Summary of the Limited Reconnaissance Effort Regarding the Naturally Occurring Suspect Material at the Grand Canyon National Park

NPS-GCNP-RMC-01

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EXECUTIVE SUMMARY

RMC Consultants, Inc. (RMC) was contracted by the NPS to perform a preliminary survey of the Grand Canyon's South Rim Visitor's Center. This activity was required since some rock specimens at the site were thought to contain naturally occurring radioactive materials. RMC along with Arcadia Consulting (collectively referred to here as The Team), designed a reconnaissance effort to identify potential radiological hazards posed to NPS employees, the public, and the environment from the material collected from nearby mine sites. Personnel were dispatched to the South Rim Visitor's Center with the assumption that an unspecified quantity of soil corings were on site that potentially contained 3% of U-nat (naturally occurring Uranium). These materials were purportedly stored at the Visitor's Center, for about 40 years. It was also understood there was a mine facility located within approximately 5 miles of the visitor's center containing additional uranium ores and tailings from which these materials may have come from..

What was actually discovered were various igneous, metamorphic and sedimentary rock samples located at multiple locations (the museum, the visitor center, the interpretation garage, and the "old warehouse") of the South Rim Complex. These samples included unprocessed ore, semi-processed ore with some yellowish residue, coring samples, and samples of materials in simple geological forms.
The Team's personnel contacted NPS representatives, performed radiological measurements, and obtained all applicable documentation (with the assistance of the NPS), in order to characterize the radiological potentials. Since this reconnaissance effort was performed to identify potential radiological hazards posed to NPS employees, the public, and the environment from the materials resulting from mining activities it is intended that the information contained in this report be used as a tool to determine potential pathways of exposure thus allowing NPS personnel to implement good radiological storage, handling and display practices.

The reconnaissance yielded much data, which are incorporated in this report. State of Arizona, NRC, and EPA guidelines are described within, and the general regulatory provisions cited. Items requiring additional attention and the corresponding regulatory drivers are emphasized.

This report incorporates the general steps and methodology undertaken in the course of this reconnaissance to differentiate the nature of the hazards. Non-binding recommendations to assist in the administrative control of the naturally occurring [suspect] material are also included. It is recommended that for further guidance, especially in the areas requiring additional attention, the NPS consult with the State of Arizona Radiation Regulatory Agency.

1.0 INTRODUCTION

1.1 Background and History

Years ago uranium ore was mined in Arizona at various locations including the Grand Canyon National Park. Material collected from these activities are believed to be the source of the radioactive materials in question, with special emphasis placed on the Orphan Lode Mine. The Orphan Lode Mine lies on the South Rim just west of the Grand Canyon Village.

The mine was discovered and named by Daniel "John" L. Hogan and his partner Henry Ward. The ore body of the Orphan Lode Mine is located in a breccia pipe that extends vertically to a depth of about two thousand feet. When the mine closed in 1969, it had produced 495,107 tons of ore, including 4,257,071 pounds of uranium oxide averaging 0.43 percent. (Source: Grand Canyon Association, et. al. 1997)

The first ore shipment on April 25, 1956 contained 20.89 tons averaging 0.53 percent uranium oxide, consigned to the Atomic Energy Commission (AEC) [*now known as the Department of Energy, or DOE]* ore-buying station at Tuba City, AZ, ninety-two miles away. (C.M. Brundy, 1977, has noted that the Orphan Lode at one time yielded the highest-grade single shipments of uranium oxide ore ever in the United States; an average of 4.09 percent, four times richer than other U.S. sources.) (Source: Grand Canyon Association, et. al. 1997)

1.2 Description and Breakdown of Uranium

Because adverse effects have been documented from exposure to radiological materials, The Team has developed a listing, or brief synopsis on the properties of uranium:

Uranium, (V), element number 92, occurs only in radioactive form. Natural uranium (U-nat) is a mixture of U-238 (~99.3%), U-235 (~0.7%), and U-234 (~0.006%). U–238 is the head of the uranium/radium series and U-235 starts the uranium/actinium series. The isotopes of U-nat have extremely long half-lives: 4.5E+9 years for U-238, 7.1E+8 for U-235, and 2.5E+5 years for U-234.

