RADIOLOGICAL RELEASE OF MONAZITE SAND STORAGE AREAS AT THE GREAT LAKES NAVAL TRAINING CENTER (10231)

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ABSTRACT

The Former Monazite Sand Storage Area (FMSSA) is located within the US Naval Station at Great Lakes (NSGL), Illinois. In 1974 the Atomic Energy Commission (AEC) granted a license to Engelhard Minerals & Chemical to package and ship strategic stockpiles of monazite sand from the Great Lakes site and two other sites in Illinois and Ohio. The former AEC license indicated that 1,826,153 pounds of monazite containing 9.226% of thorium oxide were held at the Naval Station prior to its presumed shipment offsite. Monazite is a rare earth phosphate containing a variety of rare earth oxides particularly cerium and thorium oxide. According to records, the monazite ore was shipped to Holland in 1974. No records were found indicating that a closeout survey of the monazite sand storage area (current Site) was conducted following that shipment or afterward, until investigations by the Navy and Cabrera Services, Inc. (CABRERA) were initiated. The U.S. Nuclear Regulatory Commission (NRC) Region III conducted an inspection on January 19, 2000, which revealed several areas of elevated gamma activity on the north side of the former monazite sand storage area, including surface dose rates as high as 0.08 millirem per hour (µrem/h).

Limited historical information about the site resulted in an evolving conceptual site model (CSM) that required frequent updates as more information was gathered in the field. An evolving CSM, coupled with seasonal funding constraints required a very flexible approach to site characterization and remediation, and also required extraordinary lines of communication between CABRERA, our clients (US Army JMC/US Navy), and the site regulator (US NRC). This was especially true during the final phase of the project, which was undertaken within a planned residential Public Private Venture area of the site.

This project used guidance provided in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM [1]) to perform site investigation and remediation, including historical site assessment, characterization sampling and surveys, survey planning and designs, field instrument methods and instrumentation, final status surveys, and interpretation of sampling

and survey results. On-site gamma spectroscopy was utilized throughout the project for fast sample analyses and quick data turnaround. Precision excavation techniques were guided using sodium-iodide (NaI) based health physics instruments to minimize volumes of radioactive waste requiring offsite transport and disposal. Field instruments for the detection of low energy radiation (FIDLERs), as well as 3-inch by 3-inch (3x3) NaI detectors were used for this purpose.

In all, the entire project required portions of seven consecutive years to complete, with new site investigation areas added four different times. When completed, hundreds of surveys had been performed, gamma spectroscopy analyses on over 1,000 samples were completed, and over 4,800 tons of material shipped offsite for disposal. The Navy received concurrence from the NRC in 2008 that all investigation areas met the requirements for unrestricted release in accordance with 10 CFR 20.1402.

INTRODUCTION

This paper chronicles the history of Site activities associated with the FMSSA projects over a seven year period until all areas were successfully released from radiological controls. CABRERA performed all work under contract to the US Army JMC as a facilitator for the US Navy. The Navy's Facilities Engineering Command (NAVFAC) was responsible for project management, while the Naval Sea Systems Command, Radiological Affairs Support Office (RASO) provided technical and regulatory oversight. CABRERA, JMC, and the Navy worked closely with the US NRC Region III throughout the site investigations until all impacted areas were sufficiently remediated and released in accordance with Title 10 Code of Federal Regulations, Part 20, Subpart 1402 (10 CFR20.1402).

Successful completion of the project required an adaptive approach, both in terms of project management and execution, but also with regard to the continuously evolving nature of the areas of concern. The FMSSA projects were performed with modest seasonal budgets, which required CABRERA to work very closely with JMC and the Navy to scope appropriate levels of effort for each field season and track progress toward closure. Over the course of all project tasks, CABRERA mobilized to NSGL four different times over a seven year period. The Conceptual Site Model for the FMSSA also required continuous updating as more and more areas of concern were discovered. Also, what was originally expected to be surficial contamination eventually included subsurface contamination due to site construction activities.

HISTORICAL SITE ASSESSMENT

The FMSSA is located within the US Naval Station at Great Lakes, Illinois. The Site was formerly used by the Defense Logistics Agency as a storage area for strategic quantities of monazite sands. Monazite is a rare earth phosphate containing a variety of rare earth oxides particularly cerium and thorium oxide. Monazite contains 5-7% of radioactive thorium and 0.1 to 0.3% of uranium, by mass, with isotopes from the thorium series dominating the radiological signature. Thorium has wide industrial applications and has been mined as monazite sand since the 1930's.

