CONCRETE SLAB AND BIO-SHIELD SAMPLING, CHARACTERIZATION, AND ANALYSIS USING THE *TRUPRO*® ADVANCED SAMPLING AND ANALYSIS SYSTEM AT OMEGA WEST REACTOR LOS ALAMOS NATIONAL LABORATORY

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ABSTRACT

Radioisotopes can penetrate porous concrete and contaminate the concrete well below the easily measured surface. The challenge is to determine the extent and the magnitude of the problem in real-time. The concrete profiling technology, *TRUPRO*® in conjunction with portable radiometric instrumentation produces a profile of radiological or chemical contamination through the material being studied. The data quality, quantity, and representativeness may be used to produce an activity profile from the hot spot surface into the material being sampled. This activity profile may then be expanded to ultimately characterize the facility and expedite waste segregation and facility closure at a reduced cost and risk. Performing a volumetric concrete or metal characterization safer and faster (without lab intervention) is the objective of this characterization technology. This way of determining contamination *can save considerable time and money*.

The objective of this Facilities Project was to deploy a concrete sampling and profiling tool to Omega West Reactor (OWR) located at Technical Area 2 in Los Alamos Canyon. The OWR slabs and subsurface structures were to be sampled and characterized in support of cost effective, waste minimization and safe removal of the slabs and bioshield foundation footers for the U.S. Department of Energy Cerro Grande Rehabilitation Project.

The concrete profiling technology, *TRUPRO*® has four major components: a drill with a specialized cutting and sampling head, drill bits, a sample collection unit and a vacuum pump. The drill head is used under hammer action to penetrate hard surfaces. This causes the bulk material to be pulverized as the drill travels through the radioactive media efficiently transmitting to the sampling unit a representative sample of powdered bulk material. The profiling equipment is designed to sequentially collect all material from the hole. The bulk material samples are continuously retrieved by use of a specially designed vacuumed sample retrieval unit that prevents cross contamination of the clean retrieved samples. No circulation medium is required with this profiling process; therefore, the only by-product from drilling is the sample. The data quality, quantity, and representativeness may be used to produce an activity profile from the hot spot surface into the bulk building material. The activity data obtained during the profiling process is reduced and transferred to building drawings as part of a detailed report of the radiological problem. This activity profile may then be expanded to ultimately characterize the facility and expedite waste segregation and facility closure at a reduced cost and risk.

INTRODUCTION

The DOE is in the process of D&D for many of its nuclear facilities throughout the United States. These facilities must be dismantled and the demolition waste sized into manageable pieces for handling and disposal. The facilities undergoing D&D are typically chemically and/or radiologicaly contaminated. To facilitate this work, DOE requires tools capable of profiling the bulk building materials to depth. The objective of this Facilities Project was to deploy a concrete sampling and profiling tool to Omega West Reactor (OWR) located at Technical Area 2 in Los Alamos Canyon. The OWR slabs and subsurface structures were to be sampled and characterized in support of cost effective, waste minimization and safe removal of the slabs and bioshield foundation footers for the U.S. Department of Energy Cerro Grande Rehabilitation Project.

Pre-demolition surveys and potential decontamination of contaminated concrete slabs are important. This document describes how *NMNT* used the *TRUPRO*® Profiling System Equipment (US Patent Application #60/371971). The results acquired from OWR slabs, bioshield and subsurface footers at OWR site using *TRUPRO*® were used to develop a more detailed subsurface radiological contamination profile from which a strategy of cleanup action could be derived.

There was a need to detect activation products, Co-60 and Tritium at depth within the building material matrix in real time to support the OWR evaluation of cleanup goals for soil of Cobalt-60 and Tritium and to allow for immediate response to contamination and increased worker safety awareness. The accepted method for detecting Cobalt-60 is gamma spectrometry and for Tritium, Liquid Scintillation Counting (LSC) was performed.

Profiling the concrete slabs and concrete slab subsurface material at OWR to depth included the following desired capabilities and design features of the equipment: (a) powered by a mobile diesel electric power generator unit coupled to 200 foot power cables, (b) removed 24 samples of concrete using a specialized tungsten carbide drilling technology, (c) removed fifteen-inch depths of potentially contaminated concrete from predetermined sampling points sequentially from depths of fifteen-inch to twelve feet (15 – 144 inch), (d) collected all concrete particulate from sampling operations into specialized filter units and (e) produced representative samples in a powdered form for optimal counting by a portable scintillation system and gamma spectrometer.