The progeny elements include two noble gases: radon-222 and radon-219; a third, radon–218, occurs in very low frequency and is documented as having no adverse biological effects These gaseous radionuclides are released in uranium mines and then decay to alpha- and beta–emitting isotopes of polonium, bismuth, thallium, astatine, and lead. The radon and the radon progenies adhere to atmospheric dust particles and, when found in elevated concentrations, constitute a inhalation hazard.

Most exposures to uranium and its progeny's have occurred during the mining, processing, and fabrication of uranium into fuel elements for nuclear reactors or weapons. During this process, the uranium exists in several different physical states and chemical compounds.

Raw ores contain from 0.1% to 1.0 % uranium, chiefly in the form of U_3O_8. During the milling operation, the ore is concentrated, leached, and processed to ammonium diuranate and U_3O_8, a mixture called 'yellowcake'.

Uranium is considered either a chemical or a radiological hazard depending on its isotopic composition and radiation history. With U-nat, the total quantity of metal absorbed is the determinant regardless of the compounds involved.

In view of extensive industrial experience, it appears that natural uranium is less toxic to man than expected based on animal experiments. There has been no evidence of chronic chemical toxicity after years of exposure to low levels (Scott et al., 1970). (Source: NCRP Report No. 65)

1.3 Purpose

This reconnaissance effort was performed to identify potential radiological hazards posed to NPS employees, the public, and the environment from the materials resulting from mining activities. It is intended that the information contained in this report be used as a tool to determine potential pathways of exposure and allow NPS personnel to implement good radiological storage, handling and display practices.