The former AEC license indicated that 1,826,153 pounds of monazite containing 9.226% of thorium oxide was held at the Naval Station prior to its presumed shipment offsite. In 1964,

the Atomic Energy Commission (AEC) granted license #STC-133 to the General Services Administration authorizing the storage and repackaging, as necessary, to store and transfer uranium and thorium solids at specific locations, including the Naval Station in Great Lakes. While this license is still presently active, the inclusion of the Naval Station Great Lakes was terminated in April 1981. In 1974, the AEC granted license #STE-8179 to Engelhard Minerals & Chemicals Corporation, authorizing the package and shipment of a strategic pile of monazite sand from the Site. According to records, the monazite ore was shipped to Holland in 1974.

The AEC also granted license #SMC-1207, authorizing "Repackaging of monazite sands in U.S. Department of Transportation (DOT) approved containers." These operations were confined to the following locations: Savannah Army Depot, Savannah, Illinois; Army Ammunitions Plant, Ravenna, Ohio; and U.S. Navy Administrative Command, Supply Depot (currently referred to as Naval Station Great Lakes), Great Lakes, Illinois. This former AEC license indicated that 1,826,153 pounds of monazite sand containing 9.226% of thorium oxide was held at the Naval Station prior to shipment off-site. Records show that monazite sand was shipped to W.R. Grace & Company, Chattanooga, Tennessee. The sand was shipped from Great Lakes and Savannah, Illinois from early September through mid-October 1974; and from Ravenna from early November through mid-November 1974. There is limited information on the extent of residual contamination resulting from these operations. No records have been found indicating that a closeout survey of the FMSSA (current Site) was ever conducted, prior to efforts described herein beginning in 2000.

SITE CHRONOLOGY

Initial Monazite Sand Identification (2000)

NRC Region III conducted an inspection on January 19, 2000, which revealed several areas of elevated gamma exposure rate levels on the north side of the former monazite sand storage areas (see Fig. 1). A scoping survey by CABRERA in March 2000 identified several areas of elevated gamma activity and confirmed the presence of ^{232}Th daughter radionuclides using sodium iodide (NaI) gamma measurements. Gamma radiation levels above the ambient level were identified in the construction zone where a warehouse was being built, along the north fence line, and in locations between and surrounding tanks H, L, and K. During the scoping survey, six soil samples were collected from areas where elevated gamma radiation levels were observed. ^{232}Th concentrations in the samples ranged from 0.93 pCi/g to 64.31 pCi/g, with an average activity concentration of approximately 17 pCi/g. As a result, soils excavated to support construction activities were stockpiled in the northwest portion of the FMSSA so they could be surveyed for the presence of monazite at a later date.

Characterization Surveys of Soil Pile and North Fence Area (2003)

CABRERA was contracted through JMC to further investigate the findings described above and begin remediation activities in impacted areas where monazite sands were found in 2000. Scope of these efforts included removal of impacted surface soils in the North Fence Area and incremental survey and segregation of the soil pile created during construction activities. The soil pile, prior to remedial activities, covered an area approximately 100 feet by 50 feet and was

approximately 16 feet high. The soil pile was reconfigured in order to ease remediation and to ensure uniformity between the SUs. The remediation occurred incrementally, as one foot lifts of soil from the pile. Each lift was evaluated as a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 SU prior to its removal. Survey and segregation of the soil pile continued until a depth of approximately 1-ft remained above native soil. The results of the surveys and samples from each lift were examined to determine if monazite sands were present in concentrations higher than a derived concentration guideline level (DCGL)of 1 pCi/g above background. This value corresponds to the NRC soil screening value published in NUREG-5512, Volume 3 for ^{232}Th in equilibrium with its decay progeny [2]. The Navy chose to use the screening value for ^{232}Th as a conservative measure rather than developing a site-specific DCGL since a residential reuse scenario was the preferred end state for the property. Disposition of the soil pile required eight FSS 'lifts' to complete. Most of the soil pile was suitable for release for unrestricted use, approximately 1,730 cubic yards (cy). This soil was beneficially reused to provide additional capping material for a nearby, on-site landfill. Approximately 70 cy of soil from the soil pile exceeded the DCGL and were disposed off-site at the U.S. Ecology Grandview, Idaho facility as unimportant quantities of source material. The highest concentration of ^{232}Th identified in the soil pile was 2.7 pCi/g.