NMNT's findings indicate that there was no measurable Cobalt-60 contamination at all the points sampled. The total Co-60 activity ranged from non-detect to 159.8pCi/g. However there was considerable amount of Tritium contamination in subsurface concrete and soils. The Lower Concrete Bioshield foundation to depth was generally more contaminated than the bulk of the upper concrete reactor floor slab material. The total Tritium activity ranged from non-detect to 434,770 pCi/g. The subsurface reactor soils were typically hotter than the concrete bioshield values.

TECHNICAL FIELD

TRUPRO® was deployed to accomplish subsurface concrete and soil sampling and characterization using hammer drilling with particulate capture with profiling in depth at the Omega West Reactor. Radioactive material characterization and remediation of the nuclear

facility to be decommissioned at the OWR was assessed for the presence of radionuclides throughout the concrete slabs and subsurface matrices. The objective was to sample and analyze Co-60 and H-3 contamination at variable depths in 13 slab and Bioshield foundation locations at OWR. It took two days for 1 technical operator and 1 health physicist in inclement, hot, dry, and dusty weather to collect 24 samples. The portable system was easy to mobilize and move around 2,000 square feet of variable-textured surface-contaminated slabs and footers. A diesel generator, 200 feet of power cable, connecting plastic hoses, vacuum drill, and vacuum pump were pretty easy to move around despite the broken slab surface conditions. It took 1 radiochemist 2 days to analyze 24 samples for beta and gamma isotopes.

The first 6 inch sample took approximately 2 minutes to retrieve. A known mass of each incremental depth of dust sample was weighed out on a calibrated balance. 2 mls of distilled water and 2 mls of Instagel LSC cocktail were added to a 20 mls LSC vial and shaken thoroughly too evenly disperse the concrete dusts throughout the volume of LSC cocktail. The dusts were homogeneously distributed throughout the matrix to present the best sample geometry. The dusts constituted a mass of very fine particulate so minimizing self-absorption of any activity present. Each sample was placed in the counting chamber of the tritium calibrated LSC and analyzed for tritium activity for 10 minutes. From the start of sampling to the completion of analysis, a total time of 20 minutes per sample was observed. This is a vast improvement in time and cost over the baseline technology and a more representative sample was acquired in a safer and more precise manner. The concrete profiling mechanism was moved to position two and samples were acquired for the first incremental sample to the predetermined depths as described for Hole 1 above.

Sampling of Reactor Floor Concrete Slab, Bioshield Subsurface and Subsurface Soils

Concrete structures were sampled so not to miss areas of radiological interest and increase the understanding of the distribution of contamination from the slab surface to depth and to the subsurface soil interface. Value was added to the data set by sampling the worst case areas to generally characterize all of the slab area so no surprises would be uncovered on lifting the slab.

Four sampling locations were selected from the East Wall Slab area based on the previous coring locations (locations 1 – 4 on Fig. 1). Spots were selected for sampling that encompassed two previous coring sampling points at the base of the East Wall and evenly spread over the slab area at positions of interest.

On the upper section of slab 4 sampling locations were selected from the Experimental and Reactor Floor Area (locations 5 – 8 on Fig. 1). Two of the sampling positions were on the slab North and South Reactor Experimental Area on the East side of the reactor pad and footer and the other two were on the main upper slab.

Three sampling locations were selected from the Lower Concrete Section of Reactor Bioshield Foundation Area based on the historical understandings of neutron activation and tritium contamination (locations 9 – 11 on Fig. 1). The slab area was composed of an old lower area of concrete and a new upper area of concrete that entombed the reactor outlet coolant pipes. Three spots were identified on the lower older and harder of the concrete layers on the East, South and North faces of the pit area. It was also decided to attempt to sample the new slab old pit bottom

