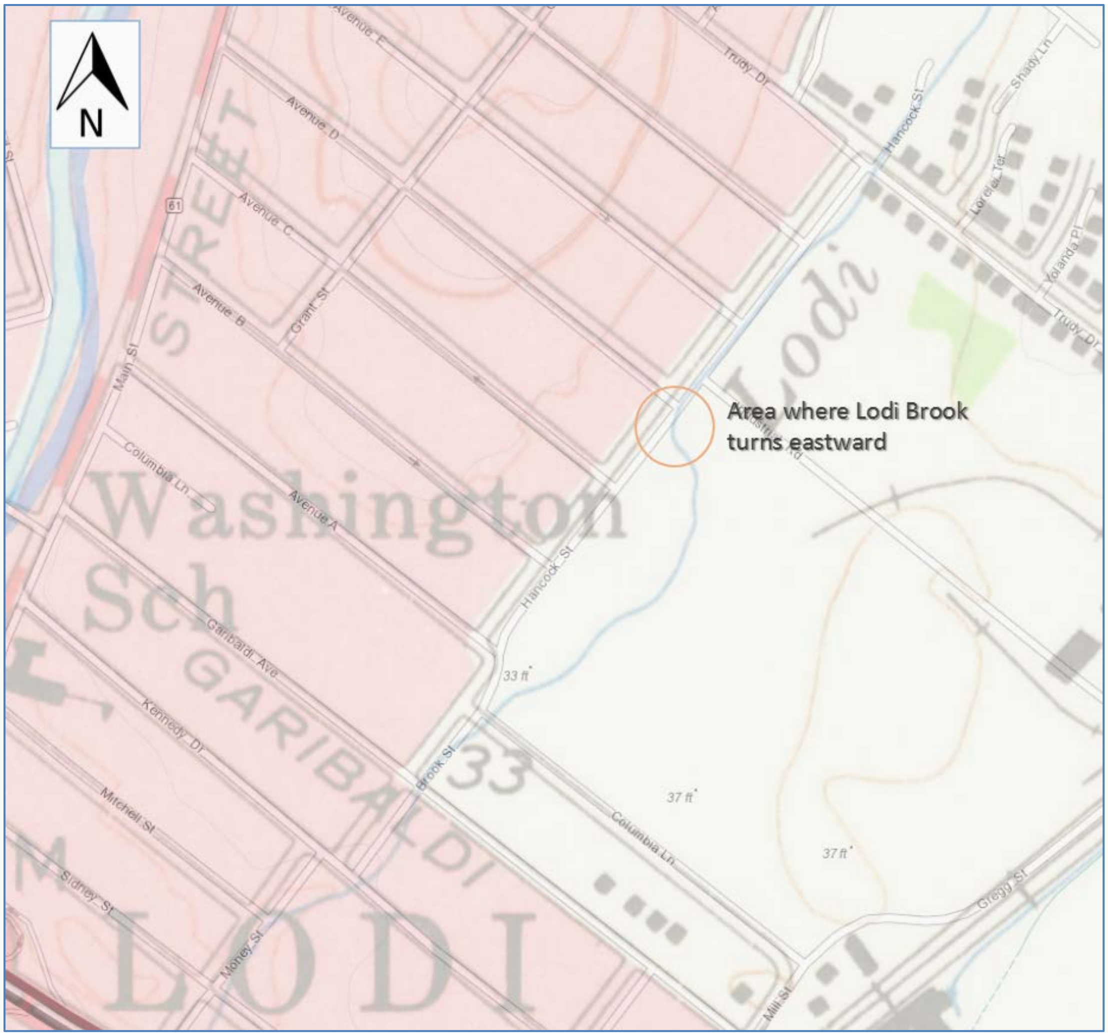
Locations exhibiting radium-226 (Ra) and Th-232 concentrations below the established unrestricted use release criteria (0.2 Bq/g [5 pCi/g] above background) are shown in blue. Locations with concentrations above the unrestricted use criteria but below the restricted use criteria (0.55 Bq/g [15 pCi/g] above background). Locations in red exceeded the restricted use criteria. The action levels are discussed further below.

Figure 1 - Subsurface Soil Sample Locations



The historic channel of the Lodi Brook in 1955 is shown in Figure 2. It should be noted that areas of elevated concentrations occurred in areas near the historic channel of the brook, within its flood plain, and that contamination is no longer identified along Hancock Street (the primary investigation area) when the brook channel turned eastward near Avenue D, but is again identified in the southern portion of the road as the brook returned to a northeast-southwest direction. This observation serves as verification of the established CSM.