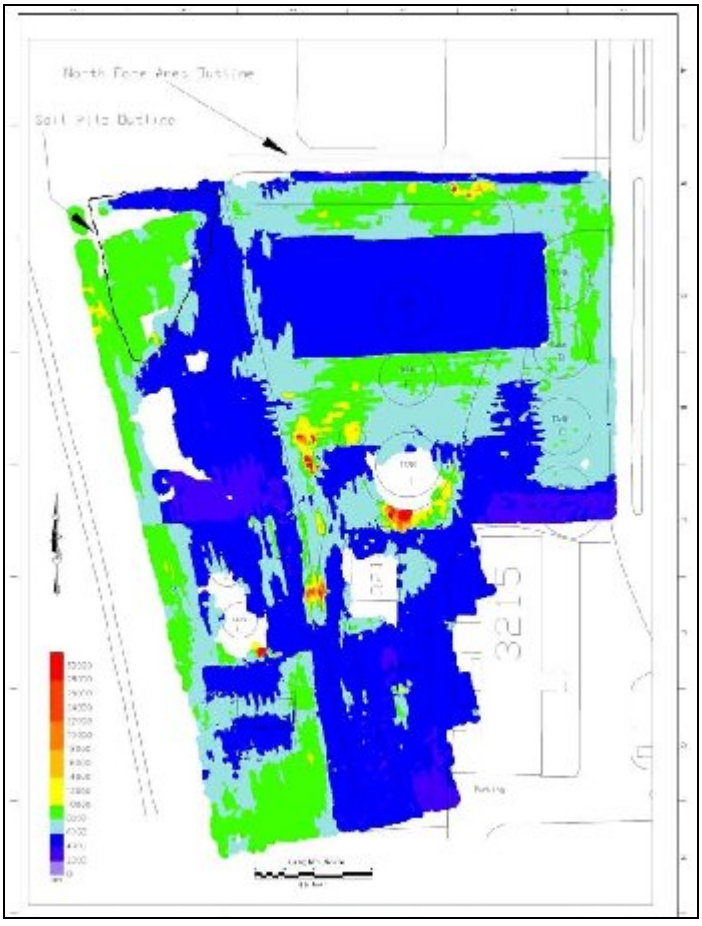

Fig. 1. Initial Gamma Walkover Survey Map of FMSSA (2000)

Characterization surveys were performed on the base of the soil pile and the one foot soil layer beneath it. ^{232}Th concentrations ranged from -0.13 to 1.1 pCi/g above background.

Characterization surveys in the North Fence Area (NFA) indicated that a thin surface layer of contamination was present throughout requiring remediation. Concentrations of ^{232}Th up to 8.6 pCi/g were observed within the top 12 inches of soils in this area, which required excavation of 170 cy of soil. These soils were also transported to US Ecology Idaho for disposal.

During the 2003 characterization survey, soil samples were also collected from the soil pile and North Fence Area to provide information regarding chemical contaminants that could affect disposal options. Laboratory analyses performed were in accordance with U.S. Ecology Waste Acceptance Criteria (WAC) requirements. These analyses included a toxicity characteristic leachate procedure (TCLP), total metals, mercury, semi-volatiles, volatiles, chlorinated herbicides, and organochlorine pesticides. The sample analytical results were below Title 40 Code of Federal Regulations (CFR) Part 261 land disposal limits, indicating that no treatment for hazardous chemical constituents was required.

Characterization and Remediation of Center Tank and Recreation Areas (2004/2005)

CABRERA re-mobilized to the Site in 2004 to perform characterization and remediation of areas identified to the south of the North Fence Area during previous gamma walkover surveys. These areas were referred to as the Center Tank and Recreation Areas. The initial scope of work included a confirmatory gamma walkover survey of the entire area, collection of up to 100 subsurface soil cores using a direct-push macrocore soil sampler, e.g., Geoprobe®, and analysis of all samples in an onsite gamma spectroscopy laboratory. The results of the surface and subsurface soils samples were compared against the net 1.1 pCi/g DCGL for determination of whether monazite contaminated soils would require remediation and offsite disposal. Subsurface samples were collected to a depth of 4 ft with samples taken at intervals of 1 ft. Downhole gamma logging was also performed in each open borehole as a means of comparison with the soil samples. Downhole gamma logging can be a valuable tool for providing supplemental subsurface characterization information, as it measures the *in situ* soils around where the macrocore collected its sample.