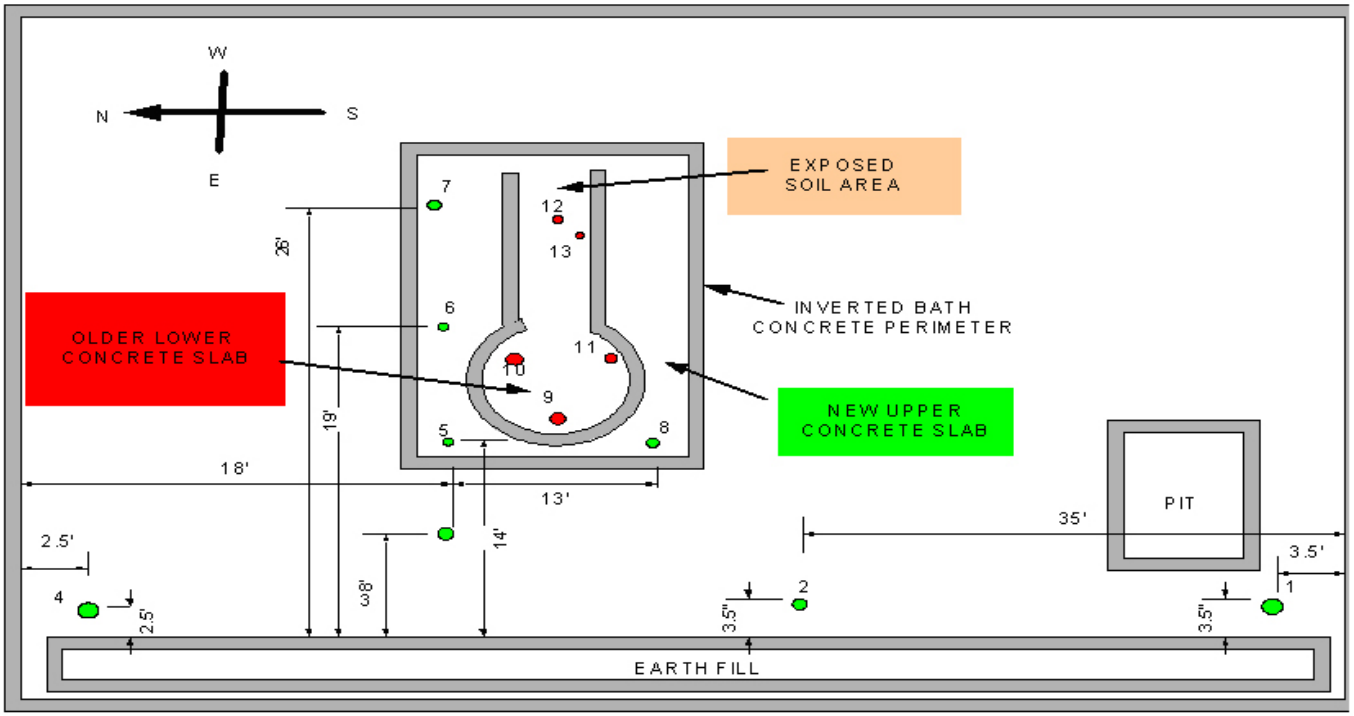

Fig. 1. Sampling Locations Around Reactor Slab & Within the Bioshield Subsurface Concrete and Soils.

interface as no contamination data was available for this part of the reactor structure. The activity of the old concrete and the inaccessible pit sub surface was determined by sampling to a predetermined 12 inch to 24 inch depth increment.

Two sampling locations were selected from the Reactor Subsurface Soil Area (locations 12 – 13 on Fig. 1). A point directly beneath where the reactor cooling pipes exited the reactor was chosen for sampling to deep depth of 48 inches into the subsurface soil. Another location a few feet away at the soil North pit wall interface was chosen adjacent to this deep hole to see if we could sample further, but too much underlying rebar and concrete was present in the sub surface structure. It was then decided to core sample from 24 inches to 48 inches at mid pit to observe degree and depth of Tritium and Fission Product activity levels.

Sample Analysis

Tritium, and Cobalt-60 analyses was carried out for the slab and soil samples. The Co-60 and H-3 results are presented in Table I.