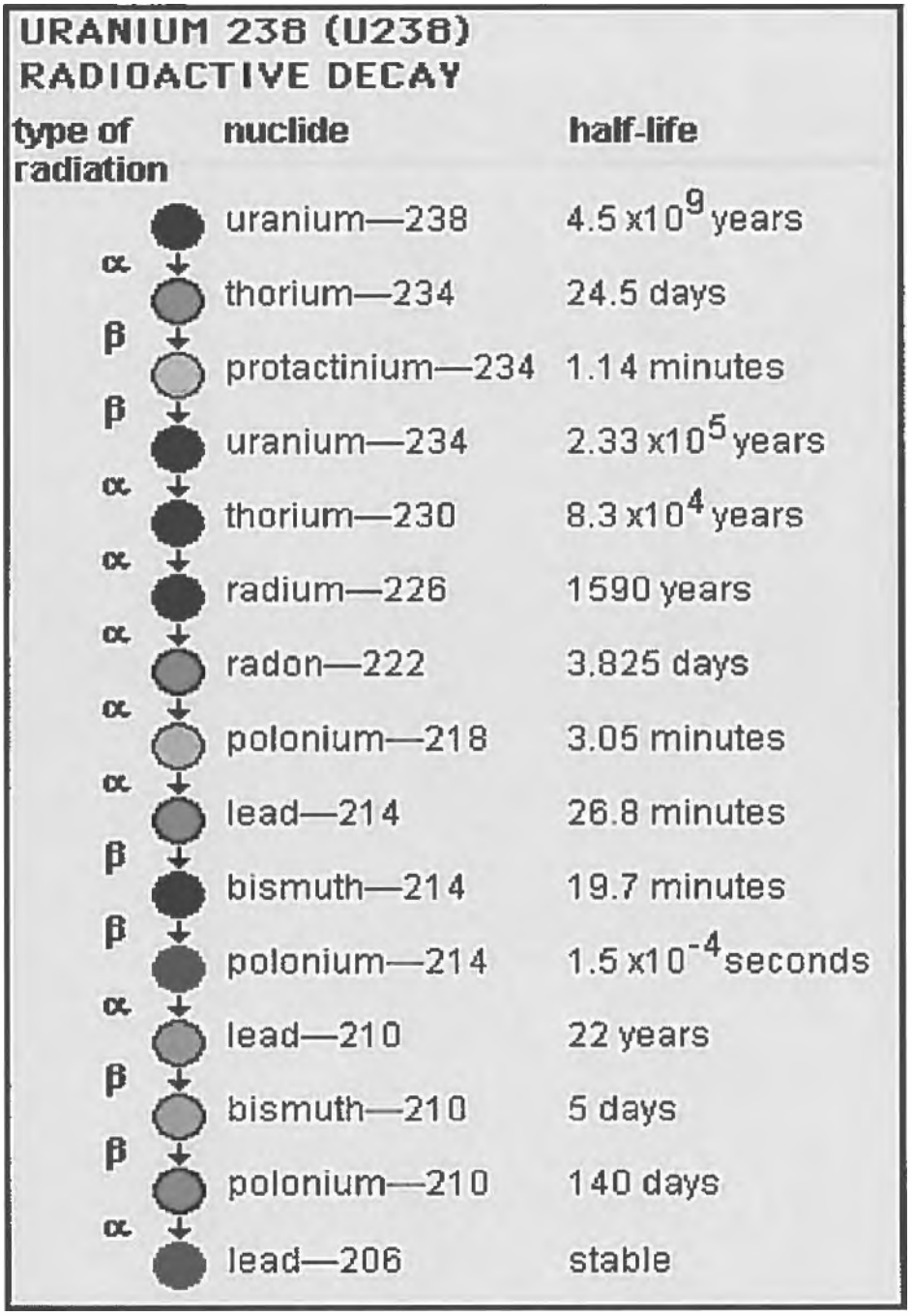
2.0 METHODOLOGY AND DISCLAIMERS

Upon arrival at the Grand Canyon National Park, the initial step was to attempt to gather all relevant paperwork on the suspect material. Written documentation regarding previous characterization of the suspect material was not readily available; therefore field measurements were used to gather real-time information (data).

Radiological instrumentation sensitive to alpha, beta, and gamma radiations were used for total direct (instrumentation) and indirect (removable swipe) measurements of radioactivity from suspect materials.

Considering the uranium decay chain, alpha, beta, and gamma emitting radionuclides were the only isotopes of concern. No air sampling was performed, as the likelihood of particulate materials being generated was considered remote at the time. The Uranium decay chain is attached as Figure 1.

Figure 1 – Uranium Decay Chain



A Ludlum Model 2224 was used for alpha direct measurements, (direct beta measurements were not available due to a light leak in the instrument); a Ludlum Model 2929 was employed for alpha and beta indirect measurements. Photon emitting radionuclides were measured using a Ludlum Model 19. All instruments were performance/source checked and certified to be in calibration before being used.

3.0 TECHNICAL DATA GATHERING

3.1 Evaluation

Based off of the initial reports provided by the NPS the following steps were taken; calculations were performed to determine the specific activity of the material to be encountered, the State of Arizona Regulations were acquired, and DOT regulations reviewed. Personal protective equipment, sampling media, log sheets, and radiological detection equipment was shipped to Flagstaff Arizona for later pickup and transfer to the site.

Once on-site, NPS personnel were contacted, and any related documentation provided by the NPS was referenced as a resource before beginning the field analysis.

4.0 AREAS OF INTEREST

The suspect material was found to be stored in five separate locations. These were the **Museum Collection, Natural History Room**; the **"Old Warehouse"**; the **Interpretation Garage**; the **NPS Administration Visitor Center (Basement)**; and the **NPS Administration Visitor Center (Uranium Mining Display)**.

4.1 Locations

4.1.1 Museum Collection, Natural History Room - (Swipe Series 000) various rock specimens contained in storage shelves, and samples of ore from the Orphan Lode Mine were found. **The samples had a known assay of 42% U-nat** (see appendices).