CABRERA utilized onsite gamma spectroscopy throughout the project to provide quick analyses of soil samples during characterization and remediation efforts. The laboratories consisted of a sample preparation area (soil drying and grinding) and a shielded high-purity germanium detector (HPGe) system. The lab was accepted for FSS use with an offsite laboratory used for analysis of quality assurance split samples for intercomparison.

Remediation of the soils identified in the Center Tank and Recreation Areas began in late 2004 based on the results of the characterization survey. During the planning phase of these efforts, it was estimated that 400 *ex situ* cy (or approximately 350 tons) of contaminated soils would require offsite disposal as low-level radioactive waste. This was based on the surficial characterization data collected over the previous years. Analysis of the surface and subsurface soil samples collected during the 2004 characterization effort uncovered a substantial amount

additional subsurface contamination that was not predicted by the previous data. The remedial volume estimate based on the 2004 data set grew to approximately 1500 *in situ* cy after analysis of these soil cores, with nearly 90% of the estimated volume expected in the first 1 ft of soils. A diagram of the boring locations is provided in Fig. 2. The magnitude of the ^{232}Th analysis results is represented by the colors on the plot, from green (lowest) to red (highest).

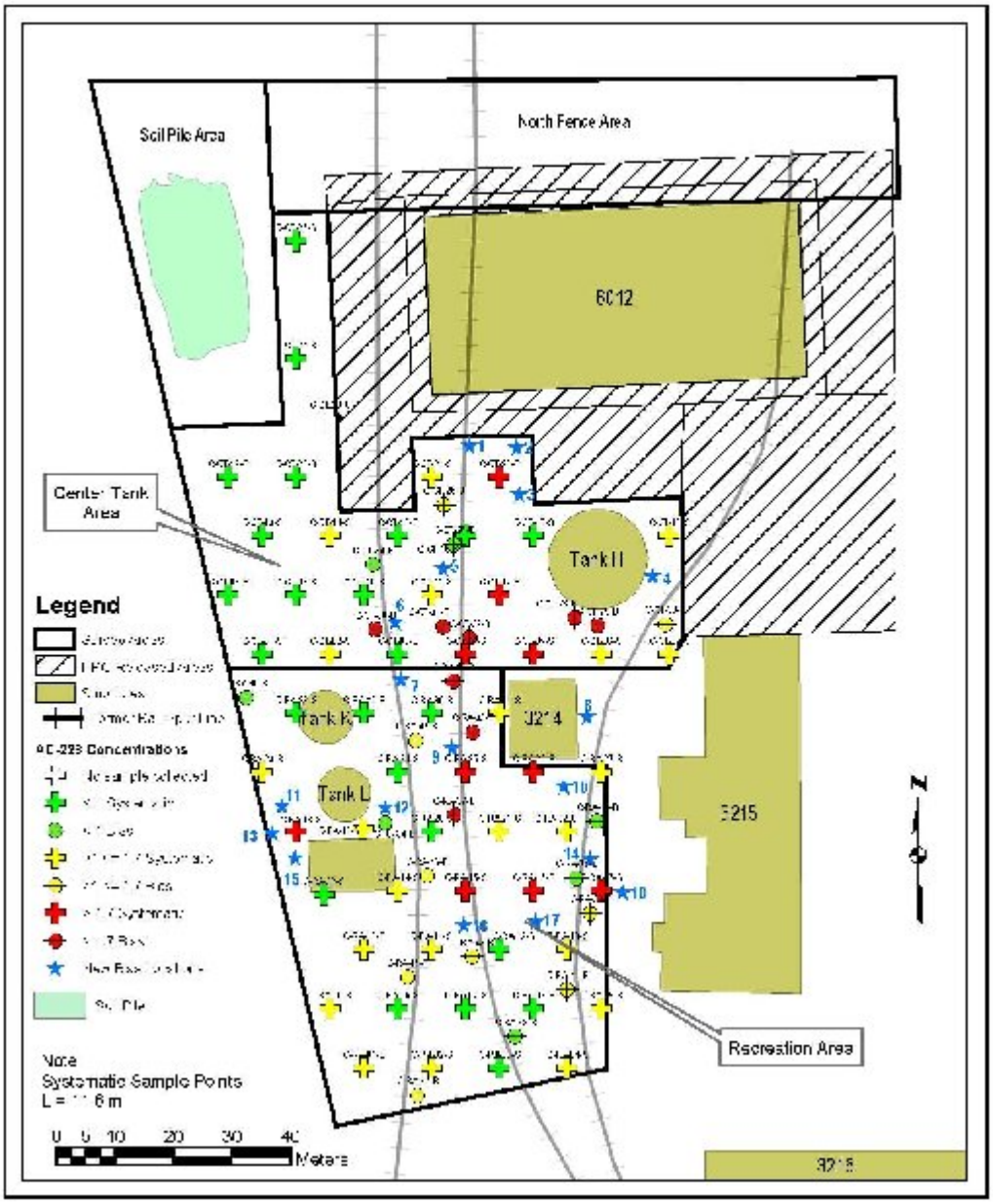

Fig. 2. Characterization Sampling Layout for Center tank and Recreation Areas (2004)

The contamination profile shown in Fig. 2 shows Th-232 clustering in the eastern portion of the Center Tank and Recreation Areas, collocated where the old railroad tracks use to traverse the center portion of the FMSSA. When remediation of these soils began, it was discovered that monazite sands were dispersed through the underlying railroad ballast material, causing an unexpected increase in waste volume. It was also discovered during remediation in the Recreation Area that the surface grade of a large portion of the site was elevated with up to 30

cm (12 in) with compacted gravel during construction of Building 3214. Thus, previous surface gamma walkover surveys would have not identified subsurface contamination. This also led to growth in waste volumes of soils contaminated with monazite sands that required packaging and offsite disposal, due to the eventual identification (and removal) of subsurface contamination that had not been previously identified and accounted for. The growth in waste volumes required use of project funds originally slated for waste transport and disposal for field excavation operations. Excavated wastes were instead stockpiled on site and covered for the winter waiting additional project funding.