Samples were analyzed for Tritium using a portable Liquid Scintillation Counter that was calibrated using a Tritium standard. A known mass, 0.1 g to 0.25 g of each incremental depth dust sample was weighed out on a calibrated balance. 2 mls of distilled water and 2 mls of Instagel LSC cocktail were added to a 20 mls LSC vial and shaken thoroughly too evenly disperse the concrete dust throughout the volume of LSC cocktail. The dusts were homogeneously distributed throughout the matrix to present the best sample geometry. The dusts constituted a mass of very fine particulate minimizing self-absorption of any activity present. A calibration check was performed for Tritium after every 10 samples to verify instrument performance.

Cobalt-60 was measured with Gamma spectrometry using a Sodium Iodide detector housed in a modular portable 3-inch walled lead shield in conjunction with gamma analysis software installed on a Dell laptop. A calibration check for the NaI gamma detector was performed for Co-60 using the NIST Mixed Multiple Nuclide Radioactive concrete block after every 10 samples to verify instrument performance by monitoring the Cs-137 peak drift.

Results

Co-60 results are shown in Table I. Figure 2 shows the distribution of Cobalt-60, analyses at various points sampled throughout the reactor slabs and subsurface structures at the incremental sampling depths.

4 sampling locations were selected from the East Wall Slab area based on the previous coring locations (locations 1 – 4 on Fig. 1). Cobalt-60 activity levels as shown in Table I were of no consequence. On the upper section of slab 4 sampling locations were selected from the Experimental and Reactor Floor Area (locations 5 – 8 on Fig. 1). Cobalt-60 activity levels as shown in Table I were of no consequence. 3 sampling locations were selected from the Lower Concrete Section of Reactor Bioshield Foundation Area based on the historical understandings of neutron activation and tritium contamination (locations 9 – 11 on Fig. 1). Cobalt-60 activity

Table I. Tritium and Co-60 Results.

ID #	Sample Location	Depth (inches)	[1]Tritium (Solid)	[2]Tritium (Water)	[3]Co-60
			[4]pCi/g		
S/1	Hole 1, east slab, next to wall 3 feet	0 to 6 inch concrete to soil	ND	ND	1.55
S/2	Hole 1, east wall north	6 to 12 inch soil	ND	ND	4.52
S/3	Hole 2, south of east wall	0 to15 inch concrete	ND	ND	ND
S/4	Hole 2, south of east wall	15 to 39 inch soil	ND	ND	44.8
S/5	Hole 3, 6 ft from east wall, 6 foot behind reactor, 1 ft left of rail	0 to15 inches concrete	ND	ND	2.06
S/6	Hole 4, south of east wall,	0 to 15 inch concrete	ND	ND	1.55
S/6	Hole 4, south of east wall (DUPLICATE)	0 to 15 inch concrete	ND	ND	NA
S/7	Hole 4, south of east wall	8 to 32 inch soil	ND	ND	2.31
S/7	Hole 4, south of east wall (DUPLICATE)	8 to 32 inch soil	ND	ND	NA
S/8	Hole 5, south side of hole experimental area	0 to15 inch concrete	ND	ND	2.57
S/9	Hole 6, south rim	0 to 15 inch concrete	ND	ND	2.28
S/10	Hole 7, Mid/core edge west of bioshield, 3 ft from outer edge	0 to 15 inch concrete	ND	ND	2.36
S/11	Hole 8, NE experiment area	0 to 15 inch concrete	ND	ND	1.69
S/12	East side pit under reactor - lower slab 1/1	0 to12 inch concrete	107,824	ND	ND
S/13	East side pit under reactor - lower slab 1/2	12 to 36 inch concrete	434,770	ND	1.96
S/13	East side pit under reactor - lower slab 1/2 (DUPLICATE)	12 to 36 inch concrete	410,537	ND	NA
S/14	East side pit under reactor - lower slab 1/3	36 to 48 inch concrete	231,247	ND	54.26
S/14	East side pit under reactor - lower slab 1/3 (DUPLICATE)	36 to 48 inch concrete	234,861	ND	NA
S/15	South side pit, 3 feet from wall 2/1	0 to 12 inch concrete,	48,177	ND	5.40
S/16	South side pit, 3 feet from wall 2/2	12 to 36 inch concrete	4,001	ND	1.23
S/17	South side pit, 3 feet from wall 2/3	36 to 56 inch concrete	ND	ND	32.98
S/18	North side pit 4 feet under 3/1	0 to 12 inch concrete	142,548	ND	13.23
S/19	North side pit 4 feet under, 6 ft from side 3/2	12 to 24 inch concrete	80,505	ND	2.40
S/20	North side pit 4 feet under, 6 ft from side, 10 inch from hole 8 3/3	24 to 36 inch concrete	29,010	ND	1.36
S/21	Lower bottom slab of pit North side pit 3/4	36 to 48 inch concrete	107,193	ND	134.92
S/22	Mid pit 16 foot from E. wall	0 to 24 inch soil	7,127	ND	56.72
S/23	North side pit 7 foot down, , 8 feet from surface slab	0 to 24 inch soil	12,290	ND	159.83
S/24	10 foot from surface, front of hole wall, bottom of hole	24 - 48 inch soil	12,813	ND	19.94