Figure 2 - Lodi Brook Historic 1955 Topographic Imagery



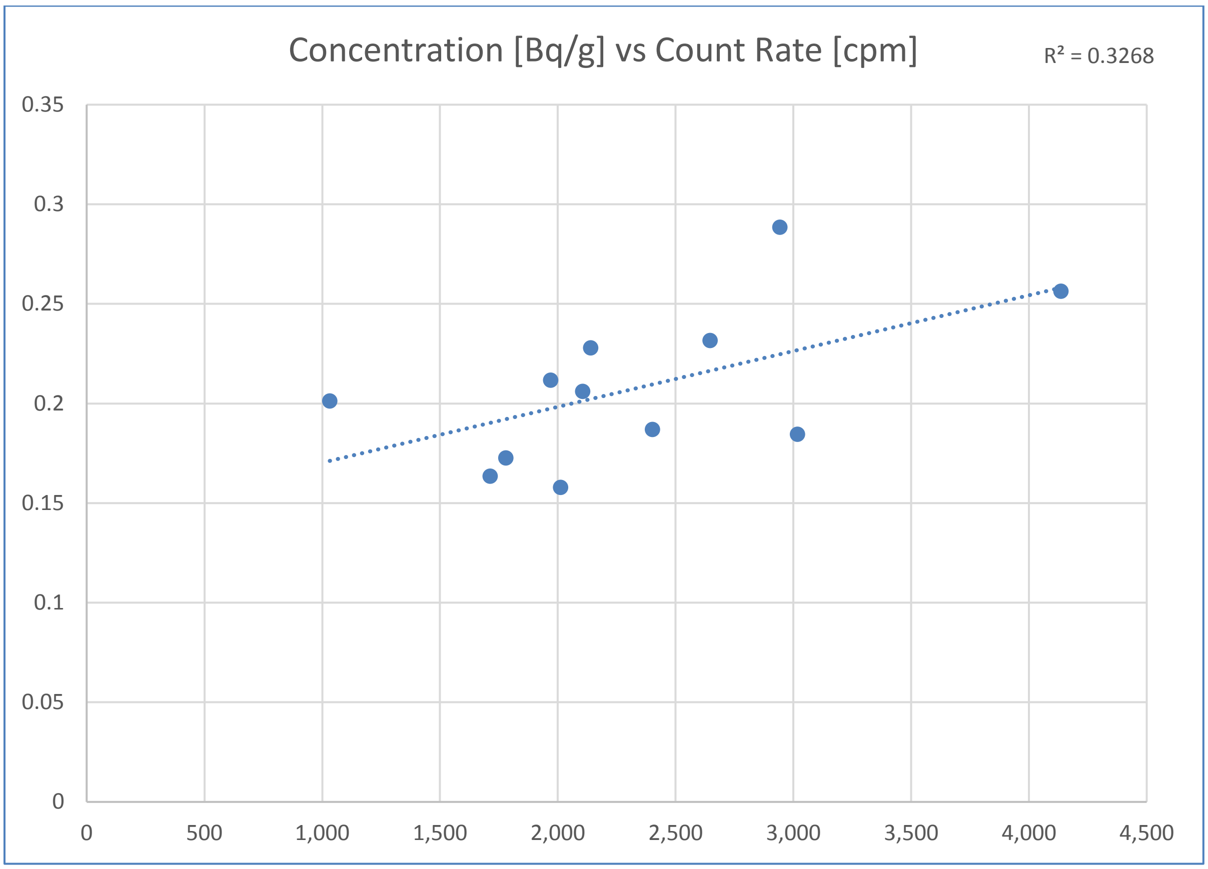
Action Levels

The FMSS Soils and Buildings ROD commercial or restricted use cleanup criteria for subsurface soils is an average of 0.55 Bq/g of Ra-226 and Th-232 combined (above background) with an as low as reasonably achievable (ALARA) goal of 0.2 Bq/g, and an average concentration of 3.7 Bq/g [100 pCi/g] total uranium, above background. The commercial criteria also cites the more restrictive residential criteria as an “As Low As is Reasonably Achievable” (ALARA) goal. The most likely exposure scenario is that of a utility repair worker accessing subsurface utilities for a short duration to perform repairs such as a gas or sewer main break or maintenance of the culvert.

The FMSS Soils and Buildings ROD residential or unrestricted cleanup criteria for soil is an average concentration of 0.2 Bq/g of Ra-226 and Th-232 combined and an average concentration of 3.7 Bq/g total uranium (U), above background, regardless of depth. Because properties which are subject to the Restricted Use criteria require the application of LUCs [5] and routine evaluation, RPI's were compared to the Unrestricted Use criteria for this evaluation. Throughout this document, cleanup criteria is synonymous with the Derived Concentration Guideline Level (DCGL) as defined in MARSSIM.