CABRERA returned to the Site in spring 2005 to continue excavation and waste handling operations in defined areas of the Center Tank and Recreation Areas. It was the objective of the field effort to excavate around existing structures, if possible. This approach focused on testing whether former operations in the FMSSA resulted in monazite deposits below existing structures. The results of remediation support surveys using a 3x3 NaI detector showed that veins of monazite were found beneath the foundation of Building 3214. The Navy was informed that Building 3214 would likely need to be demolished to allow remediation of the underlying soils to below the project DCGL. Field excavation and waste packaging activities continued until seasonal project funding was again expended, leading to a small amount of soils requiring onsite stockpiling for transport and disposal at a later time. Between the 2004 and 2005 field seasons, approximately 2100 tons of contaminated soils were shipped offsite as low-level radioactive waste to US Ecology's Grandview, ID facility as unimportant quantities of source material.

Public-Private Venture Investigations (2006 – 2008)

Up to this point in the project, CABRERA's scope and efforts had concentrated on the FMSSA within the controlled area of the base. In 2006, the Naval Station Great Lakes began a public-private venture (PPV) for military housing. The property was located adjacent to the FMSSA. As part of the PPV, baseline environmental evaluations of the properties were completed. Radiological scan surveys identified six areas within the PPV footprint (named Areas 3A – 3F) with measurements above background. The areas of concern are shown in Fig. 4. CABRERA was asked by the Navy to investigate these areas more thoroughly to ascertain if the deviations from background were due to the presence of monazite sands. These investigations included:

- Performance of 100% gamma walkover surveys in suspect areas to confirm results of PPV contractor;
- Analysis of soil samples in each area for isotopic uranium and thorium composition;
- Nuclide ratio analysis to test levels against expected signatures for monazite sands; and
- An evaluation of coal fly ash from regional coal-fired power plants to gauge the probability that a few of the areas may be due to coal ash fallout.