[1] Measured with a Calibrated Beta Scout LSC, MDL = 8.36 pCi/g
[2] Measured with a Calibrated Beta Scout LSC, MDL = 1.85 pCi/g,
[3] Measured with a Calibrated Gamma Spec, MDL = 0.02 pCi/g
[4] Corrected for Background

ND = Non Detect
NA = Not Applicable

levels as shown in Table I were of no consequence. 2 sampling locations were selected from the Reactor Subsurface Soil Area (locations 12 – 13 on Fig. 1). Cobalt-60 activity levels as shown in Table I were of no consequence.

The tritium results are shown in Table I. Figure 2 shows the distribution of tritium, analyses at various points sampled throughout the reactor slabs and subsurface structures at the incremental sampling depths.

Four sampling locations were selected from the East Wall Slab area based on the previous coring locations (locations 1 – 4 on Fig. 1). Tritium activity levels as shown in Table I were Non Detects. On the upper section of slab 4 sampling locations were selected from the Experimental and Reactor Floor Area (locations 5 – 8 on Fig. 1). Tritium activity levels as shown in Table I were Non Detects. 3 sampling locations were selected from the Lower Concrete Section of Reactor Bioshield Foundation Area based on the historical understandings of neutron activation and tritium contamination (locations 9 – 11 on Fig. 1). Tritium activity levels as shown in Table I were of consequence. The East side of the pit older lower slab Tritium activity in the first 12 inches was 107,824 pCi/g to 434,770 pCi/g from 12 to 36 inches in depth. The South side of the pit older lower slab Tritium activity in the first 12 inches was 48,177 pCi/g to 4,001 pCi/g from 12 to 36 inches in depth, from 36 to 56 inches the Tritium activity was Non Detect. The North side of the pit older lower slab Tritium activity in the first 12 inches was 142,548 pCi/g to 80,505 pCi/g from 12 to 24 inches in depth, 29,010 pCi/g for 24 to 36 inches and 107,193 pCi/g for 36 to 48 inches. 2 sampling locations were selected from the Reactor Subsurface Soil Area (locations 12 – 13 on Fig. 1). The soil Tritium activity in the first 24 inches was 12,290 pCi/g to 12,813 pCi/g from 24 to 48 inches in depth.

CONCLUSIONS

Based on the current survey of slab contamination levels, the following conclusions were drawn:

- There was measured Tritium and Cobalt-60 contamination within the concrete slab above background at the points sampled. Cobalt-60 was 1.23 – 159.8 pCi/g and H-3 was 4,001 – 434,770 pCi/g. The data will be independently verified before further use.

- Radionuclide contamination data for slab subsurface soils, and ground water, do not adequately characterize the extent or amount of site contamination that may exist on or off the site.

- Despite hot weather conditions and poor slab surface conditions sampling and profiling to depths below slab surfaces and deep into subsurface structures and soils at this site was relatively straightforward and can be used in the acquisition of incremental samples to measure contamination.

- The Older Lower Slab structure and soils were generally more contaminated than the bulk of the upper newer concrete slab material.

- Provided new screening characterization for contaminants of concern in the slabs, and subsurface concrete soil interfaces.

- Provided detailed information on the extent of contamination by complementing existing surveys to determine where more surveying/sampling might be conducted.

- Provided a protocol to identify historical unknowns through the ability to sample inaccessible areas of the building matrix.