Based on past project experience in downhole gamma logging, a "rule-of-thumb" trigger level of 2,500 counts per minute (cpm) (inclusive of background) on a 0.5" x 1" sodium iodide (NaI) probe suggests that the unrestricted use DCGL for Ra-226 + Th-232 above background may be close to being approached. This was evaluated retrospectively by identifying concentrations near the unrestricted use DCGL. This evaluation is shown on Figure 3.

Figure 3 - Soil Concentration vs DHG Count Rate



Extrapolating the best fit line results in a count rate of 3,490 cpm, implying that the use of a 2,500 cpm "rule-of-thumb" field screening level may be appropriately conservative. The somewhat low R^2 value suggests that significant uncertainty can exist in downhole measurements based on geometry, differing soil materials, presence of nearby contamination not in the sample interval, and other effects. It may also be interesting to note that, at the Welsbach/GGM Superfund site, a field screening trigger level of 1,200 cpm/30 seconds (i.e. 2,400 cpm) with a 0.5" x 1"

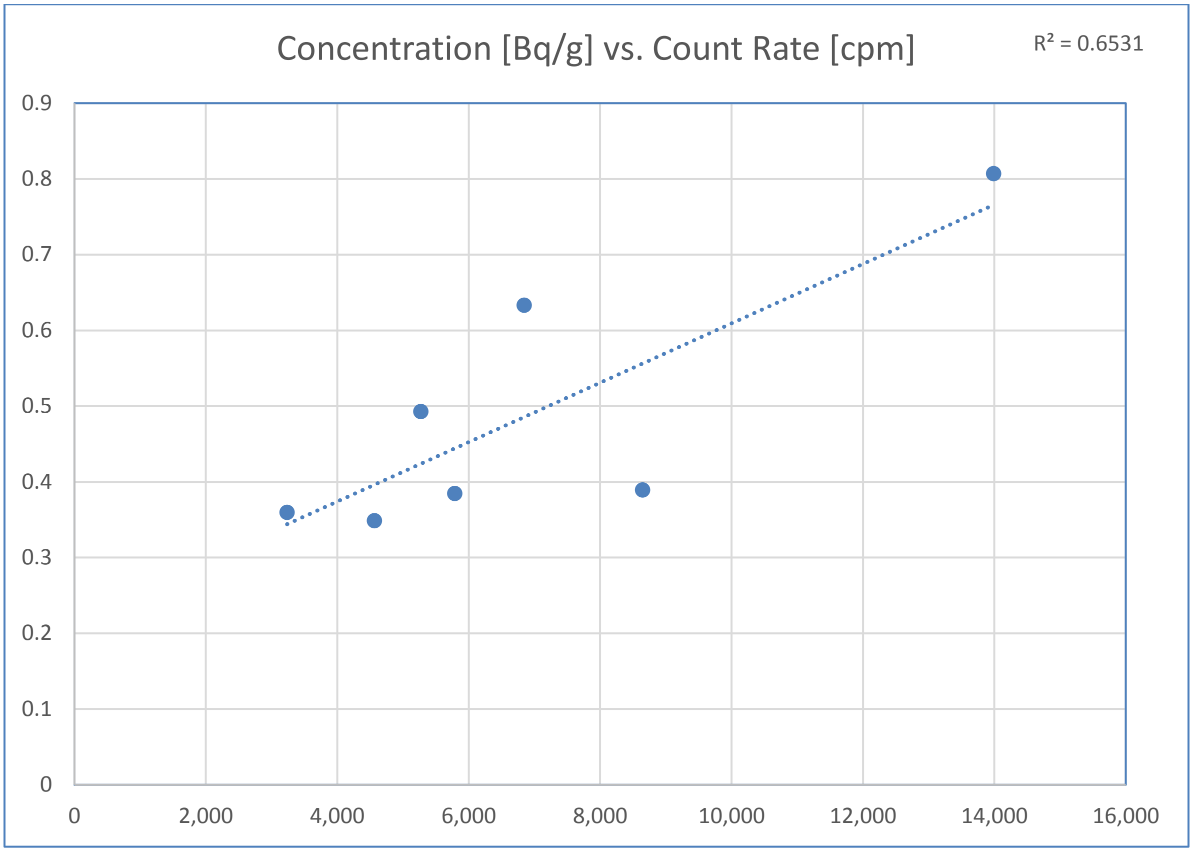
NaI probe is utilized, in very good agreement with USACE experience with downhole gamma logging. The Th-232:Ra-226 ratio at the Maywood site is generally 4:1 or greater, implying that 2,500 cpm corresponds to roughly 0.15 Bq/g Th-232 and 0.04 Bq/g Ra-226. This was verified post survey by evaluating sample data which exceeded the established DCGL to ensure that elevated material encountered was of FUSRAP origin and not NORM (i.e. road base/slag/coal ash, etc.). The results are shown in Table 1.