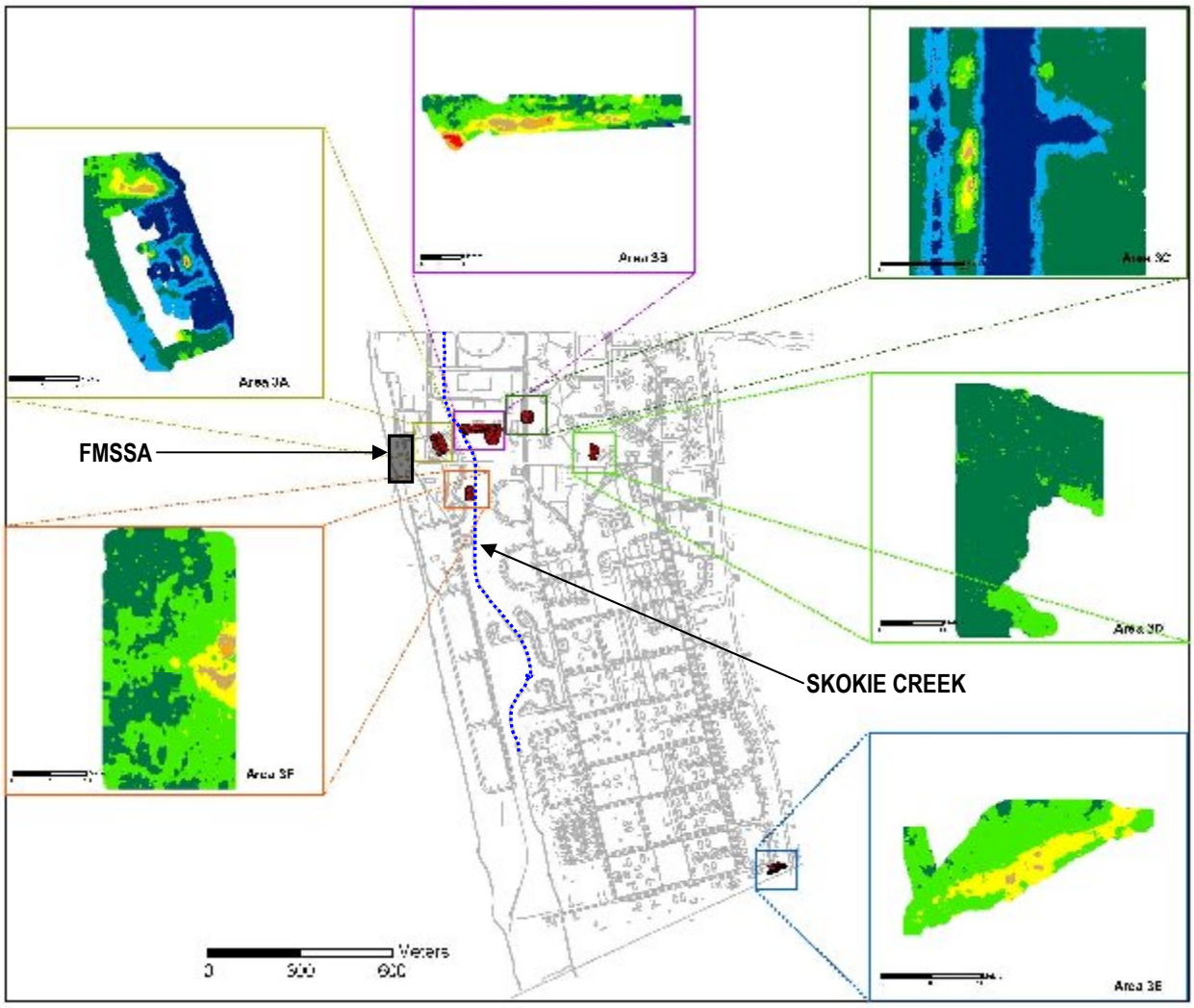

Fig. 3. Site Map With Results of Gamma Scan Surveys in PPV Investigation Areas

Investigation of these areas demonstrated that a number of the areas were only variations in background; however, the areas directly across the security fence to the east of the FMSSA, areas (list areas) were determined to have elevated concentrations of Th_{nat} indicative of monazite contamination. Results of the nuclide ratio analysis performed on the soil samples are provided in Table I. The calculated nuclide ratios for the PPV samples actually showed a more significant correlation to 'pure' monazite sand (assuming 10% thorium by mass) than samples collected within the FMSSA. This indicates less dilution of the monazite with unimpacted native soils in the samples. Therefore, the scope of the project was expanded to include these areas.