4.1.2 Old Warehouse - (Swipe Series 100) various rock specimens. Swipes and direct measurements were performed on rock specimens suspected of containing radioactive material. **No obvious radiological concerns were found**. (See appendices).

4.1.3 Building #183 (Interpretation Garage) – (Swipe Series 200) drill core samples. Door #4 of the Interpretation Garage has a sample cabinet containing drill core

samples from the Orphan Lode Mine. **No obvious radiological concerns were found** (see appendices).

4.1.4 Visitor Center (Basement) – (Swipe Series 300) the Chemical Storage Locker in the basement contained many specimens of rock samples. Some are suspected of containing naturally occurring radioactive material (NORM). **The dose rate survey revealed increased levels of gamma radiation upon entry.** (See appendices).

4.1.5 Visitor Center (Uranium Mining Display)– (Swipe Series 500) three pieces of uraninite were on display behind a glass enclave. Because of limited ventilation, the potential exists for the buildup of radon-222 and radon-219 gases.

Table 1 - Summary of Survey Results

On the following page, Table 1 outlines the results of the investigation:

The most active radiation measurements and material with accompanying documentation are noted in the following surveys: (Background levels are indicated on the attached survey reports.) The readings are believed to be from isotopes of U-nat and its progeny, which emit alpha, beta, and gamma radiations.

Table 1 - Summary of Survey Results

Location	Description	Swipe #s	Dose Rate on Contact [1]	Dose Rate @ 1 Meter [2]	Total Activity – Direct (α) [3] (dpm/100 cm²)	Total Activity – Removable (α) [4] (dpm/100 cm²)	Total Activity – Removable (β) [4] (dpm/100 cm²)
Museum Collection, Natural History Room	Various rock specimens and limestone core contained in storage shelves	*Swipe Series 000*					
	Discovered with a μR/hr survey	Swipe 001 (Rock # 20081)	5 mR/hr	0.5 mR/hr	32,564	251	1281
	Ore from the Orphan Lode Mine	Swipes 002-004	Taken on samples of ore from the Orphan Lode Mine. The samples had a known assay of 42% U-nat (see appendices).				
Old Warehouse	Various rock specimens	*Swipe Series 100*	Swipes and direct measurements were performed. No radiological measurements showed total or removable contamination of levels of concern.				
Building #183 (Interpretation Garage)	Drill core samples	*Swipe Series 200*	Door #4 of the Interpretation Garage has a sample cabinet containing drill core samples from the Orphan Lode Mine. No radiological measurements showed total or removable containing of levels of concern.				
NPS Administration Visitor Center	Various rock specimens	*Swipe Series 300*	The chemical storage locker in the basement contained many specimens of rock samples. Some are suspected of containing NORM. The dose rate survey indicated increased gamma radiation up entry into this area.				
		Swipe 300 (Rock #21137)			31,980	74	124

(Basement)		Swipe 307 & 308 (Rock #20.071)			76,852	403	933
		Swipe 309 (Rock #47363				1206	2257
Location	Description	**Swipe #s**	**Dose Rate on Contact [1]**	**Dose Rate @ 1 Meter [2]**	**Total Activity – Direct (α) [3] (dpm/100 cm^2)**	**Total Activity – Removable (α) [4] (β) [4] (dpm/100 cm^2)**	
NPS Administration Visitor Center (Basement) cont.	Various rock specimens cont.	Swipe 313 (Rock #7540)	0.49 mR/hr		51,212	374	795
		Swipe 316 (Rock #7539)	0.8 mR/hr		64,032	249	514
		Swipe 318 (Rock #20235)	3.2 mR/hr		64,032	97	290
		Swipe 320 (Rock #17508)	4.8 mR/hr		3,205,058	244	6,295
		Swipe 322 (Rock #20.057)	0.2 mR/hr		6,339	37	157
		Swipe 324 (Rock #20.082)	4 mR/hr		96,083	37	38