Table 1 - Typical FMSS contamination concentrations

Parameter	Ra-226 (Bq/g)	Th-232 (Bq/g)	U-238 (Bq/g)	Ra + Th (Bq/g)	Th-232:Ra-226 Ratio
Min	0.04	0.20	0.01	0.26	2.8
Mean	0.20	2.99	0.10	3.18	10.3
Median	0.14	0.91	0.04	1.06	5.9
Max	0.65	22.37	0.57	23.01	34.4
Stdev	0.16	5.65	0.18	5.79	9.4

A similar evaluation to the one discussed above was performed to determine if a correlation value could be identified for the Restricted Use criteria. The results of this evaluation are shown on Figure 4.

Figure 4 - Soil Concentration vs. DHG Count Rates



Once again, there appears to be a reasonable correlation between downhole gamma count rates and soil concentrations. USACE had previously used a “rule-of-thumb” investigation level of 7,500 cpm. Extrapolating the best fit line to the restricted use release criteria results in a count rate of 9,790 cpm, again implying that 7,500 cpm may be an appropriately conservative “rule-of-thumb” investigation level for downhole gamma logging. For this evaluation, there was a slightly higher R^2 value, suggesting that as contamination concentrations increase, the influence of the variables discussed above becomes less apparent in observed count rates and a stronger correlation exists.

Survey and Sampling Methodology

Sampling efforts were conducted using a team of USACE Kansas City and Buffalo District employees with assistance from Cabrera Services Inc. and their subcontracted driller. Surveys of the RPIs of concern involved sub surface soil sampling with onsite lab gamma spectroscopy analysis, walkover gamma scanning with a 2” x 2” NaI detector mated to a Trimble differential GPS unit, and down-hole gamma logging with a 0.5” x 1” NaI detector. All work was conducted in accordance with existing approved FMSS Plans and Standard Operating Procedures.

Some RPIs were designated for remediation or LUCs based on the historical data and the conceptual site model alone (without additional data collection).

In all, a total of approximately two kilometers (1.25 miles) of roadway were identified for investigation via subsurface drilling. Borings were spaced at 15 m (50') intervals based on a random start triangular grid encompassing the streets and easements along the streets (generally extending about two meters from the curb). The width of two lane roadways in the investigation area were typically 7.5 meters (25') across. Thus, each boring represented roughly 115 square meters (1,250 square feet). This translates to a total of 17 boring locations per 2,000 square meter MARSSIM Class 1 Survey Unit.

The MARSSIM sample designed was based on the assumption of Unrestricted Release, as any Restricted Release would still require deed notice and routine appraisal by the Government. The required number of samples per Survey Unit was determined to be nine samples. Per MARSSIM, this number was increased by 20%, requiring the collection of 11 samples per Survey Unit to be released.

Walkover data was ultimately of somewhat limited utility, as the contaminated media was generally located below both the roadway and several feet of soil. The areas identified as anomalous based on a Z-score evaluation were nearly always associated with asphalt patch and not with FUSRAP contamination.

Surface and subsurface sampling was performed at the intervals with the highest downhole gamma scan reading. Surface samples were obtained from the first six inches of soil if the RPI surface is soil.

A continuous soil core direct push rig was utilized to sample subsurface soils. Soil cores were drilled to the point below ground surface that coincides with the deepest location where contamination had been identified on adjacent properties or where there is the potential for contamination, based on historical data and assumptions. Soil cores were planned to extend to a depth of at least one-foot beyond the deepest excavation elevation when possible. Soil coring continued beyond that depth if downhole gamma logging results indicate that deeper contamination may be present.

In general a minimum of three samples was obtained at each subsurface sampling location: in the first 0.15 meters (6 inches) of soil (or soil beneath any road base), at the depth where the maximum gross gamma measurement is observed, and at the deepest elevation of excavation on adjacent remediated properties or one foot beyond the apparent fill depth based on whichever is encountered first, i.e., the highest elevation. Additional subsurface soil samples were collected at the discretion of the field team leader based on downhole gamma count rates and professional judgement.