Table I. Results of Nuclide Ratio Analyses Performed on PPV Soil Samples

SU[1]	Number of samples	Th-232 to U-238 Ratio			Indicated Contaminant Source	Th-232 to Th-230 Ratio			Indicated Contaminant Source
		Mean	Standard Deviation	Max		Mean	Standard Deviation	Max	
3A	5	3.22	0.67	4.21	Monazite	2.62	0.58	3.53	Monazite
3B	5	3.54	0.69	4.13	Monazite	3.28	0.92	4.08	Monazite
3C	5	4.45	1.36	5.91	Monazite	3.52	0.55	4.09	Monazite
3D	5	0.74	0.15	0.87	Other[2]	0.60	0.04	0.66	Other[2]
3E	5	0.61	0.07	0.70	Other[2]	0.61	0.07	0.72	Other[2]
3F	5	3.63	1.60	5.78	Monazite	2.92	1.48	4.89	Monazite
RA	5	0.98	0.22	1.30	N/A[3]	0.69	0.06	0.75	N/A[3]
CA	20	1.68	0.63	2.94	Monazite	1.44	0.57	2.67	Monazite

NOTES:
Shaded cells indicate confirmed monazite contamination areas.
1. SU=Survey Unit; 3A~3F =Six PPV Areas of Interest; RA=Reference Area; CA=Known Monazite Sand Contaminated Area.
2. May include coal ash, building materials, or other sources of natural radioactivity.
3. Reference areas are assumed to be free of contaminants.

Until this point in the project the DCGL 1.0 was pCi/g above ambient background for ^{232}Th. However, as the scope of the contamination footprint grew into the PPV area, it was decided to pursue a site-specific DCGL with the NRC as a means for controlling project cost while still pursuing a technically defensible cleanup value. In 2007, CABRERA prepared a site-specific DCGL evaluation for the Site, which calculated a ^{232}Th cleanup value of 4 pCi/g, based on a resident gardener scenario, to support the remaining remediation and FSS activities at the Site. A 'Resident Gardner' is analogous to an 'Urban Resident' scenario, with all suitable dose pathways turned on except for consumption of groundwater from a site well. This choice was considered appropriate since this site is located in a suburban portion of Chicago with municipal drinking water supplies. This DCGL value, with support from JMC and RASO, was submitted to NRC Region III and approved for use for all remaining activities associated with the FMSSA [2].

Characterization activities within the PPV areas were similar to those used at the original FMSSA. Gamma walkover surveys and Geoprobe samples were collected at both systematic and biased locations to bound the areas that required remediation to below the DCGL. The contamination was found to be around and underneath several buildings (in Areas 3A and 3B), along the banks of a portion of Skokie Creek (shown in Fig. 3) and behind a ball field. Characterization and remediation efforts continued through 2007 until the remediation encroached upon the foundations of several buildings. The highest concentration of ^{232}Th identified in the impacted soils was 32 pCi/g. The Navy decided to have CABRERA temporarily restore the excavations with geotextile fabric and clean backfill for the season so that it could pursue demolition of all above ground buildings in the fenced area over the winter months without threat of further contamination migration. The project was demobilized waiting more funding and the successful demolition of the structures. During this phase of the project, soft-sided 'Super Sack" lift liner containers (with 10 cy capacity) were used for all waste packaging activities instead of hard-top intermodal containers. Lift-liners were chosen since they could be sealed and temporarily stored on site without having to pay container rental charges. The Navy also preferred a sealed container for storage rather than having several outdoor soil stockpiles in

the PPV area that may require maintenance. Each lift liner was filled, sealed, and temporarily stored in a central location on-site until they could be transported to a nearby railhead in Kenosha, Wisconsin. The lift-liners were then trans-loaded into gondola railcars and manifested to the offsite disposal facility. The 2007 remediation efforts resulted in a total of 1520 tons of waste in 19 railcars shipped to US Ecology in Idaho, and 170 tons in 2 railcars shipped to Waste Control Specialists (WCS) in Andrews, Texas.