NPS Administration Visitor Center (Uranium Mining Display)	Three pieces of uraninite on display behind glass enclave	*Swipe Series 500* [5]	The potential exists for the build-up of Radon-222 and Radon-219 gases due to the limited ventilation of this area.				
		Swipe 500 (Rock #17093)			9,264	54	190
		Swipe 502 (Rock #17091)			19,167	43	281
		Swipe 504 (Rock #17087)			6,346	86	200

[1] Micro-R Meter – Ludlum Model 19 [2] Ludlum Model 19 (γ and χ-ray) [3] Ludlum Model 2224 [4] Ludlum Model 2929
[5] Swipe Series 400 was not used

5.0 REGULATORY REVIEW

In order to comprehend the compliance requirements, The Team has compiled a brief synopsis of the regulations impacting the handling, storage, and display requirements as currently developed, both locally, and nation wide.

5.1 State of Arizona

The State of Arizona defers regulation of uranium and uranium by-products in their state codes by supplying an exemption for unrefined and unprocessed ore containing source material. This exemption remains in effect provided that the person does not refine, or process the ore, except as authorized in a specific license (Article 3, R12-1302.(B)). The State of Arizona does however provide guidance on limiting dose to the public. Since NPS Grand Canyon employees have not been specifically trained in the handing of radioactive materials, they (in the opinion of The Team) should be considered as "public" and not as occupational workers. This approach to personnel characterization is the most conservative.

5.2 Nuclear Regulatory Commission

10 CFR Part 20, Subpart A – "General Provisions", 20.1002 (Scope) applies to "persons licensed by the commission to receive, possess, use, transfer, or dispose of by-products, source, or special nuclear material or to operate a production or utilization facility under Parts 30 through 36, 39, 40, 60, 61, 70, or 72 of this chapter…" The material controlled by the NPS would have to be evaluated (quantified ?) to determine if the licensing quantities described in Appendix C of this section apply. The licensing amount for U-nat is 100 μCi. If the quantities apply, then 10 CFR Part 20, Appendix C to § 20.1001 – 20.2401 "Quantities of Licensed Material Requiring Licensing," Subpart A, and 10 CFR Part 20 where applicable would need to be followed.

5.3 Environmental Protection Agency

40 CFR Part 192.12 (b)(1) (UMTRA) states that in any occupied or habitable building…(the) radon decay product concentration [including background] is not to exceed 0.02 Working Levels. In any case, the radon decay product concentration [including background] shall not exceed 0.03 WL; and (2), the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

40 CFR Part 192 has provisions concerning dose to the public from AEC (now DOE) activities. The dose is limited to 25-millirem whole body to any member of the public.

5.4 Department of Transportation

49 CFR Part 173.435, (DOT) Table A_1 and A_2 values for radioactive nuclides define the shipping quantity for U (natural) as unlimited.

6.0 RECOMMENDATIONS

6.1 Items Requiring Additional Attention

The State of Arizona codes are for the most part silent regarding the suspect materials; however, since Arizona is an agreement state, the EPA, and NRC regulations can apply. It is recommended that the NPS contact the State of Arizona, Radiation Regulatory Agency, for further guidance addressing the following:

- The specimens, which have dose rates that exceed the 20 microroentgens per hour greater than background (40 CFR Part 192.12 (b)(1)), should be identified to the State so that the State can make a determination as to the applicability of the aforementioned regulation.

- An area-monitoring program should be considered to ensure that NPS employees are not exposed to more that 25 millirem/yr from the suspect materials.

- NPS Grand Canyon employees, who have the potential of encountering these materials throughout their normal workday, should be trained in the basics of radiological awareness/safety training.

6.2 Observations

- The materials identified in this report should be relocated to a secure area with industry recognized radiological signs/labeling and tamper indicating seals.

- If the material is considered beneficial to the NPS, it is recommended that all rock specimens be placed either in impermeable material during storage, or in ventilated specimen containers. These materials should only be removed when personal protective equipment (PPE) measurements are met (i.e., gloves, and perhaps lab coats if the material appears friable and subject to becoming airborne).