In all, a total of 337 samples from 119 unique boring locations were collected. In addition, 38 duplicate samples from 13 duplicate boring locations were collected as part of the QA/QC process. All soil samples were prepared and analyzed by dry, equilibration-corrected gamma spectroscopy. Samples were analyzed by the USACE FUSRAP Maywood Laboratory (UFML), an on-site Government owned NJ certified radiochemistry laboratory.

Sample results, along with the evaluation of historic data and information discussed above, was used to generate coordination plans for local utilities, with instructions on where the subsurface is free of contamination and can be worked without contacting FUSRAP, where contamination may be present, but only at depths where it is unlikely shallow work would require radiological controls (i.e. greater than six feet), and areas where local utilities must coordinate with FUSRAP prior to intrusive activities. A figure showing the full extent of the investigation and areas identified is shown in Figure 4.

The information collected will assist USACE and other stakeholders in determining areas where it may be feasible to temporarily re-route traffic and/or utilities to perform what may be relatively “easy” remediation where practical. It will also inform long term decision making for current and future stakeholders regarding where inaccessible contamination may be present in areas where remediation may not be feasible (i.e. underneath major State and Interstate highways) and facilitate administrative actions such as deed notices and LUCs.

Figure 5 - RPI Final Status Areas Delineation

Rights of Entry and Community Relations

An Administrative Record file for the remedial action was established within 60 days of the start of on-site activities. In addition, the USACE publicized plans for the remedial action in a newsletter that was distributed to the community mailing list and made available at the USACE Public Information Center, 75A West Pleasant Ave, Maywood, New Jersey, and online at http://www.fusrapmaywood.com in January 2002.

In August 2002, the USACE and EPA released the Proposed Plan for Soils and Buildings at the FUSRAP Maywood Superfund Site for public comment. The public comment period was held between 14 August 2002 and 11 November 2002. USACE coordinated with the Boroughs of Maywood and Lodi regarding on site activities and conditions throughout the investigation.

Specific activities coordinated with the Property owner included:

- Access and safety protocols for FUSRAP personnel
- Traffic control and site security
- Logistics for vehicle and equipment access
- Status of water liner pair coordination with local officials

Challenges and Lessons Learned

Because all related field work and drilling was performed in a highly developed urban area consisting of residential, commercial, industrial, and municipal properties, local law enforcement agencies were informed of the work and were present on site to perform traffic control. Additional, work was primarily conducted during working hours, between the hours of 0900 to 1600, in order to minimize impacts to traffic and to minimize the potential disturbance to residences along the areas of investigation.

Due to the presence of significant below subsurface and above surface utilities, all intrusive work required coordination with local utilities. In New Jersey, this is accomplished via New Jersey One Call (NJOne call), who will perform utility mark-outs in identified areas within 72 hours. In addition USACE policy at the FUSRAP Maywood Superfund Site is that any intrusive subsurface work areas be evaluated by a third party geophysical surveyor. As a third consideration, all drilling contractors are required to perform their own NJOne call notice 72 hours prior to work.

Despite the very conservative approach utilized during investigations, in two instances, subsurface water lines were struck. In both cases, the location of water lines marked on the surfaces were inaccurate by more than five feet. The cause of this is that many of the water lines in the areas investigated were constructed of transite at depths of 2 meters (six feet) bgs or greater, which are not easily identifiable using traditional surface utility identification methods. An example of this is shown in Photograph 1.

Photograph 1 - Water Line Strike

Due to this, several locations were abandoned due to seemingly unusual/impossible water line configurations identified in mark outs. USACE was able to fully assist the local Department of Public Works in ensuring that water line repair work was being performed in areas not impacted by radiological contamination, and would have been able to provide assistance in staging and disposing of any contaminated material were any encountered.

CONCLUSIONS

The use of USACE staff augmented with contractor and subcontractor support has been very beneficial in ensuring that quality work is performed with adequate oversight and the ability to make in field changes and address issues in real time.

USACE's direct involvement in the investigation has allowed for higher quality document generation and has allowed for streamlined resolution of regulator questions and concerns.

The generation of targeted area of concern maps has allowed for a significant improvement in coordination with local utilities with regard to which areas may be impacted and which areas they may "dig freely" in, and has already paid dividends, with several planned utility events already addressed expediently.

REFERENCES

1. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016-Rev 1. July 2000.

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4. Engineering Evaluation/Cost Analysis for a Removal Action in Support of NJDOT Roadway Improvement Projects at the FUSRAP Maywood Superfund Site, Prepared for the USACE by Stone & Webster, Inc. July 2001.

5. DRAFT FMSS Land Use Control Implementation Plan. August 2013.