In late spring of 2008 CABRERA returned to the site for the final time to complete remediation and waste packaging in the remaining PPV areas. No further characterization efforts were required. The foundation slabs of the former buildings in the PPV area were segmented and removed as clean construction debris to allow access to the subsurface monazite contamination. The temporary stone backfill was removed allowing access to the remaining areas of monazite contamination. Remediation along the east bank of Skokie Creek was also completed (between Areas 3A & 3B) to finally finish impacted areas associated with the FMSSA. CABRERA packaged and shipped 878 tons of soils from under building foundations and the east bank of Skokie Creek during 2008 before completing final restoration of Site areas and demobilizing. Waste was shipped in Pac-Tec bags in gondola railcars to WCS in TX.

The FSS report for the FMSSA and PPV areas was prepared in June 2008 [2] and submitted to the NRC for review and approval. The Navy received concurrence from the NRC in 2008 that all impacted areas met the requirements for unrestricted release in accordance with 10 CFR 20.1402.

KEYS TO SUCCESS AND LESSONS LEARNED

There were many keys to success and lessons learned over the course of the eight years of projects performed at NSGL. A list of the major items catalogued over the years is provided below:

- The project required extraordinary teamwork and communication between CABRERA and our DoD clients and regulators to ultimately reach a successful conclusion. All parties had to exhibit tremendous flexibility and patience to cope with limited funding mechanisms, several scope growth cycles, and expansion of the project.
- Limited historical information about the site resulted in a conceptual site model that evolved as more information was gathered in the field. This process drastically affected the approach to site characterization and remediation, which each field season being essentially managed as its own ‘mini-project.’
- The presence of an onsite gamma spectroscopy laboratory allowed for fast turnaround of samples and provided what was effectively no limit to the number of samples that could be collected and analyzed. This capability saved project schedule and cost due to a vast reduction in offsite sample analysis costs, including large markups for fast turnaround times. Sample results were typically available the next day (or sooner).
- Although the root cause of the contamination within the PPV area was never proven, remediation efforts during the 2007 field season uncovered evidence of a likely scenario. When viewing the results of the gamma walkover survey maps for all impacted areas, one

could see the potential for a contiguous pathway from the FMSSA at the far west of the Site through a majority of the impacted PPV areas. The potential pathway for contaminant migration was discovered during remediation of the east and west banks of Skokie Creek. During the soil remediation on the western bank of Skokie Creek (area to the left in Fig 4), a former road bed of asphalt was uncovered approximately 12 to 24 inches below the established ground surface. This discovery, coupled with the presence of a corrugated metal culvert in the same section of Skokie Creek led the field team to the conclusion that a bridge was present over the creek at some period in the past. The presence of a road in this portion of the base adds valuable input into the Conceptual Site Model for the FMSSA and provides an explanation for the presence of monazite as far east as SU 10 shown on Figure 4. The impacted area to the south (SUs 11 and 12) was most likely due to relocation of excavated soils during the construction of the housing units. Excavation activities in 2007 and 2008 revealed that the grade level of the residential area had been raised 30 to 45 cm (12 – 16 in) during construction of the buildings.

Fig. 4. Map of All FMSSA Impacted Areas at NSGL and a Photo of Corrugated Metal Culvert Pipe in Skokie Creek where Suspected Bridge Would Have Been Located.

CONCLUSIONS

In all, the entire project required portions of seven consecutive years to complete, with new site investigation areas added four different times. When completed, hundreds of surveys were performed, gamma spectroscopy analyses were completed on over 1,000 samples , and over 4,800 tons of material were shipped offsite for disposal. The Navy received concurrence from the NRC in 2008 that all impacted areas met the requirements for unrestricted release in accordance with 10 CFR 20.1402.

REFERENCES

1. Multi-Agency Radiological Site and Survey Investigation Manual. US Nuclear Regulatory Agency, NUREG-1575. August, 2000.
2. Site Specific Derived Concentration Guideline Level – Final, Naval Station Great Lakes. Cabrera Services, Inc., May 2007.

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William Morris is a retired environmental program manager for the Naval Sea Systems Command, Radiological Affairs Support Office and supported this project during the last two years of project life. He received a Bachelor of Science in Chemical Engineering from the University of Wisconsin and a Master of Science in Nuclear Physics (Applied) from Catholic University. He has over 39 years of health physics and environmental management experience. He is currently Chairman of Accredited Standards Committee N43 on Equipment for Non-Medical Radiation Applications.