- If the material will be continually stored in enclosed areas with limited ventilation and accessible to people, an air monitoring (for radon) program should be developed so that an understanding of the amount of exposure is

understood when attempting to handle the specimens after the enclosure is breached.

- The NPS should consider developing a program that prohibits the accidental accumulation of potentially radioactive material, and consider implementing a system that determines if items are radioactive (a baseline risk assessment).

- An administrative controls program should be developed to characterize the type of personnel who should be allowed to access this material. In general, personnel who do not have training on the inherent radiological constituents should not be allowed direct material access.

7.0 CONCLUSION

Through this limited reconnaissance a number of specimens that possess radiological activity have been identified at the Grand Canyon National Park. These specimens appear to be naturally occurring and have likely originated from the Orphan Lode Mine.

Typically when dealing with radiological material the regulations are very clear and concise. This, however, does not hold true for the materials identified at this site. The final disposition of these materials has yet to be defined and cannot be completed without the guidance of the State of Arizona Radiation Regulatory Agency.

There does not appear to be any eminent danger to employees, the public, or the environment from these materials. However, since there is potentially conflicting guidance from the State of Arizona, Nuclear Regulatory Commission, Environmental Protection Agency, and the Department of Transportation, additional research must be performed to definitively characterize the exact regulatory framework within which this material lies.

8.0 SOURCES OF INFORMATION

The following resources were contacted for the completion of this project:

- Technical Measurements Company for instrumentation
- Assorted maps and drawings of the Grand Canyon National Park
- Title 10 CFR Part 20, 30, 40, 50, 51, 70 and 72 (NRC)
- Title 10 CFR , Part 835, Appendix A (DOE)
- Title 40 CFR, Part 192 (EPA – UMTRA Title I)
- USC 42 CFR, Part 88 (U.S. Congress – UMTRCA)
- Title 49 CFR, Parts 173 - 177 (DOT)
- Title 12. Natural Resources, Chapter 1. Radiation Regulatory Agency (Arizona Administrative Code)

9.0 ACRONYM LIST

AEC	U.S. Atomic Energy Commission
AZ	Arizona
CFR	U.S. Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPM	Disintegrations per Minute
EPA	U.S. Environmental Protection Agency
ITR	Independent Technical Review
MAP	Management Action Process
mR	milliroentgen
NCRP	National Council on Radiation Protection and Measurements
NORM	Naturally Occurring Radioactive Material
NPS	U.S. Department of the Interior, National Park Service
NRC	U.S. Nuclear Regulatory Commission
RAP	Remedial Action Plan
RRA	Arizona Radiation Regulatory Agency
RRM	Residual Radioactive Material
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
U-nat	Naturally occurring uranium
U.S.C.	United States Code
WL	Working levels

10.0 LIST OF REFERENCES

1. 40 CFR Part 192, Subpart D – "Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended."

2. National Council on Radiation Protection and Measurements, "Management of Persons Accidentally Contaminated with Radionuclides," *NCRP Report No. 65*. Washington, D.C.: 1980

3. National Research Council, Health Effects of Exposure to Low Levels of Ionizing Radiation, Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR V), National Academy Press, Washington, D.C. 1990.

4. Reg. Guide 8.29; Instruction Concerning Risks from Occupational Exposure."

5. Billingsley, Spamer, Menkes, "Quest for the Pillar of Gold-The Mines & Miners of the Grand Canyon," U.S. Geological Survey and Grand Canyon Association. Grand Canyon, AZ: 1997

11.0 LIST OF APPENDICES

Appendix A	Contamination Survey Forms
Appendix B	Radiation Survey Forms
Appendix C	Assay Data

APPENDIX A

CONTAMINATION SURVEY REPORTS

APPENDIX B

RADIATION SURVEY REPORTS

APPENDIX C

ASSAY DATA